Q-Series
Tiger Sparks: Is Asia's innovation boom creating a new world order?

Equity Strategy
Asia Pacific

Niall MacLeod
Strategist
niall.macleod@ubs.com
+852-2971 6186

Matthew Gilman
Strategist
matthew.gilman@ubs.com
+852-2971 8173

Yankun Hou
Strategist
yankun.hou@ubs.com
+852-3712 4451

Edward Teather
Economist
edward.teather@ubs.com
+65-6495 5965

Mark Leung
Strategist
mark.leung@ubs.com
+852-2971 8636

Ting Gao
Strategist
S1460515090002
ting.gao@ubssecurities.com
+86-213-866 8856

Asia's R&D spend on track to exceed Europe and the US combined by 2020

There's been an explosion in creativity and innovation in China. In areas such as Artificial Intelligence (AI) and Fintech, Chinese companies are increasingly world-class. Improved education (2.8m Science/Engineering graduates annually, 5x US levels), intensified R&D, government policy and availability of capital are fuelling this. This follows a well-trodden path elsewhere in north Asia. Japan, Korea, and Taiwan have blasted through the middle income trap with the help of innovation. Faced with China's rise, these countries are not standing still. Though China's R&D spend will likely surpass the US as early as 2018, the region as a whole is likely to spend more than the EU and US combined by 2020.

Smokestack to lab tech – our innovation scorecard highlights the big changes

We've built a detailed regional scorecard tracking education, R&D, funding, and patents, to understand who is innovating, how this is changing (back to 2005), and the industries that are gaining an edge. The speed of change and ongoing investment suggests north Asia is likely to close the gap with the US further. China has rocketed up our scorecard since 2005 and Korean R&D, as a % of GDP, is now on par with Israel, long considered one of the world's most innovative economies. Our analysis suggests an innovation dividend in the coming decade for north Asian companies. Our data also shows a yawning innovation gap in the region, with south Asia (ex-Singapore) lagging.

The market is not paying up for Asia's innovation

We believe Asia's innovation is being underestimated. Valuing innovation is hard. But using a simplistic proxy – EV/Cumulative R&D spending – shows a discount being applied to Asia's R&D spending, especially in Japan and Korea. This tallies with what relative earnings multiples show – many sectors where Korea, Japan and China look good on an innovation basis trade at a discount to global peers (page 5). This suggests that investors are sceptical about Asian companies' ability to turn spending into profits.

Four key conclusions

1. Chinese innovation is likely to help shift the debate away from concerns about overinvestment and credit toward newer areas of growth. We see scope for the market (beyond currently fashionable internet stocks) to re-rate over the medium term as investors recognise this. 2. Korea in particular stands out – R&D has been increasing sharply, now among the highest globally. This does not appear to be priced into stocks. If Korean companies can monetise their R&D spending, there is potential for considerable re-rating. 3. Much of south Asia risks missing out on an innovation dividend. Valuations suggest too rosy a long-term growth picture being priced-in, though there are some reasons for optimism in India, despite aggregate innovation metrics looking weak. 4. North Asia's pace of innovation underpins our work from earlier this year that active managers have a better outlook in these markets.

Innovation initiative: An innovation boom is taking place globally, driven by unprecedented growth in R&D, human capital and resources in Asia, particularly North Asia. Congruence of technological advancement in computing power, data storage, and artificial intelligence alongside radically new business models is having transformative and disruptive impacts on many industries. This report is part of an ongoing initiative by UBS Research to uncover where innovation is now, why it is flourishing and where it is likely to take place in the future. We aim to translate what prevalent trends mean for economies, sectors, companies and investors in the years and decades to come.

Contents

Executive summary ... **3**

How to measure innovation and where it's happening? ... 3

Identifying industry hotspots ... 4

Asia's innovation boom is not in the price ... 5

Four key conclusions: ... 6

Innovation and why it matters ... **8**

Our country innovation scorecard ... **10**

Key country observations: five things stand out ... 12

Debates: size, iteration and the business environment ... 14

Industries: where's Asia gaining? ... **17**

Key industry snapshot observations ... 19

Using UBS Evidence Lab to triangulate our findings ... 20

Is Asia's innovation being priced in? ... **22**

The key top-down conclusions ... **25**

Country innovation scorecard in detail ... **28**

1. Education ... 28

2. R&D spending ... 32

3. Funding ... 36

4. Patents ... 39

Historical overall scorecard ... 41

Niall MacLeod
Strategist
niall.macleod@ubs.com
+852-2971 6186

Matthew Gilman
Strategist
matthew.gilman@ubs.com
+852-2971 8173

Yankun Hou
Strategist
yankun.hou@ubs.com
+852-3712 4451

Edward Teather
Economist
edward.teather@ubs.com
+65-6495 5965

Mark Leung
Strategist
mark.leung@ubs.com
+852-2971 8636

Ting Gao
Strategist
S1460515090002
ting.gao@ubssecurities.com
+86-213-866 8856

Executive summary

China's innovation is creating a shift in perceptions

China now spends more on R&D than the EU countries, and is on track to surpass US spending by 2018. Patent filing by Chinese entities at the US Patent Office has risen ten-fold in the past ten years – already surpassing the UK and we estimate there will be more patents filed than by Germany by 2018. Education standards have soared. China now turns out 2.8 million science and engineering graduates each year, five times the level of the US. In short, China is innovating aggressively.

But this isn't simply a China story. Across APAC, innovation is accelerating

But the rest of the region is not standing still. Korean R&D spending as a share of GDP is now on par with Israel – long considered a leader in innovation, for example. In this Q-Series on Innovation in Asia, the first in a series of reports from UBS, we take a top-down look at where it is happening, why it matters and what it means for regional equities.

How to measure innovation and where it's happening?

Measuring and predicting innovation is an incredibly complex endeavour. A scholar could navigate from Adam Smith to Joseph Schumpeter to Edward Deming to Michael Porter to Philip Kotler and still not get close to the complexity of the issue. Academic debates still exist on the role of "agents" versus "context" in innovation emergence, or the aspect of "discovery" versus "creation", or even how much policy, industry structure or competition can effectively influence innovation throughput out of a system.

For the purposes of assessing where innovation is taking place at a region-wide level and in a global context, by necessity this note focuses on a number of the innovation building blocks that are measurable and for which comparable data exists.

See page 10 for the country scorecard

We've created a country innovation scorecard, containing education, R&D, financing and patent metrics for 14 APAC countries, along with the US, UK, Germany and Israel (generally considered advanced innovation countries). We've been restricted by consistent data availability, and have for example, left out Defence spending, long considered a progenitor of innovation.

There are various detailed innovation scorecards in existence, such as the Global Innovation index. Where ours differs is that we've taken it back to 2005 to show not only where the region is but the big deltas over the last 10-15 years. Figure 1 provides a summary of where our innovation scores per country are today and how and by how much they've changed since the mid-2000s.

Figure 1: Summary of the Innovation Scorecard – now and then

	Historical		Current		Change	
	Score	Rank	Score	Rank	Score	Rank
Korea	2.04	5	2.81	2	+0.77	+3
China	0.70	12	1.38	9	+0.69	+3
Vietnam	0.10	18	0.25	16	+0.15	+2
India	0.53	14	0.82	13	+0.28	+1
US	2.77	2	3.05	1	+0.27	+1
Germany	1.58	6	1.79	6	+0.21	0
Thailand	0.27	15	0.43	15	+0.15	0
New Zealand	0.92	11	1.06	11	+0.14	0
Singapore	1.53	7	1.67	7	+0.13	0
UK	1.49	8	1.53	8	+0.04	0
Taiwan	2.61	3	2.52	4	-0.09	-1
Australia	1.45	9	1.30	10	-0.16	-1
Japan	2.45	4	2.16	5	-0.29	-1
Malaysia	0.56	13	0.73	14	+0.17	-1
Indonesia	0.14	16	0.25	17	+0.11	-1
Philippines	0.14	17	0.24	18	+0.10	-1
Israel	2.79	1	2.74	3	-0.04	-2
Hong Kong	1.00	10	0.96	12	-0.04	-2

Source: UBS Note. See page 10 for more details.

North Asia is very competitive versus Europe and the US on many metrics. Asia seems some way behind the US and Europe on education, but on R&D spending is generally ahead. Indeed on our estimates, we think Asia's R&D is likely to exceed the combined spending in both the US and Europe by 2020.

On our measures, north Asia is competitive and rising fast on innovation metrics

Korea is a standout at a country level, number two on our innovation scorecard overall, rocketing up three places since 2005. China too has seen a surge both in its overall score and overall rank, albeit still some way short of the best in class. Based on government targets, and the rate of change on a number of the innovation metrics we track, we are confident that both China and Korea will progress substantially further in the coming years. We think it highly likely that China emerges as a major innovating and high value added economy over the coming decade, as the economy moves from "made in" to "create in" China.

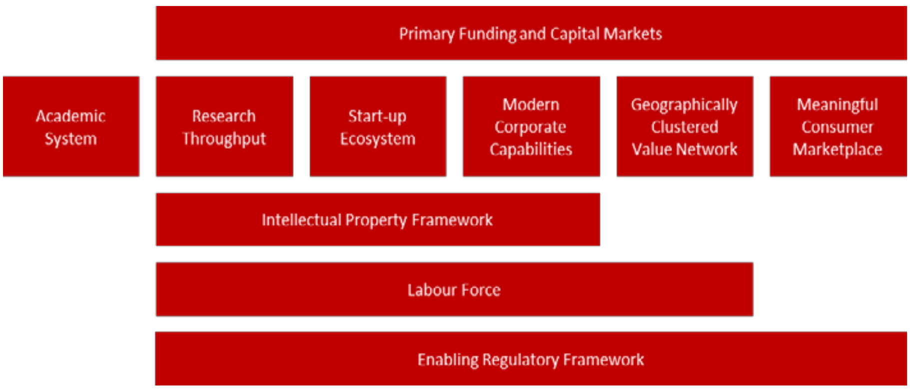
Korea is a standout. But China too has rocketed up our metrics since the mid-2000s

The picture for south Asia is less rosy. There is one pocket of real strength – Singapore. Malaysia and India score well on some metrics, particularly education. But the region overall is in danger of missing out on an innovation dividend. On some of our metrics, south Asia has actually regressed since the mid-2000s.

Identifying industry hotspots

Our analysis going forward (across the series of documents) will be based on assessing how different countries and sectors score against some fundamental building blocks (see Fig 2) that can influence the pace of innovation throughput out of a system. Some of these building blocks might positively or negatively impact innovation throughput depending on different factors, and we will elaborate on these in our analysis as well. In areas where our analysis highlights "innovation sparks" could occur, we will conduct a deeper dive into that area.

Figure 2: Innovation building blocks



Source: UBS

To see where Asian industry has pockets of strength, or lead indicators suggest a more robust competitive environment ahead, we've focused our attention on the north Asian countries – Japan, China, Taiwan and Korea – and compared how they look compared to US, German and UK peers.

As with the country scorecard, we have limited our analysis to factors which are both measurable and comparability exists. We've looked at patent data on grants at the US patent office, along with rate of change of grants, R&D spending data as a share of the global sector's total spending alongside the rate of change of R&D spending and some academic excellence metrics for 13 broad industry categories. This approach means we've left out Software/Internet/AI, where patenting is difficult, but education data suggests China, for example, is a global leader.

The full 'industry snapshot' and details are on page 16. Figure 2 shows a hotspots summary in three categories: Establishment, Challengers and Next Generation. Japan looks established in a number of sectors, from Chemicals to Engineering, to Medical Tech, and Vehicles. Korea is strong in Tech and Materials, and up and coming in Chemicals, Industrial Machinery and Vehicles. China outside of Civil Engineering is generally among the Challengers or Next Generation in most areas.

Figure 3: Where are Asia's strengths and its greatest potential?

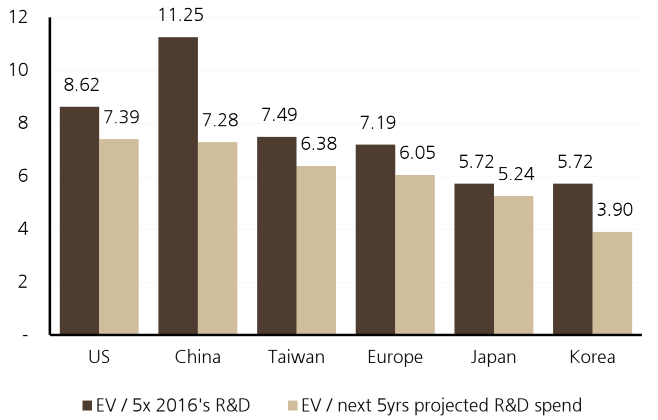
	(established leaders) The Establishment	(somewhat established and growing) The Challengers	(up & comers) The Next Generation
Chemicals	Japan,	Korea	China
Civil Engineering	Japan, Korea, China		
Computer Technology	Japan, Korea, Taiwan		China
Environmental Technology			Korea, China
Home Appliances & TV	Japan, Korea	China, Taiwan	
Industrial Machinery	Japan	Korea	China, Taiwan
Materials, Metallurgy	Japan, Korea	China	
Medical Technology	Japan		Korea
Optics	Japan		
Pharmaceuticals			Korea, Taiwan
Semiconductors	Taiwan, Korea		China
Telecommunications		China	
Vehicles in General	Japan	Korea	China (commercial not auto)

Source: UBS

Asia's innovation boom is not in the price

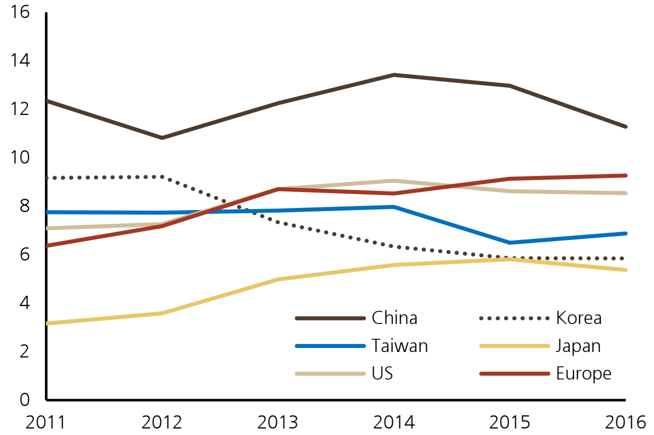
Valuing innovation is difficult. To try, we've used a simple measure: cumulative R&D spending for the past five years, and compared this to Enterprise Value for several Asian countries, Europe and the US. While there are accounting differences that can distort this analysis, Figure 4 shows that the market seems to be unwilling to pay up for R&D in Japan and Korea – suggesting that either investors are sceptical about the ability of companies in these markets to monetise their spending, or setting up an opportunity for rerating as the current innovation boom materialises in market share gains and higher profits.

Figure 4: EV/5 Year Cumulative R&D Expense



Source: Worldscope, Thomson Datastream, UBS

Figure 5: EV/5 Year Cumulative R&D Expense (time series)



Source: Worldscope, Thomson Datastream, UBS

Granted, China does not look as compelling on this basis, but the data is likely distorted by the rapid increases in R&D spending – and likely growth ahead. Projecting the next five years based on the past five years growth, China's multiples would drop back to being in line with the US.

Figure 5 shows that in many sectors where we think there is an innovation edge, valuations also look attractive in a global context.

Figure 6: Asia's innovation sectors where valuations are also attractive

THE ESTABLISHMENT	Current Fwd P/E	P/E prem/(disc) to Global Sector	P/E rel to Global equities vs. ave since 2011	THE CHALLENGERS	Current Fwd P/E	P/E prem/(disc) to Global Sector	P/E rel to Global equities vs. ave since 2011	THE NEXT GENERATION	Current Fwd P/E	P/E prem/(disc) to Global Sector	P/E rel to Global equities vs. ave since 2011
Japan Chemicals	14.0	-14%	-13%	Korean Chemicals	10.0	-38%	-17%	Korean Environ. Tech	10.8	-34%	-18%
Japan Civil Eng'ring	11.2	-22%	-36%	Korea Vehicles	6.9	-25%	-14%	China Chemicals	8.3	-49%	-30%
Japan Mats & Metal	11.0	-22%	-17%					China Environ. Tech	9.6	-41%	-18%
Korea Semiconductors	5.1	-65%	-45%					China Ind. Mach.	10.7	-41%	-14%
Korea Civil Eng'ring	7.0	-51%	-39%					China Semiconductors	11.8	-17%	-48%
Korea Comp Tech	7.6	-43%	-44%								
Korea Home Appl.	11.6	-14%	-25%								
Korea Mats & Metal	10.2	-28%	-10%								
China Civil Eng'ring	8.0	-45%	-12%								

Source: IBES, Thomson Datastream, UBS

Investors appear to be underestimating Asian innovation

History suggests this is a mistake

It appears that global equity investors – both on our R&D valuation metrics and more straightforward earnings multiples – are to be convinced that Asia is able to innovate. Decades of evidence in Japan, and the boom in R&D spending, patent filing and education improvement should serve as a warning that underestimating Asia's innovation rise is a mistake.

Four key conclusions:

The change in the shape of the economy supports a longer-term re-rating of Chinese equities

1. For China we think the market may be missing the shift up the value chain that is taking place. Government policy appears determined to raise the value added of the economy. Meanwhile, data suggest this is actually happening, with China rocketing up our innovation scorecard.

While investors are clearly excited about the growth rate in internet-related stocks, the old perceptions about China remain – that this economy is a prisoner of over-indebtedness, with over-reliance on smokestack industry. Just as valuations in the mid-2000s reflected optimism around a perceived economic miracle, valuations in recent years have reflected all the fears of overinvestment. The truth is probably somewhere in between.

We are confident based on what is happening in innovation, that perceptions about China are likely to be very different five years from now. In turn, we believe valuation multiples five years from now are likely to be shaped by how China has transformed. As investors increasingly recognise the transition, partly led by innovation, we think fears around the health of the financial system will gradually give rise to more optimism about the future and a more broad-based re-rating of Chinese equities.

2. Korea is a stand-out in terms of R&D spending. It is now in line with Israel as the highest spender as a share of GDP, long considered a core innovative economy. As we showed, this is not being reflected in measures such as EV/cumulative R&D. A key question remains whether Korean companies will be able to turn R&D spending into profits. But should they be able to do so as they appear to have been doing, we think there is considerable apparent value in the stockmarket, given where absolute and relative valuations are relative to both regional and global equities.

There is optionality in the price of Korean equities for innovation

3. Large parts of ASEAN are simply missing an innovation dividend. This matters because it suggests that these countries are likely to be prisoners of their labour market competitiveness. It's not that they can't grow fast, but they will be especially dependant on foreign direct investment with their exchange rates and overall competitiveness of labour likely to matter.

Optimism around long-term growth in ASEAN may be misplaced

Given the longer-term growth rates being priced into consumer stocks in ASEAN versus north Asia (see figure 31), implying bullish expectations of medium term per-capita income growth, we think investors may be too optimistic about the ability of these economies to generate productivity growth to match their varying demographic dividends.

4. A strong case for active investing in Asia. Our analysis of innovation in Asia gives us greater confidence that the region, and especially north Asia, is likely to continue to develop quickly, with major shifts in both the shape of the economy and new entrants to the stock market. This suggests a strong case for active investing in Asia. In our February report on Active/Passive investing, we showed how the rapidly changing nature of the economies in Asia was also leading to much more rapid change in the composition of stock markets. In turn, the change in index composition was a headache for passive managers, as they were unable to access the growth of new companies coming into the indices. We estimated there was around 120 basis points of annual alpha over the past ten years that a passive manager was missing because of the development-led changes in economies and stock markets.

Innovation supports active investing

Innovation and why it matters

Innovation is about taking things and making them better

The OECD defines innovation[1] as "the implementation of a new or significantly improved product (goods or services) or process or marketing method or new organisational method in business practices, workplace organisation or external relations". In short, innovation is the ability to take something and make it better.

Asia has been innovating for decades. Indeed it has been at the core of the export driven growth model that much of north Asia has pursued: take existing technologies and improve them. Convergence theory has allowed Asia to copy methods of production and technology. But as cheap labour has thinned out, it's productivity and innovation that's helped Asia move up the value chain.

As part of this process, the region has become increasingly high-end and complex in its manufacturing ability. The seminal MIT Atlas of Economic Complexity[2], which measures this, shows that the more complex the manufacturing base of a country, the better its future growth prospects.

For example, in the MIT study, Thailand ranks 31st in the world for manufacturing complexity, and sixth in Asia, 17 places above New Zealand, and 48 places above Australia. Taken with other factors to predict growth, the MIT study suggests Thailand could be the third-best per capita GDP growth country, globally out to 2020. If this plays out, it suggests a positive story for employment and wages.

Who is an innovator and not just an iterator?

Who owns the IP behind this manufacturing? This is the more likely determinant of profits in the economy, which matters more for investors than GDP growth. Thailand is a complex manufacturer, but much of this has come from Japanese FDI into manufacturing. But the IP and profits from this labour are accumulated largely in Japan. This contrasts with other countries in north Asia, such as Korea which, like Thailand, are complex manufacturers, but Korea has accumulated capital and IP allowing it to sustain competitiveness even as labour has become more expensive.

As a generalisation, north Asia's economic model has emphasised not only the employment of labour in manufacturing through FDI, but the ability of domestic companies to absorb knowledge, copy it, iterate it, innovate it and ultimately compete with it. In turn this has allowed them to move up the value chain.

This is evident in a number of industries where not only have Korean, Japanese and Taiwanese come to the fore in terms of exports, but also in terms of profits. Figure 7 shows the percentage of exports from Autos and Tech in Korea, Japan, Malaysia and Thailand, and the percentage of broadly equivalent market cap in each country accounted for by these industries[3]. Generally, Korea and Japanese exports are reflected in those sectors also being a sizable part of market cap. In south Asia, the opposite is true.

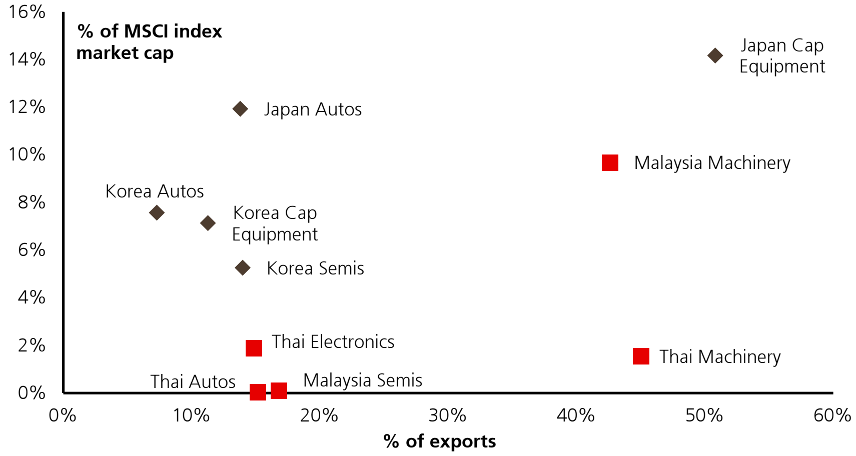
---

[1] OECD, 2005, "The Measurement of Scientific and Technological Activities: Guidelines for Collecting and Interpreting Innovation Data: Oslo Manual, Third Edition".

[2] "The Atlas of Economic Complexity: mapping paths to prosperity' Ricardo Hausmann, The MIT Press, 2014

[3] We've been generous to Malaysia, given the capital goods sector is largely Plantation/Trading/Construction/Property Development, and In Korea, Samsung electronics – 29% of the overall market – is excluded from the Semi sector.

Figure 7: Exports versus Market Cap. North Asia tends to have its exports reflected in market cap.



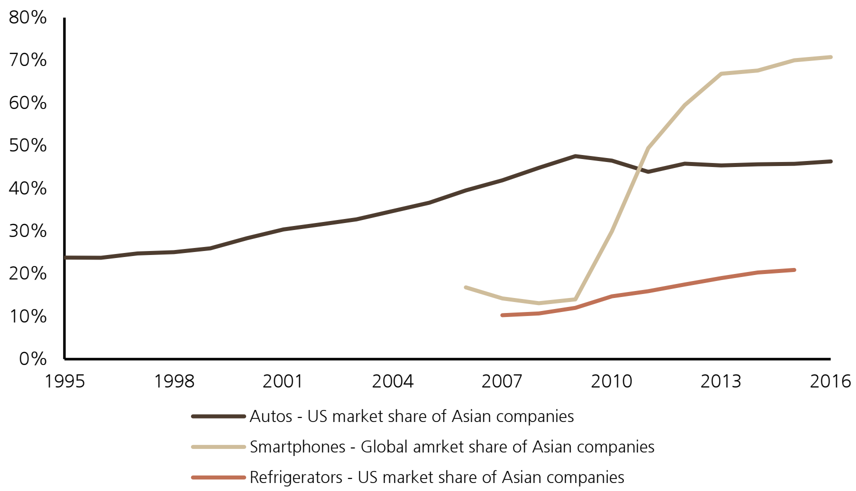
Source: Thomson Datastream, UBS.

The dislocation between exports and market cap in south east Asia over north Asia demonstrates who actually owns the intellectual capital and potentially earns the profits, versus simply provides labour. In our view, innovation is a key contributor that allows a country to go from simply being a provider of cheap labour to its companies being able to deploy capital and generate returns on that capital in a more sustainable way as wages rise.

A key question then is where are countries in this innovation process? Are they stuck in the middle income trap, their fortunes largely determined by the competitiveness of their labour markets, prisoners of their exchange rate rather than able to reap an innovation as well as demographic dividend?

A second key set of questions is where are APAC countries in a global context and where are they going? Over the last 30 years, Asian companies (mainly in north Asia) have taken market share in a number of industries. We believe China is joining this trend, started in Japan and followed in Korea and Taiwan. Will this continue, which industries is it happening, and what does it mean?

Figure 8: The rise of Asian market shares in various industries



Source: UBS

Our country innovation scorecard

We've compared APAC to four leading 'innovator' countries – the US, UK, Germany and Israel

Innovation Studies[4] generally focus on 'input' measures of innovation such as education, R&D and the availability of capital, and 'output' measures of innovation, which normally focus on patenting data. We've focused on these four areas, to identify where Asia Pacific Countries lie on the innovation trajectory, today, and ten years back, in contrast to four innovation leaders - the US, Germany, UK and Israel.

For sure, there are challenges focusing on these factors. For example, patent information doesn't capture the growth of software and internet businesses and AI, where patent filing won't show up. Likewise, it doesn't capture business process innovation/rigorous cost efficiency, that can't be tracked through these measures, but is equally important.

However to be able to measure something, we need 'measurables', and we've created a scorecard focused on these four major areas. Figure 9 shows the scorecard.

By focusing on Education, R&D, Financing and Patents

We've grouped the main factors into four broad areas of Education, R&D, Funding and Patents. For R&D we've focused on R&D as a percentage of GDP, and the number of R&D workers per thousand of the workforce; for education, we've focused on the quality of best universities, the number of science and engineering graduates, and the quality of academic journal output (the H score); for funding, we've focused on the availability of VC funds, and the free cash flow of the tech sector (with a few liberal additions like Softbank in Japan) given the role these sectors are playing in funding innovation and start-ups. To measure the output of innovation, we've focused on the number of filed patents at the US Patent Office over the last year and the cumulative number of granted patents, both on a per capita basis. For each data-point, we've also provided a rank of how that country shapes up compared to the other countries.

For a detailed explanation of each of the factors, the methodology, why we've used it and discarded other factors, please refer to pages 25-38. We also show the historical scorecard for comparison on page 39.

Various bodies provide their own innovation indices or frameworks. We've leant heavily on the OECD's approaches and data. We've also considered other publications like the Global Innovation Index, a comprehensive index, though in our view many of the indicators may serve as better measures of growth, rather than innovation. Our scorecard has an advantage we believe in that we have replicated it for 2005 to show how countries are changing over the last decade.

Any scorecard is hindered by its choice of inputs. There are some inputs for example like Defence spending, that we believe are likely to play a critical role in innovation (likely benefiting US, Israel, China, Korea, and possibly India) but due to a lack of data has been excluded as we explain on page 32.

[4] See for example 'Measuring Innovation, A New Perspective', OECD 2010, or

Figure 9: Country scorecard (today) – China has moved up the rank quite a bit while Japan slipped

	R&D						Education									Funding						Patents						Summary		
	R&D / GDP	*Score*	*Rank*	Res. / kwks	*Score*	*Rank*	QS Ranking	*Score*	*Rank*	H Score	*Score*	*Rank*	STEM / kcapita	*Score*	*Rank*	5yrs VC / GDP	*Score*	*Rank*	IT FCF / GDP	*Score*	*Rank*	Filing / mcapita	*Score*	*Rank*	Aggr / mcapita	*Score*	*Rank*	*UBS Score*		*Overall Rank*
US	2.79	0.65	6	9.14	0.39	9	99.00	1.00	1	1965	1.00	1	1.22	0.35	12	0.29%	0.93	2	1.19%	0.71	2	895.6	0.96	2	2,015.4	0.88	2	3.05		1
Korea	4.23	0.99	2	17.44	0.75	2	75.67	0.76	7	536	0.27	8	3.26	0.94	2	0.04%	0.13	10	1.68%	1.00	1	748.9	0.80	4	1,459.1	0.64	5	2.81	↑	2
Israel	4.27	1.00	1	23.37	1.00	1	48.43	0.49	13	584	0.30	7	--	--	18	0.32%	1.00	1	0.34%	0.20	4	931.3	1.00	1	1,721.1	0.76	4	2.74		3
Taiwan	3.05	0.71	4	12.98	0.56	7	58.07	0.59	10	406	0.21	13	3.48	1.00	1	0.02%	0.06	13	0.98%	0.58	3	875.2	0.94	3	2,278.2	1.00	1	2.52		4
Japan	3.28	0.77	3	13.85	0.59	5	79.73	0.81	6	871	0.44	4	1.63	0.47	8	0.01%	0.04	16	0.26%	0.16	5	679.4	0.73	5	2,006.2	0.88	3	2.16	↓	5
Germany	2.88	0.67	5	15.17	0.65	3	70.77	0.71	8	1059	0.54	3	2.34	0.67	3	0.04%	0.14	8	0.07%	0.04	8	365.3	0.39	6	904.8	0.40	6	1.79		6
Singapore	2.20	0.52	8	14.02	0.60	4	70.33	0.71	9	454	0.23	10	1.01	0.29	15	0.22%	0.71	4	0	--	13	331.2	0.36	7	752.7	0.33	7	1.67		7
UK	1.70	0.40	10	13.19	0.56	6	96.53	0.98	2	1213	0.62	2	1.45	0.42	9	0.11%	0.33	6	0.02%	0.01	10	204.2	0.22	8	433.5	0.19	8	1.53		8
China	2.07	0.48	9	4.88	0.21	13	82.23	0.83	3	655	0.33	6	1.79	0.51	7	0.26%	0.82	3	0.18%	0.11	7	15.6	0.02	12	21.2	0.01	13	1.38	↑	9
Australia	2.20	0.52	7	8.97	0.38	10	81.57	0.82	5	795	0.40	5	2.34	0.67	4	0.02%	0.08	12	0.02%	0.01	9	160.7	0.17	10	369.0	0.16	10	1.30	↓	10
New Zealand	1.15	0.27	12	10.95	0.47	8	54.67	0.55	11	428	0.22	12	2.24	0.64	5	0.06%	0.17	7	0	--	13	148.5	0.16	11	253.7	0.11	11	1.06		11
Hong Kong	0.76	0.18	13	7.33	0.31	11	81.77	0.83	4	447	0.23	11	1.31	0.38	11	0.04%	0.13	11	0.02%	0.01	11	168.3	0.18	9	369.1	0.16	9	0.96		12
India	0.63	0.15	14	1.09	0.05	16	49.00	0.49	12	478	0.24	9	1.15	0.33	14	0.18%	0.58	5	0.23%	0.13	6	6.4	0.01	14	9.3	0.00	14	0.82		13
Malaysia	1.30	0.30	11	5.79	0.25	12	44.43	0.45	14	224	0.11	15	1.92	0.55	6	0.04%	0.14	9	0	--	13	15.1	0.02	13	35.3	0.02	12	0.73		14
Thailand	0.63	0.15	15	2.26	0.10	14	39.10	0.39	15	269	0.14	14	1.21	0.35	13	0.00%	0.01	18	0.01%	0.01	12	2.3	0.00	15	5.0	0.00	15	0.43		15
Vietnam	0.37	0.09	16	1.49	0.06	15	--	--	18	167	0.08	18	1.45	0.42	10	0.01%	0.02	17	0	--	13	0.3	0.00	17	0.2	0.00	18	0.25		16
Indonesia	0.08	0.02	18	..			32.50	0.33	16	175	0.09	17	0.71	0.20	16	0.02%	0.05	15	0	--	13	0.2	0.00	18	0.2	0.00	17	0.25		17
Philippines	0.14	0.03	17	0.67	0.03	17	31.50	0.32	17	189	0.10	16	0.44	0.13	17	0.02%	0.06	14	0	--	13	1.2	0.00	16	1.8	0.00	16	0.24		18

Source: UNESCO Institute for Statics, OECD, QS World University Rankings, Scorpus, Commission on higher education of Philippines, Indonesia Ministry of National Education, National Statistics (Taiwan), Thomson Reuters, Factset, CEIC, WIPO, IP5, UBSPTO, The Central Bureau of Statistics (Israel)

How the Scoring Works: – the country with the best datapoint gets a score of 1 point, and each other country's score is a fraction of this based on how their datapoint compares to the leading country. For example Israel's R&D Spending/GDP is 4.27%. As the highest scoring country, it gets 1 point. New Zealand, with a R&D spend of 1.15% of GDP gets a score of 0.27 (equal to 1.15 divided by 4.27).

Note: R&D / GDP is a country's R&D expenditure to GDP in percentage. Res. / kwks is the number of researchers per thousand labour force. QS Ranking is the average QS scores for top 3 universities. H score is a country's number of articles that have received at least h citations. STEM / k capita is the number of STEM (Science, Technology, Engineering and Mathematics) students per thousand population. 5 yrs VC / GDP is the percentage of total venture capital investment to GDP in the past 5 years. IT FCF / GDP is the free cash flow of a country's MSCI IT index constituents to GDP. Filing / mcapita is the number of patent filed per million population. Aggr / mcapita is the number of patent granted per million population. Check the appendix for more details.

Key country observations: five things stand out

Advanced Asia looks competitively positioned

1. The Advanced Asia performers are on many measures not far from the level of innovation in the US and are already higher than Germany and the UK on our overall scorecard. For example in R&D spend as a percentage of GDP Korea, Japan and Taiwan and China are now higher than the UK. Indeed on this measure Korea is on par with Israel as the highest spender in the world. Educational standards remain shy of the US and UK (though generally on par with Germany). Funding in Asia in aggregate for the advanced economies is largely on par with all bar the US. And on patenting, the advanced economies show up very strongly, both in terms of granted patents and recent filings on a per capita basis.

Figure 10: Scorecard – now and then

	Historical		Current		Change	
	Score	Rank	Score	Rank	Score	Rank
US	2.77	2	3.05	1	+0.27	+1
Korea	2.04	5	2.81	2	+0.77	+3
Israel	2.79	1	2.74	3	-0.04	-2
Taiwan	2.61	3	2.52	4	-0.09	-1
Japan	2.45	4	2.16	5	-0.29	-1
Germany	1.58	6	1.79	6	+0.21	--
Singapore	1.53	7	1.67	7	+0.13	--
UK	1.49	8	1.53	8	+0.04	--
China	0.70	12	1.38	9	+0.69	+3
Australia	1.45	9	1.30	10	-0.16	-1
New Zealand	0.92	11	1.06	11	+0.14	--
Hong Kong	1.00	10	0.96	12	-0.04	-2
India	0.53	14	0.82	13	+0.28	+1
Malaysia	0.56	13	0.73	14	+0.17	-1
Thailand	0.27	15	0.43	15	+0.15	--
Vietnam	0.10	18	0.25	16	+0.15	+2
Indonesia	0.14	16	0.25	17	+0.11	-1
Philippines	0.14	17	0.24	18	+0.10	-1

Source: UBS Note the total scores for 'Current' are higher than the historical data due to some datapoints missing historically and as a result a country not getting any score at that point.

There is a pronounced North – South gap

2. Within Asia, there is a clear gulf between north Asia and south Asia. Korea, Taiwan, Japan, stand out as already very advanced, albeit Japan has slipped somewhat compared to historical levels. Hong Kong and Singapore and increasingly China – the Asia 6 - are also considerably higher than south Asia. And that gap continues to expand.

3. Lumping south Asia together is somewhat unfair. For starters, Singapore is one of the most advanced economies on our scorecard measure. Of the remaining ASEAN economies in our study, Malaysia stands out as somewhere between the Advanced Asia Six and The Philippines, Indonesia and Thailand. These latter three seem well off-the-pace on innovation – indeed on some measures in our scorecard, these economies have actually regressed in the past 5-10 years. India is a mixed bag. On measures where 'innovation' is compared to the size of the economy, or on a per capita basis, India lags the region badly. There is hope however: elite education is high – the QS rankings suggest that elite Indian universities are better than Israel and not far off the level of Taiwan. The breadth of innovation inputs may not be high in India, but the tip of the iceberg is sharp.

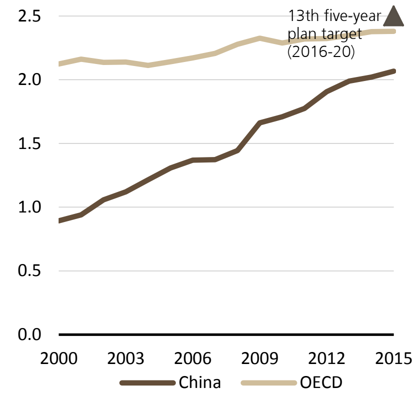
4. One of the most important country messages that stands out is the rise of China. The government has stated its intention to modernise the economy; for example in the 13th Five Year Plan Explicitly the State Council has called for R&D to

rise to 2.5% of GDP by 2020. What matters here is that our scorecard, and the data underlying it, shows the surge in creativity and innovation that is happening in China. On our scorecard, China has surged 69 basis points and three places between our historical data and current levels.

China looks likely to become an advanced tech country soon

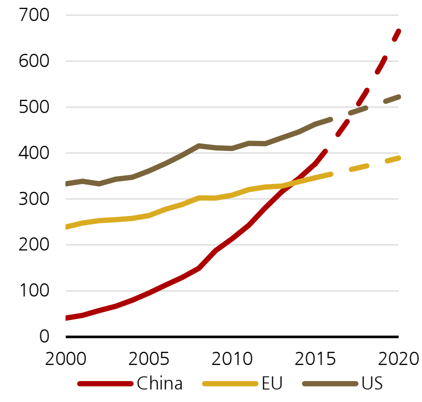
Though like India, when outputs are normalised for the size of the population, the scale of innovation doesn't looks quite as high – for example, China is on track to be the biggest user of the International Patent system, but on a per capita basis is still well behind the US. Nevertheless, the speed of change is dramatic, and if it continues at only half the pace of the last ten years, China will shift into the top-echelons on our scorecard. And the scale of the investments are such that the number of innovations are likely to be high – on our estimates, Chinese R&D is likely to surpass the spending in the US by 2018.

Figure 11: R&D Expenditure to GDP



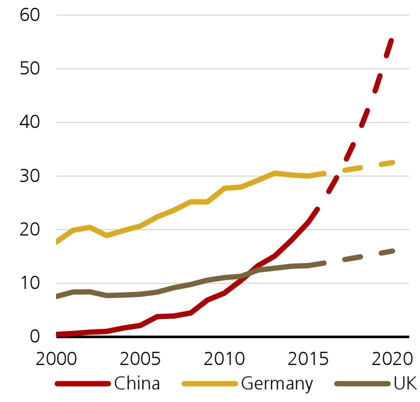
Source: OECD, Xinhua News Agency

Figure 12: R&D Expenditure (bn USD)



Source: OECD

Figure 13: Number of Patent Filed (k)



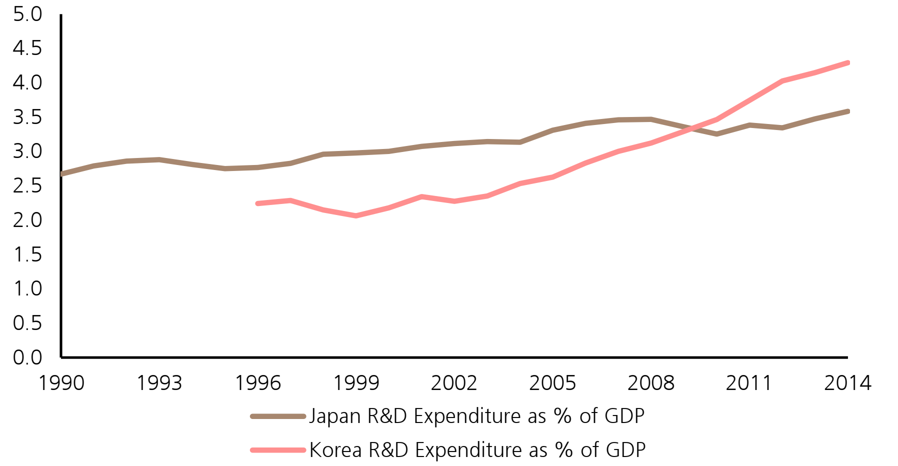
Source: WIPO

A key conclusion of our analysis is that China is highly likely to become an advanced technology country in many areas in the coming years – and potentially lose the perception of simply being a copying and cheap producer economy. Perceptions matter – in the 1990s, Korea was seen as a me-too economy, whereas today, in many high-tech areas, Korea now leads, technologically. This seems the path that China is set on – and highly likely to achieve – within the next five years.

Korea stands out

5. Finally, Korea stands out on our scorecard within Asia. While inevitably questions arise on whether R&D can be turned into innovation – and for our purposes, profits – the sheer levels and growth in R&D suggests that the economy is likely to continue moving up the innovation curve from already high levels. What is striking is how this contrasts to neighbour Japan. Here too, the economy stands tall in our scorecard. But Japan has tended to drift from already high levels, and on some measures like R&D spend, has stagnated in the past five years in sharp contrast to Korea.

Figure 14: Korean R&D spend as a share of GDP is now the highest in the world. Japan by contrast has stagnated, off admittedly high levels. Might Korean innovation overtake Japan?



Source: World Bank, OECD, CEIC, UBS.

Debates: size, iteration and the business environment

The scorecard is a useful measure to see what is driving changes and where individual strengths lie. Because we have normalised data, it looks at the propensity to innovate relative to GDP and population, not the total capacity to innovate overall.

There is a justified debate about this: given the R&D spend that is taking place in China, there are likely to be more major innovations coming out of that economy than say in Singapore, despite the latter looking better on many measures. This isn't the simple maths of China spending 40x Singapore's R&D – that's part of it. But there is, for example, strong evidence that economic clustering is important for innovation[5]. Thus there is likely to be an asymmetric benefit to those that have bigger spending power and the clusters that go along with this.

Figure 15 shows how the scorecard would change if we used absolute levels rather than normalised data.

[5] See for example "The New Geography of Innovation" Xavier Tinguely, Palgrave MacMillan 2013.

Figure 15: Country scorecard if we used absolute levels rather than normalised data

	R&D				Education						Funding				Patents				Summary		
					QS		H		STEM		5yrs VC		IT FCF				Granted				
	R&D b$	*Rank*	Res. (k)	*Rank*	Ranking	*Rank*	Score	*Rank*	(k)	*Rank*	m$	*Rank*	m$	*Rank*	Filing (k)	*Rank*	(k)	*Rank*	*UBS Score*		*Overall Rank*
US	503.9	1	1,477	2	99.0	1	1965	1	391	3	52940	1	214687	1	287.4	1	646.8	1	3.41	↓	1
China	409.2	2	3,926	1	82.2	3	655	6	2,449	1	28694	2	20356	3	21.3	5	29.0	6	2.01	↑	2
Japan	169.9	3	910	3	79.7	6	871	4	207	4	586	8	11600	4	86.4	2	255.1	2	1.11	↓	3
Germany	112.8	4	651	4	70.8	8	1059	3	191	5	1499	5	2477	7	29.8	4	73.9	4	0.77	↓	4
UK	46.3	7	443	7	96.5	2	1213	2	95	9	3027	4	653	9	13.3	7	28.2	7	0.72	↓	5
Korea	74.2	5	465	6	75.7	7	536	8	166	7	567	9	23267	2	38.2	3	74.4	3	0.68		6
India	50.3	6	546	5	49.0	12	478	9	1,512	2	3886	3	4758	6	8.3	8	12.2	9	0.64		7
Australia	24.3	9	112	9	81.6	5	795	5	56	13	333	10	311	10	3.8	10	8.8	10	0.47		8
Taiwan	33.6	8	151	8	58.1	10	406	13	82	11	101	14	5214	5	20.5	6	53.5	5	0.42		9
Hong Kong	3.2	14	28	16	81.8	4	447	11	10	16	123	13	65	11	1.2	12	2.7	12	0.36		10
Singapore	10.5	12	44	14	70.3	9	454	10	6	17	665	7	0	13	1.8	11	4.2	11	0.34		11
Israel	13.1	10	90	11	48.4	13	584	7	--	18	947	6	1026	8	7.8	9	14.4	8	0.32		12
New Zealand	2.0	17	27	17	54.7	11	428	12	10	15	97	15	0	13	0.7	13	1.2	13	0.27		13
Malaysia	10.6	11	84	12	44.4	14	224	15	59	12	131	12	0	13	0.5	14	1.1	14	0.22		14
Thailand	7.0	13	91	10	39.1	15	269	14	83	10	14	17	35	12	0.2	15	0.3	15	0.21		15
Indonesia	2.4	15	--	18	32.5	16	175	17	183	6	136	11	0	13	0.1	17	0.1	17	0.17		16
Philippines	1.0	18	30	15	31.5	17	189	16	45	14	54	16	0	13	0.1	16	0.2	16	0.15		17
Vietnam	2.1	16	83	13	--	18	167	18	133	8	13	18	0	13	0.0	18	0.0	18	0.06		18

Source: UNESCO Institute for Statics, OECD, QS World University Rankings, Scorpus, Commission on higher education of Philippines, Indonesia Ministry of National Education, National Statistics (Taiwan), Thomson Reuters, Factset, CEIC, WIPO, IP5, UBSPTO, The Central Bureau of Statistics (Israel)

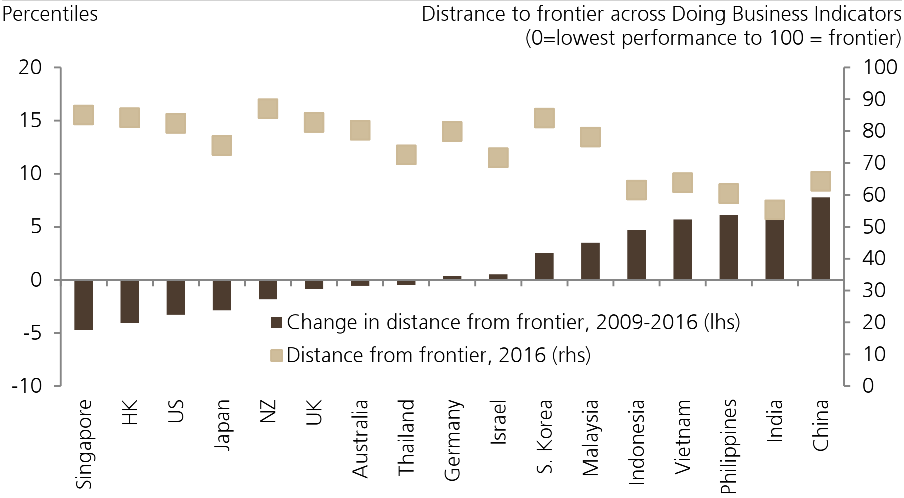
Secondly, knowledge generated in a lab needs to be adapted to the factory floor; new skills and processes need to be learnt by doing and refined[6]. In the other direction, skills and knowledge generated on a factory floor need to be formalized (perhaps in a lab) and distributed widely for overall productivity to be enhanced within a firm or across an industry. This can take time. Absent the urgency provided by competitive pressure and the associated consumer feedback, advantages that may have been gained in the lab can be lost in the marketplace.

The more competitive the business environment and the less protection afforded incumbents by regulation, the more likely entrepreneurial activities will turn to using innovation. To paraphrase Schumpeter's description of creative disruption; the capitalist engine requires the new consumer goods, new methods of production and new forms of industrial organisation that revolutionise the economic structure from within incessantly destroying the old one, incessantly creating a new one.

The World Bank's Doing Business Index provides a doorway to this last mile not by measuring competitive intensity directly but by measuring some of the barriers to it. Figure 16 shows the distance to best practice across a range of ease of doing business metrics and the change in that distance over the last 7 years. Here again Asia looks to be either the equal of the more developed economies (Singapore, Korea) or is gaining ground (China, India, Philippines, Vietnam, Indonesia).

[6] For deeper analysis of the process of learning by doing and its importance see Learning by Doing: The real connection between Innovation, Wages and Wealth; 2015; James Bessen

Figure 16: Improving ease of doing business in Asia could lead companies to increase reliance on innovation rather than regulation to remain competitive



Source: World Bank

Industries: where's Asia gaining?

We've created an 'industry snapshot' for 13 key industries to assess how Asia stacks up relative to the US today and where it's catching up.

Given that south Asia is generally lagging in our country scorecard, for the purposes of industry analysis, we've focused on Korea, Japan, China and Taiwan and compared this to the US (and though not shown in the table, the UK and Germany)

Our 'industry snapshot' does not try to rank Asia across a series of metrics like we did for countries, but instead tries to paint a picture of where Asian countries sit in absolute terms today versus the US - on measures of number of patents, R&D spend (we show as a percentage relative to global sector R&D spend) and education using the H-score (quality of academic journal output); and how much Asia is growing in certain industries based on the rise of patents and R&D spending growth. For ease of interpretation, red is the weakest number, green the best versus the other countries in the table (as well as Germany and the UK although they are omitted from our published table).

Because it is difficult to file patents on software or around Artificial Intelligence, we've had to restrict our analysis away from these areas. Particularly on AI, this is unfortunate as it likely misses the strength that China in particular has developed, in this area.

Two other health warnings with the data: 1) as the Patent Data is looking at Patents filed at the US Patent Office, it likely overstates the importance of US Patents – there is a very strong tendency for self-filing within a country. 2) The R&D spending as a percentage of that sector globally might give misleadingly low results. For example, 3.9% of Chemical sector spending globally is from Korea. Keep in mind however that Korea is only 2% of global market cap in MSCI, so any number above this suggests that industry is punching above its weight.

Figure 17: Industry snapshot (green = strong globally; red = weak globally)

	China					Japan					Korea					Taiwan					US				
	Patent grants growth*	Patent grants, 2015	5yr R&D CAGR	R&D % of global sector	Education H index, 16-17	Patent grants growth*	Patent grants, 2015	5yr R&D CAGR	R&D % of global sector	Education H index, 2016-17	Patent grants growth*	Patent grants, 2015	5yr R&D CAGR	R&D % of global sector	Education H index, 2016-17	Patent grants growth*	Patent grants, 2015	5yr R&D CAGR	R&D % of global sector	Education H index, 2016-17	Patent grants growth*	Patent grants, 2015	5yr R&D CAGR	R&D % of global sector	Education H index, 2016-17
Chemicals	0.29	471	30.6%	0.5%	327	0.19	3,274	3.0%	31.5%	279	0.23	779	10.8%	3.9%	233	0.21	281	1.5%	0.8%	158	0.2	8,128	-0.1%	16.4%	570
Civil Engineering	0.21	92	11.3%	44.4%	125	0.25	304	2.0%	18.5%	103	0.25	94	16.1%	8.0%	87	0.21	66	4.7%	0.4%	75	0.23	3,968	6.6%	7.5%	206
Computer Technology	0.23	1,127	34.5%	5.1%	290	0.18	6,091	1.3%	25.1%	231	0.24	2,702	19.7%	5.9%	206	0.2	561	4.5%	14.6%	208	0.21	26,811	10.0%	42.4%	807
Environmental Tech	0.28	42	17.9%	21.9%	262	0.22	455	n/a	0.0%	220	0.23	84	45.0%	31.2%	182	0.2	2	3.5%	3.8%	164	0.21	1,245	6.9%	21.1%	545
Home Appliances & TV	0.24	550	24.3%	1.6%	89	0.16	4,074	-1.4%	44.5%	53	0.21	1,730	11.8%	41.3%	76	0.22	388	12.1%	0.7%	73	0.23	6,236	4.1%	7.4%	166
Industrial Machinery	0.24	230	8.2%	9.3%	296	0.22	2,317	6.3%	36.8%	252	0.24	417	9.2%	0.6%	204	0.26	246	14.4%	1.2%	143	0.22	6,228	1.2%	15.0%	520
Materials, Metallurgy	0.29	76	18.5%	4.8%	184	0.24	706	4.3%	38.5%	189	0.28	143	17.2%	12.7%	139	0.17	93	4.4%	1.7%	103	0.23	948	-3.6%	5.6%	255
Medical Technology	0.25	95	17.1%	0.0%	104	0.23	1,210	5.9%	11.1%	155	0.29	200	44.7%	0.3%	104	0.22	86	2.1%	0.0%	90	0.21	10,624	7.9%	58.5%	411
Optics	0.41	476	n/a	0.0%	253	0.21	5,414	0.1%	97.1%	265	0.2	927	n/a	0.2%	184	0.19	117	n/a	0.0%	137	0.22	2,663	-4.0%	2.0%	431
Pharmaceuticals	0.26	132	27.4%	0.4%	356	0.2	430	1.9%	13.3%	535	0.24	136	16.3%	0.5%	301	0.24	159	12.2%	0.1%	279	0.21	3,725	2.5%	42.9%	1,323
Semiconductors	0.35	595	11.4%	0.5%	259	0.21	4,671	-3.4%	4.9%	265	0.23	2,673	15.9%	12.5%	201	0.27	2,849	11.9%	11.3%	180	0.22	5,576	8.7%	61.1%	582
Telecommunications	0.28	1,698	8.2%	8.4%	160	0.21	4,493	0.1%	1.1%	106	0.25	3,053	12.1%	0.1%	108	0.2	835	-1.2%	3.0%	116	0.25	18,440	2.3%	48.8%	434
Vehicles in General	0.25	66	15.2%	4.7%	79	0.25	2,316	7.1%	38.4%	69	0.33	415	12.0%	5.2%	60	0.24	168	12.5%	0.4%	55	0.24	3,324	2.3%	26.4%	138

Source: WIPO, IP5, Scorpus. Note: Patent grants growth is measured as 2015 patent grants as % of sum of that of 2011-15

Note: The patent data for Taiwan is less robust due to sourcing issues. Nevertheless, it does allow us to see pockets of strength within countries, as well as make some broad observations.

Key industry snapshot observations

A few high level points stand out. Firstly, the US still seems some way ahead of other countries in most industries. This reflects the size and quality of the academic talent pool and its leadership in patents and R&D spend. But bear in mind, that as the largest economy and market, we would expect it to rank highest on many of these metrics in absolute terms (unlike our country scorecard we have not normalised the data). The US is also at an advantage as we have focussed on patents granted at the US Patent Office. Nevertheless, the US clearly shows strong leadership in many of these industries.

Japan remains a key source of strength given many decades of accumulating knowledge and building up patents. By contrast, China still has a low level of accumulated patents, but scores much better when we take into account the rate of change. Similarly, the growth in R&D spending suggests that the rate of change of knowledge is very fast, although it still has a long way to catch up. Korea and Taiwan stack up less well on education, as well as relatively lowly on R&D spending and number of patents, but that in part is due to the relatively smaller size of these economies. But in growth terms, Korea stands out along with China, as trying to make great strides forwards in innovation in recent years.

Which industries is Asia doing well in? Figure 18 summarises the industries into three categories – The Establishment, where current levels of accumulate knowledge and R&D are high, the Challengers, where there is very strong catch-up evident; and the Next Generation, where the rate of change on patenting and the R&D growth is high enough to suggest a future threat.

Figure 18: Where are Asia's strengths and its greatest potential?

	(established leaders) The Establishment	(somewhat established and growing) The Challengers	(up & comers) The Next Generation
Chemicals	Japan,	Korea	China
Civil Engineering	Japan, Korea, China		
Computer Technology	Japan, Korea, Taiwan		China
Environmental Technology			Korea, China
Home Appliances & TV	Japan, Korea	China, Taiwan	
Industrial Machinery	Japan	Korea	China, Taiwan
Materials, Metallurgy	Japan, Korea	China	
Medical Technology	Japan		Korea
Optics	Japan		
Pharmaceuticals			Korea, Taiwan
Semiconductors	Taiwan, Korea		China
Telecommunications		China	
Vehicles in General	Japan	Korea	China (commercial not auto)

Source: UBS

Japan has a broad set of strengths, especially in Chemicals, Engineering, Machinery, Materials, Medical Technology and Optics.

Korea has risen through the ranks and is now firmly established as an innovation leader in Civil Engineering, Computer Technology, Home Appliances/TVs, Semiconductors and Materials (Steel, Zinc). It is now beginning to challenge the industry leaders in Chemicals, Industrial Machinery and Autos, but our work suggests that it has not yet acquired the knowledge of the industry leaders. Environmental Technology, Medical Technology and Pharma are areas where Korea appears to be ramping up investment, but from a relatively low base today.

Taiwan tends to be more narrowly focussed and is well established in Computer Technology and Semiconductors where it already makes up a large proportion of the R&D spending in these sectors, as well as having developed a large number of patents in Semiconductors (especially considering the size of the economy relative to the US). Elsewhere, we see pockets of growth and potential in Industrial Machinery and Pharmaceuticals, but Home Appliances/TV looks like an area where Taiwan is more likely to challenge in the near future given a relatively better education score in this area and similarities with its already advanced tech sector.

Chinese accumulated patents lag behind the other countries, albeit the rate of change is high and there is strong potential across most of these sectors. China is perhaps more established in Civil Engineering, Materials, Home Appliances/TV and Telecommunications, which corresponds with where China scores relatively highly on Education. But China is also seeing strong growth in patents and R&D in many other industries as we highlight in the table above, and in some of these sectors is perhaps not far away from beginning to compete internationally as they have done in the more established sectors already.

As an aside, China's particular strength in AI could prove a game changer in the manufacturing processes where it is already strong. Business management experts, such as Clayton Christensen, write about how new technologies that go against existing value chains can cause seismic shifts in market leaders[7]. This chimes with the increasing role that software is (and AI may) playing in hardware and the importance of how hardware companies learn to employ software. Getting this right can be key, and software companies may have the edge here – this would bode well for China, given the leading role that the economy is playing in AI[8].

Using UBS Evidence Lab to triangulate our findings

We've collaborated with UBS Evidence Lab to take a deeper dive into Patent Data to see if trends corroborate the trends our industry snapshot suggests i.e. Asia becoming more relevant.

To do this, we've used detailed citation analysis of Patents Filed at the US Patent Office, in three categories – Digital Communication, Batteries and OLED – and an academic technique[9] to identify in these three categories, how the source of knowledge is changing. When a new patent is filed and granted, any other patents that the new filing builds upon have to be referenced or 'cited'. Our analysis looks at the percentage of citations each country receives in that given year.

In theory, this should give a sense of the degree to which a country's patents are contributing to the build-up of knowledge in a particular area. Because our analysis is based on patents being filed at the US Patent Office, there is likely to be a bias in favour of US patents. Nevertheless, this method is useful in assessing trends. Figure 19 to Figure 21 show the data for the three sectors.

---

[7] See "The Innovator's Dilemma", Clayton Christensen, Harvard Business Review Press.
[8] See the Demise of Nokia, Donal O'Connel
[9] See Lee K, Yoon M, "International intra-national and inter-firm knowledge diffusion and technological catch-up: the US, Japan, Korea and Taiwan in the memory chip industry", Technology Analysis and Strategic Management, 2010, Taylor & Francis.

Figure 19: Sources of Knowledge for Digital Communication

	US	JP	KR	TW	CN	Other
2011	70.0%	10.7%	2.9%	0.5%	0.2%	15.6%
2012	69.0%	10.5%	3.6%	0.6%	0.3%	15.9%
2013	69.4%	9.9%	3.9%	0.6%	0.4%	15.7%
2014	69.8%	9.7%	3.6%	0.7%	0.6%	15.6%
2015	70.1%	9.4%	3.8%	0.7%	0.7%	15.3%
2016	70.1%	9.0%	4.1%	0.7%	0.8%	15.3%
2017	70.5%	8.5%	4.0%	0.8%	0.9%	15.3%

Source: UBS Evidence Lab

Figure 20: Sources of Knowledge for Batteries

	US	JP	KR	TW	CN	Other
2011	54.5%	25.2%	3.1%	1.1%	0.2%	15.7%
2012	53.1%	24.9%	3.6%	1.4%	0.5%	16.5%
2013	56.9%	22.0%	4.2%	1.3%	0.4%	15.2%
2014	54.7%	22.7%	5.4%	1.4%	0.6%	15.4%
2015	52.7%	23.9%	6.2%	1.4%	0.6%	15.2%
2016	54.9%	22.8%	5.0%	1.4%	0.4%	15.5%
2017	55.6%	21.6%	5.0%	1.4%	0.6%	15.8%

Source: UBS Evidence Lab

Figure 21: Sources of Knowledge for OLED

	US	JP	KR	TW	CN	Other
2011	33.7%	48.8%	6.9%	1.5%	0.1%	9.0%
2012	34.8%	46.5%	7.5%	1.7%	0.4%	9.2%
2013	35.1%	46.7%	7.9%	1.6%	0.1%	8.6%
2014	30.8%	47.9%	11.7%	1.7%	0.2%	7.8%
2015	28.4%	49.0%	12.1%	2.0%	0.3%	8.2%
2016	28.8%	47.1%	13.4%	2.6%	0.5%	7.6%
2017	28.2%	47.0%	13.7%	2.8%	0.7%	7.6%

Source: UBS Evidence Lab

The data shows that Korea is increasing in importance off a low level in all three areas, but relatively significant in OLED. Japan's patents seems to be of high citable quality in OLED (due to OLED materials – as Japan is not present in OLED panels manufacturing) and to a lesser extent Batteries, but seems to be losing some of its relevance in Batteries, while Korea gains. Citations to Chinese patents are rising, albeit off a very low base. This is another data point that shows the relative importance of Asia increasing. Along with UBS Evidence Lab, we will be returning to more detailed analysis of patent data, globally, in the coming months.

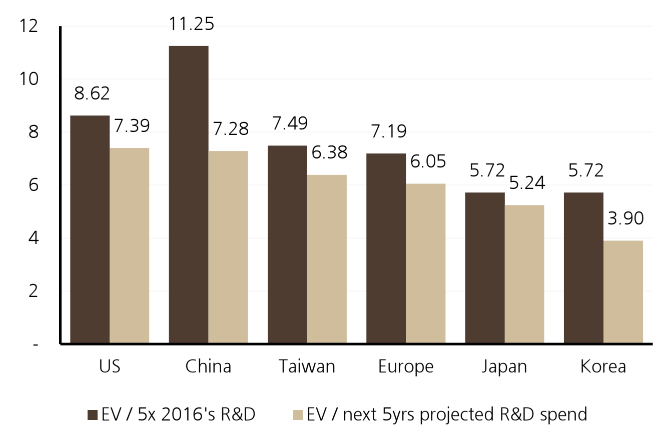
Is Asia's innovation being priced in?

EV to R&D spend suggest Asia's innovation boom is not being priced into equities

To look at this, we've constructed a simple valuation framework comparing Enterprise Value to accumulated R&D spending, for listed companies in sectors where R&D should make sense[10]. Granted, this is simplistic. But measuring innovation is itself challenging and this at least provides some comparable metric. We've taken trailing five-year R&D spending expensed in income statements. There are some challenges with this – for example, differences between US or Japanese GAAP and IFRS on the capitalisation some development costs, which likely under-reports overall R&D expense, and will cause a measure of EV/accumulated R&D spend to look higher than it is. Secondly, we've used five year accumulated R&D expenditure. We've done this because the further back in time we go, the sample of companies drops off quite quickly. Of course 5 years of expensed R&D won't reflect decades of expertise accumulated by companies. Nevertheless, we think this measure is a useful tool to look at how investors are treating the value of R&D by market.

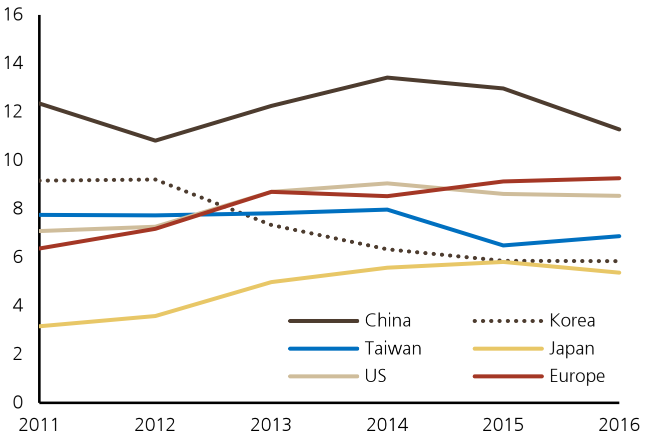
Figure 22 show the current EV/cumulative 5 year R&D expense for the key Asian countries, and the US and Europe, Figure 23 the time series over the last five years.

Figure 22: EV/5 Year Cumulative R&D Expense



Source: Worldscope, Thomson Datastream, UBS

Figure 23: EV/5 Year Cumulative R&D Expense



Source: Worldscope, Thomson Datastream, UBS

What stands out? Japan and Korea's R&D efforts appear to be underappreciated by the market at large. Indeed with the exception of China's data the market seems to be taking the view that Asian R&D is not as worthwhile as in Europe or the US. Given the degree to which Asia seems to be catching up (if not already ahead) especially of Europe, this suggests either the market believes there are structural impediments to Asia generating profits from its R&D, or that Asia's R&D efforts are being ignored by equity investors. Given the links we showed earlier between R&D, leading to Patents, leading to market share gains, we think writing-off, or underestimating Asia's innovation surge is a mistake.

The data on China suggests at first glance that R&D is being priced in. We think this is likely misleading. Firstly, the growth in R&D over the past five years compared to most countries means that a measurement of EV to five year R&D

[10] Autos, Chemicals, Construction Materials, Food & Beverages, Healthcare Equipment, Pharma & biotech, Aerospace & Defence, Electronic & Electrical Equipment, General Industrials, Industrial Engineering, Transport, Oil Equipment & services, Household Goods, Software & Computer Services, Tech Hardware & Equipment.

likely understates matters. The five year average is polluted by data that is five years old. If we looked at EV to five years' worth future R&D spend (projecting forward, past growth rates), China's multiple would come down to 7.3 be in line with the US. It's also worth noting that the cost of a R&D worker in China is one 10th to one 5th of the US. So in a sense R&D bang for buck is much greater in China than the US.

Figure 24 recreates the current spot multiples in Figure 22 for key innovation sectors.

Figure 24: Sector EV/5 year cumulative R&D valuations

	Autos & Auto Parts	Electronic & Electrical Equipment	Industrial Engineering	Tech Hardware	Pharma
China	13.7	18.5	10.4	2.6	24.9
Europe	6.5	9.5	11.8	4.0	6.1
Japan	4.8	6.6	9.3	2.9	3.7
Korea	8.4	6.2	13.4	5.4	8.4
Taiwan	11.5	7.1	24.7	6.2	7.6
US	4.9	12.1	13.1	6.8	7.0

Source: Worldscope, Thomson Datastream, UBS

Again, the same messages stand out: Japanese sectors look good on these measures (keep in mind under Japanese GAAP that R&D is likely understated anyway). Investors seem to be assuming that R&D in Korean Tech and Electronic/Electrical equipment will not be as fruitful as elsewhere. From an Asian perspective, the innovation story in China does seem to be reflected within the Chinese sectors.

Finally, Figure 25 shows the innovation hot spots, alongside valuation data. Green fonts related to valuations looking attractive versus history and MSCI World, red fonts, relatively expensive valuations.

Figure 25: Asia's innovation sectors valuations

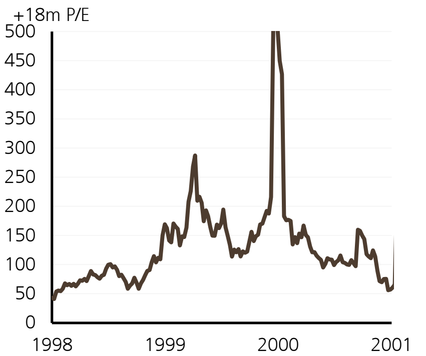
THE ESTABLISHMENT	Current Fwd P/E	P/E prem/(disc) to Global Sector	P/E rel to Global equities vs. ave since 2011	THE CHALLENGERS	Current Fwd P/E	P/E prem/(disc) to Global Sector	P/E rel to Global equities vs. ave since 2011	THE NEXT GENERATION	Current Fwd P/E	P/E prem/(disc) to Global Sector	P/E rel to Global equities vs. ave since 2011
Japan Chemicals	14.0	-14%	-13%	Korean Chemicals	10.0	-38%	-17%	Korean Environ. Tech	10.8	-34%	-18%
Japan Civil Engineering	11.2	-22%	-36%	Korea Vehicles	6.9	-25%	-14%	China Chemicals	8.3	-49%	-30%
Japan Mats & Metal	11.0	-22%	-17%	Taiwan Home Appl.	19.8	48%	-11%	China Environ. Tech	9.6	-41%	-18%
Korea Semiconductors	5.1	-65%	-45%	China Home Appl.	13.2	-1%	-1%	China Ind. Mach.	10.7	-41%	-14%
Korea Civil Engineering	7.0	-51%	-39%	China Mats & Metal	16.6	18%	-16%	China Semiconductors	11.8	-17%	-48%
Korea Comp Tech	7.6	-43%	-44%	China Telecoms Equip	15.6	6%	-8%	China Vehicles	10.2	11%	-5%
Korea Home Appl.	11.6	-14%	-25%	Korea Industrial Mach.	25.7	43%	49%	Taiwan Ind. Mach.	26.9	50%	23%
Korea Mats & Metal	10.2	-28%	-10%					Korea Pharmaceuticals	38.3	137%	33%
China Civil Engineering	8.0	-45%	-12%					China Comp Tech	22.1	68%	50%
Japan Industrial Mach.	17.4	-3%	-5%								
Japan Home Appl.	15.3	14%	-38%								
Japan Vehicles	10.0	9%	-20%								
Japan Medical Tech	23.9	30%	-2%								
Taiwan Semiconductors	15.3	7%	-2%								
Taiwan Comp Tech	12.6	-4%	-9%								
Japan Comp Tech	17.8	35%	5%								
Japan Optics	16.9	39%	7%								

Source: IBES, Thomson Datastream, UBS

Clearly, the contrary view to this is that the internet stocks, partially reflecting perhaps the innovation in AI embedded within these companies, may be telling a different story. For sure, valuations here are not at distressed levels, and as Figure

27 shows, forward P/E valuations are on the more elevated end of where they've traded over the last three years. However, we'd note that even if these valuations re-rate somewhat, they are a long way from the extremes of the TMT bubble.

Figure 26: US internet stock valuations during '99-00 tech bubble

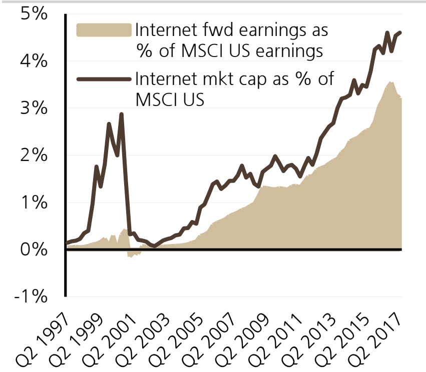


Source: IBES, Thomson Datastream, UBS

Figure 27: China internet stock valuations today

Source: IBES, Thomson Datastream, UBS

Figure 28: US internet market cap and earnings as % of index



Source: IBES, Thomson Datastream, UBS

The key top-down conclusions

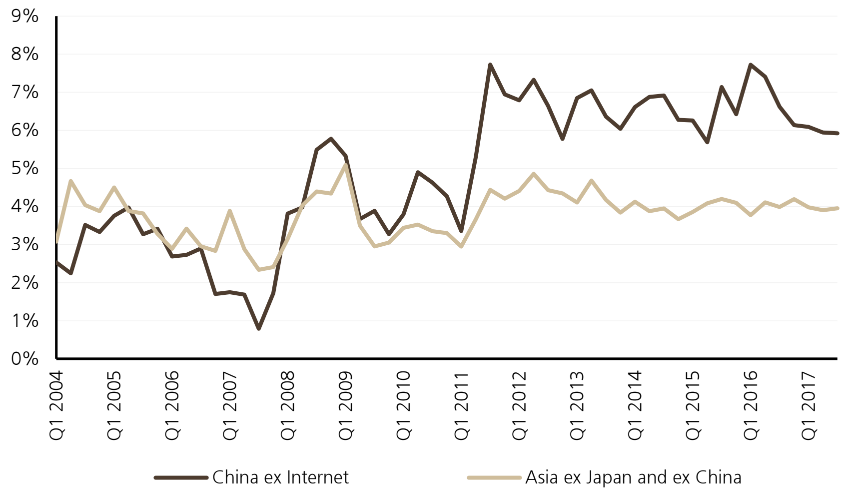
We see four key conclusions. Please note that some of these may jar from time to time with our tactical country weightings.

1. For China specifically, we think the market may be missing the shift up the value chain that is taking place. Government policy appears determined to raise the value added of the economy. Data suggests this is actually happening, reflected in China rocketing up our scorecard.

While investors are clearly excited about the growth rate in internet-related stocks, the old perceptions about China remain – that this economy is a prisoner of over-indebtedness, with over-reliance on smokestack industry. Just as valuations in the mid-2000s reflected optimism around a perceived economic miracle, valuations in recent years have reflected all the fears of overinvestment with a rise in the risk premium (see Figure 28). The truth is probably somewhere in between these two extremes.

We are confident based on what is happening in innovation, that perceptions about China likely to be very different five years from now. Multiples five years from now are likely to be shaped by how the economy has transformed as sentiment shifts more positively. This process has already started over the last year as investor recognise that in a number of areas such as AI and Fintech, China is arguably ahead of the rest of the world. We think this speaks to a gradual re-rating of Chinese equities overall.

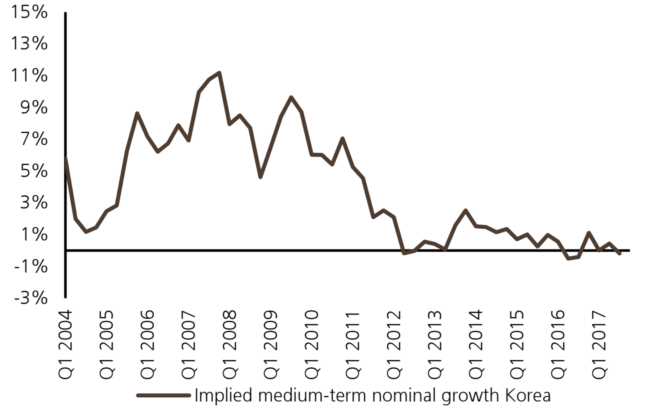
Figure 29: Market implied equity risk premium of China (ex internet) versus the rest of the region



Source: IBES, Thomson Datastream, Bloomberg, UBS
Note: implied ERP calculated using a residual income model and by assuming the next 3 years of consensus bottom-up forecasts and growth beyond that into perpetuity at the current 10-year local bond yield.

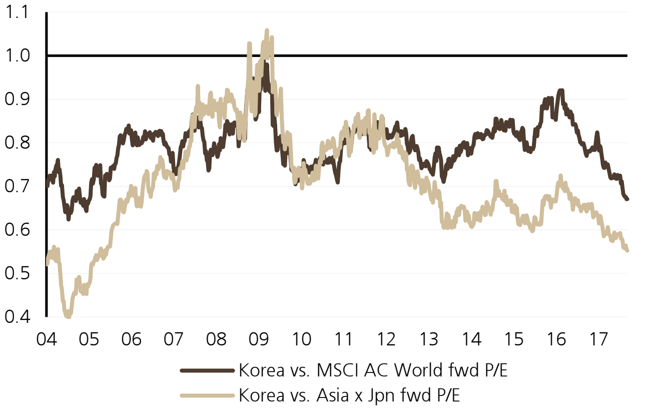
2. Korea is a stand-out in terms of R&D spending. It is now the highest spender as a share of GDP – alongside Israel, long considered a core innovative economy. As we showed this is not being reflected in measures such as EV/cumulative R&D. A key question remains whether Korean companies will be able to turn R&D spending into profits. Should they be able to do so, there is considerable apparent value in the stockmarket, given where current absolute and relative valuations are relative to both regional and global equities.

Figure 30: Korea: market implied medium-term nominal earnings growth



Source: IBES, Thomson Datastream, UBS.
Note: implied medium-term growth calculated using a residual income model assuming bottom-up consensus eps for the next 2 years, implied growth for the next 10-year period, and perpetuity growth at the 10-year local bond yield.

Figure 31: Korea relative P/E valuations



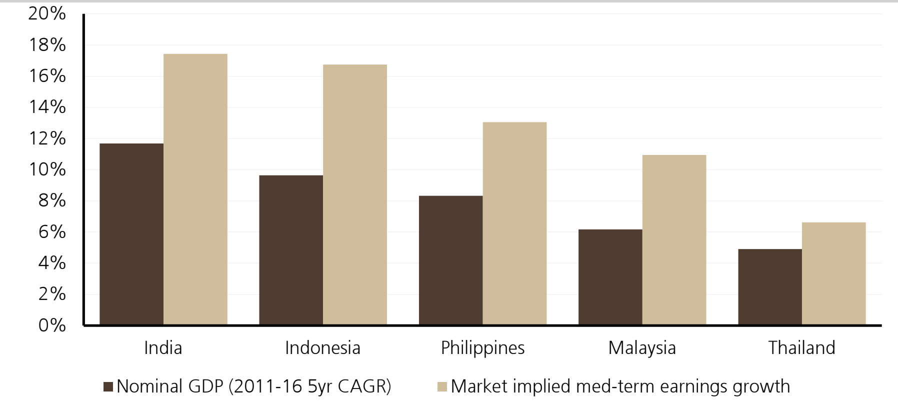
Source: IBES, Thomson Datastream, UBS.

3. One of our key findings is that large parts of ASEAN may be missing out on an innovation dividend. This matters because it suggests that these countries are likely to be prisoners of their labour market competitiveness. It's not that they can't grow quickly, but they are likely to remain dependant on FDI with their exchange rates and overall competitiveness of labour likely to be key.

Given the high long-term growth rates being priced into ASEAN consumer stocks versus north Asia, we think investors may be too optimistic about the ability of these economies to generate productivity growth to match their varying demographic dividends that valuations imply.

Malaysia stands out relative to The Philippines, Indonesia and Thailand, as being further up the innovation chain. India, though lagging in our scorecard, has some glimmers of hope – elite education is good, and the absolute scale of R&D alongside an advanced military/defence complex suggests this economy has a better innovation trajectory than Indonesia, the Philippines and Thailand. Implied growth rates suggest the market believes the longer-term outlook for India is better than these other three, which we agree with. Any de-rating of this growth relative to the other three, presents good long term opportunity in our view.

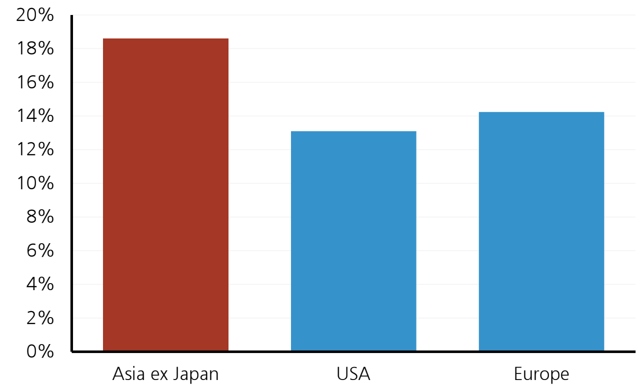
Figure 32: Market implied medium-term nominal earnings growth rates vs. last 5yrs average nominal GDP growth



Source: IBES, Thomson Datastream, UBS. Note: implied medium-term growth calculated using a residual income model by assuming bottom-up consensus numbers for the next two years, we then calculate implied growth for the next 10-year period, and assume growth beyond that into perpetuity at the current 10-year local bond yield.

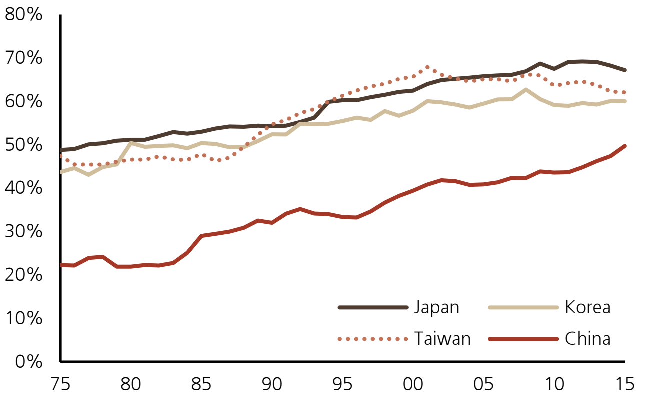
4. A strong case for active investing in Asia. In our February report on Active/Passive investing, we showed that rapid changes in the structure of Asian economies was leading to rapid change in the composition of stock markets. This change in index composition is a headache for passive managers, as they are unable to access the growth of new companies coming into the indices. We estimate there is 120 basis points of annual alpha in the last ten years that a passive manager is missing because of these changes in economies and stock markets. Our innovation analysis gives us greater confidence that the region, and especially north Asia, is likely to continue to change quickly, with major shifts in the shape of the economy and new entrants to the stock market. This supports a strong case for active investing in Asia.

Figure 33: Average annual MSCI index turnover (*number of companies added/removed as % of index*) – last 10yrs



Source: Thomson Datastream, UBS.
Note: excludes one-off impact of overseas listed stocks (ADRs) in 2015

Figure 34: Tertiary (services) industry as % of GDP



Source: Haver, UBS

Country innovation scorecard in detail

We've set out here the background to the four key components of the scorecard – the three 'inputs' of Education, R&D and Funding and the output, Patents. At the end of this section, we've also included the scorecard as it looked historically, to give some more detailed perspective to the comments we've made.

1. Education

A key input to innovation is the number of people able to innovate. Education is widely perceived as a key factor in the innovation process. To chart Asia's absolute and relative progress, we've focused on 1) the number of graduates in sciences and engineering 2) the quality of universities, 3) the academic output of universities and the quality of this.

- **A. Student data:**

UNESCO provides data for many countries on the number of science and engineering graduates. There are some countries where we've had to use years that are slightly off from our standard of 2015 and 2005. Likewise, there are some countries for which there is no historic data from UNESCO and we've either used alternative domestic sources where available.

Figure 35: STEM graduates per thousand population

	2005	2015	Change
China	0.36	1.79	1.43
Japan	5.11	1.63	(3.48)
Korea	4.22	3.26	(0.96)
Taiwan	4.46	3.48	(0.97)
Hong Kong	1.78	1.31	(0.47)
Singapore	1.10	1.01	(0.09)
Malaysia	3.07	1.92	(1.15)
Thailand	0.59	1.21	0.62
Philippines	0.35	0.44	0.09
India	--	1.15	1.15
Vietnam	0.47	1.45	0.98
Indonesia	0.66	0.71	0.05
Australia	2.25	2.34	0.09
US	1.05	1.22	0.17
Germany	0.70	2.34	1.64
UK	1.47	1.45	(0.02)
Israel	4.12	--	(4.12)
New Zealand	1.64	2.24	0.60

Source: UNESCO, CEIC, Thomson Reuters, OECD, UK Office for National Statistics, Statistics of Republic of China, Singapore Department of Statistics, Commission of Higher Education of Philippines, Ministry of National Education of Indonesia, and Trending Economics. Note: For current numbers of STEM graduates, we used 2010 data for China, 2014 data for Japan, Korea, Singapore, Philippines, Australia, US, and Germany, and 2016 data for Hong Kong. For the same historical numbers, we use 2004 data for Malaysia, Thailand and Philippines, 2002 data for Germany, and 1999 data for Israel.

This is the one area where Asia stands out in the Education side. Measured by the number of Science and Engineering graduates per 1000 of the population, Korea and Taiwan are a clear number one and two. China is still some way off, but the number of graduates in these fields has grown five-fold in the last 10 years, suggesting that in ten years if this growth rate remains, the number will be considerably higher. Interestingly, in Japan, Korea and Taiwan, despite still relatively high numbers overall relative to the sample base, the number of graduates in the sciences appears to be dropping as a % of the population.

- **B. Quality of universities**

Quacuarelli Symonds produces World Rankings for universities based on academic peer review, faculty/student ratio, citations per faculty, employer reputation and international student and staff ratios.

Figure 36: Average QS scores for top 3 universities

	2012	2017	Change
US	98.88	99.00	0.12
UK	99.01	96.53	-2.48
China	74.86	82.23	7.37
Hong Kong	83.82	81.77	-2.05
Australia	84.03	81.57	-2.46
Japan	81.69	79.73	-1.96
Korea	73.58	75.67	2.09
Germany	74.93	70.77	-4.16
Singapore	54.98	70.33	15.35
Taiwan	54.62	58.07	3.44
India	44.78	49.00	4.22
Israel	51.08	48.43	-2.65
Malaysia	44.25	44.43	0.18
Thailand	38.20	33.37	-4.83
Indonesia	32.62	29.77	-2.85
Philippines	26.50	24.40	-2.10
Vietnam	NA	NA	NA

Source: The Global Innovation Index 2013 & 2017, QS University Rankings

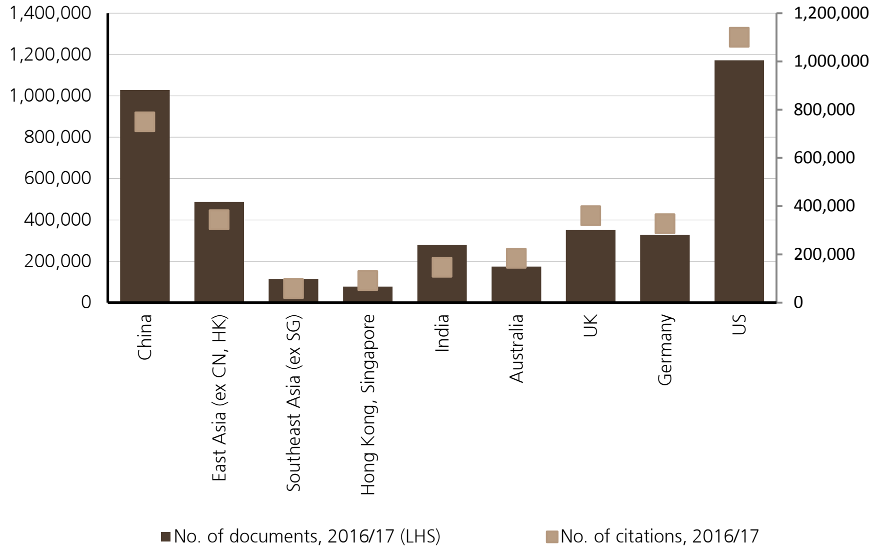
From within this gauge, we've focused on the average score of the top three universities in a particular country. On these measures, the US and UK continue to lead, but north Asia and Singapore have continued to see considerably progress of improvement, with China for example surpassing Germany by 2017 and Korea catching up fast on Japan. Thailand, The Philippines and Indonesia have seen their already low scores drop further over the last five years, while India scores higher than its R&D data would suggest, and indeed is higher even than in Israel.

- **C. Academic output**

We've also separately taken a look at the degree of academic excellence, based on document output and the quality of that output (measured by citations of documents).

Figure 37 shows that academic output from Chinese universities is now not far off the levels of the US and already sizeably ahead of European universities.

Figure 37: No. of documents vs. citations



Source: Scorpus

This partly reflects the size of the population, which we've addressed in Figure 38. On this measure, China drops off quite quickly, below Malaysia. But what is clear from the data is that various north Asian countries – particularly Hong Kong and Singapore – are demonstrating considerable output from their universities, and the growth rates of output (with the exception of Taiwan and Japan) is also very high – compared to stagnant rates of output in the US for example.

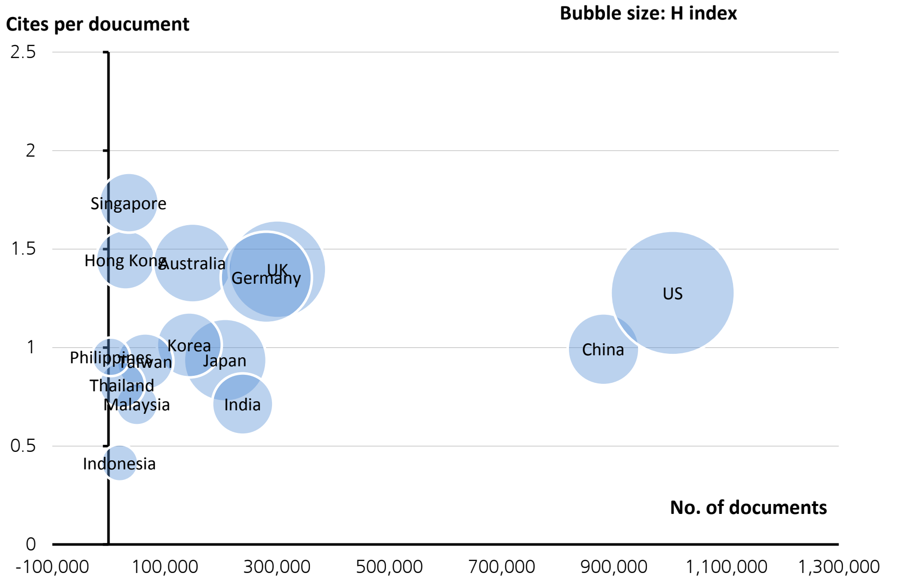
Figure 38: Document per capita (million)

	2011	2017
Australia	4,930	6,508
Singapore	5,311	6,469
UK	4,012	4,580
Hong Kong	3,301	4,095
Israel	3,652	3,858
Germany	2,938	3,393
US	2,954	3,099
Korea	2,155	2,808
Taiwan	3,027	2,775
Japan	1,651	1,637
Malaysia	937	1,595
China	437	637
Thailand	259	367
India	114	184
Vietnam	41	104
Indonesia	17	77
Philippines	21	42

Source: SCImago, CEIC, Central Bureau of Statistics (Israel)

Again, this data doesn't control for output. To do this, we've looked at the "H score" index used by SCIamago. This measures not only output, but the number of citations. The H Score is the number that represents the highest number of documents with the same number of citations. The score provides a measure of the breadth of citable documents. Figure 39 shows this in picture form – the size of the bubble representing the H score.

Figure 39: H Score, Cites and No of Academic Documents



Source: SCImago, UBS.

In Figure 40 we show the H score per country, along with how this has changed over the last 5 years. We don't have data much further back than 2013. The US, UK and Germany still show up very strongly. On this basis, Asian universities are some way off the level of US and Europe, but the rate of change of citable documents (or the H score) is about similar.

Figure 40: H scores breakdown

	2007	2016	Change
US	793	1,965	1,172
UK	465	1,213	748
Germany	408	1,059	651
Japan	372	871	499
Australia	272	795	523
China	161	655	494
Israel	235	584	349
Korea	161	536	375
India	146	478	332
Singapore	114	454	340
Hong Kong	135	447	312
New Zealand	151	428	277
Taiwan	139	406	267
Thailand	84	269	185
Malaysia	56	224	168
Philippines	58	189	131
Indonesia	52	175	123
Vietnam	52	167	115

Source: Scimago

Finally, Figure 40 shows the Education section taken together. The score for each country is simply the ratio of that country's individual metric divided by the highest score for all countries.

Figure 41: Aggregate scorecard for education

	QS Scores				H Scores				STEM graduates per thousand population				Total			
	Historical		Current		Historical		Current		Historical		Current		Historical		Current	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
US	1.00	2	1.00	1	1.00	1	1.00	1	0.20	11	0.35	12	2.20	2	2.35	1
UK	1.00	1	0.98	2	0.59	2	0.62	2	0.29	9	0.42	9	1.87	3	2.01	2
Korea	0.74	9	0.76	7	0.20	7	0.27	8	0.83	3	0.94	2	1.77	4	1.97	3
Germany	0.76	7	0.71	8	0.51	3	0.54	3	0.14	12	0.67	3	1.41	8	1.93	4
Australia	0.85	3	0.82	5	0.34	5	0.40	5	0.44	6	0.67	4	1.63	5	1.90	5
Taiwan	0.55	11	0.59	10	0.18	11	0.21	13	0.87	2	1.00	1	1.60	7	1.79	6
Japan	0.83	6	0.81	6	0.47	4	0.44	4	1.00	1	0.47	8	2.29	1	1.72	7
China	0.76	8	0.83	3	0.20	7	0.33	6	0.07	16	0.51	7	1.03	13	1.68	8
Hong Kong	0.85	4	0.83	4	0.17	12	0.23	11	0.35	7	0.38	11	1.37	9	1.43	9
NZ	0.59	10	0.55	11	0.19	9	0.22	12	0.32	8	0.64	5	1.10	12	1.41	10
Singapore	0.83	5	0.71	9	0.14	13	0.23	10	0.22	10	0.29	15	1.19	10	1.23	11
Malaysia	0.45	14	0.45	14	0.07	16	0.11	15	0.60	5	0.55	6	1.12	11	1.11	12
India	0.45	13	0.49	12	0.18	10	0.24	9	--	18	0.33	14	0.64	14	1.07	13
Thailand	0.31	15	0.39	15	0.11	14	0.14	14	0.11	14	0.35	13	0.53	15	0.88	14
Israel	0.52	12	0.49	13	0.30	6	0.30	7	0.81	4	--	18	1.62	6	0.79	15
Indonesia	0.14	16	0.33	16	0.07	17	0.09	17	0.13	13	0.20	16	0.33	16	0.62	16
Philippines	0.12	17	0.32	17	0.07	15	0.10	16	0.07	17	0.13	17	0.26	17	0.54	17
Vietnam	--	18	--	18	0.07	17	0.08	18	0.09	15	0.42	10	0.16	18	0.50	18

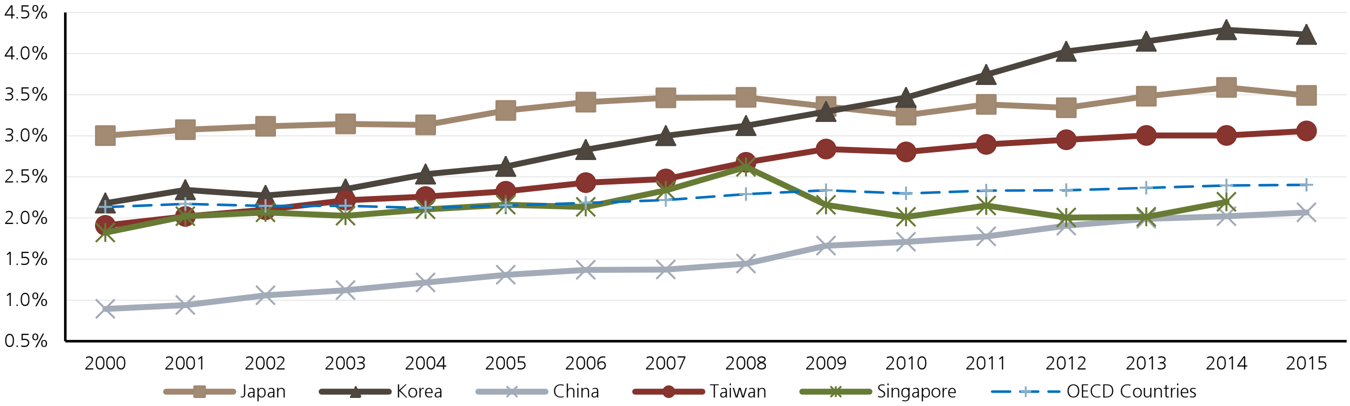
Source: UNESCO, CEIC, Thomson Reuters, OECD, UK Office for National Statistics, Statistics of Republic of China, Singapore Department of Statistics, Commission of Higher Education of Philippines, Ministry of National Education of Indonesia, Trending Economics, QS World University Rankings, and Scimago. Note: For current numbers of STEM graduates, we used 2010 data for China, 2014 data for Japan, Korea, Singapore, Philippines, Australia, US, and Germany, and 2016 data for Hong Kong. For the same historical numbers, we use 2004 data for Malaysia, Thailand and Philippines, 2002 data for Germany, and 1999 data for Israel.

What does this mean? Overall, Europe and the US lead on the education metrics, though on the number of science and engineering students, Korea and Taiwan are as they have been for some time – clearly doing well. The pace of change of Asian education is dramatic, with greater numbers of students, greater output of universities, with top universities on a par with the best globally. But citation data suggests that the breadth of quality is still found predominantly in the US and Europe, albeit the rates of change and suggest Asia is catching up relatively quickly.

2. R&D spending

The OECD sets out three forms of R&D and two major suppliers of R&D. The three types – basic research, which is experimental; applied research, which is original but focused on specific objectives; experimental development, which is based on existing knowledge with the intention of creating improvement to existing knowledge. Basic research is generally regarded as likely to provide the biggest shift to the technological frontier, but from an innovation perspective, even experimental research is important in so far as it show actors improving existing technologies.

Figure 42: R&D as % of GDP by country, 2000-2015

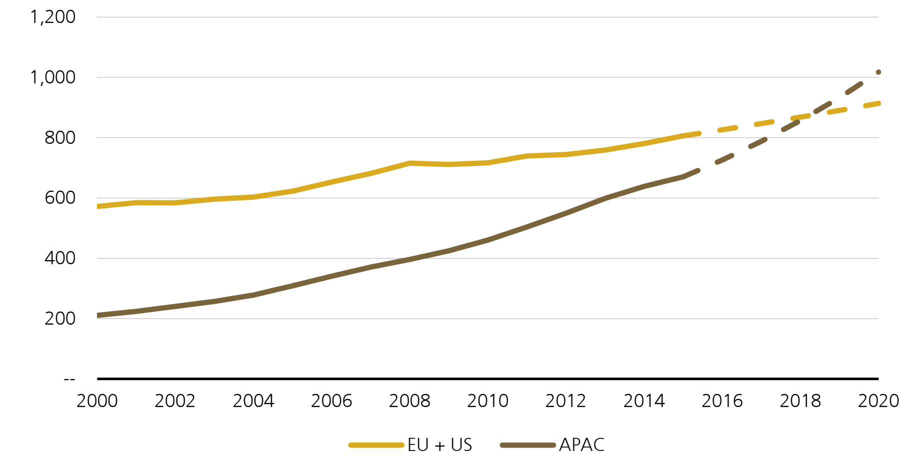


Source: OECD

In aggregate, R&D spending has been rising sharply in Asia, with Korea now on par with Israel as leading the world in term of R&D spend to GDP. This was a conscious government policy over time, but turbocharged by President Lee's administration following the global financial crisis.

China still lags behind in aggregate spending, but the government's stated goal is to lift this to 2.5% of GDP by 2020[11]. In absolute terms, we expect China's R&D spending to surpass the US level by 2019 and possibly as early as 2018. Indeed, for the region overall, we think R&D spending is likely to surpass the combined spending of the US and Europe by 2020.

Figure 43: R&D Expenditure (bn USD)



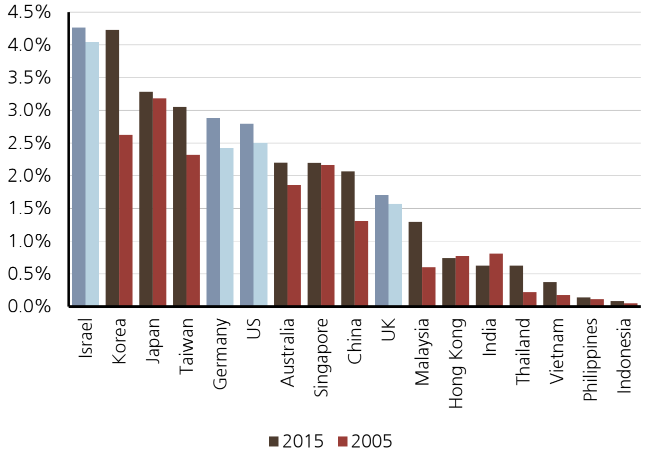
Source: OECD

So how does Asia compare on the relative metrics? We've looked at two key measures – aggregate spending on R&D and the number of employees engaged in R&D as a percentage of the overall workforce.

The Figures below set out spending on R&D by country in Asia, alongside some benchmarks elsewhere (the UK, Germany, US, Israel and the OECD averages) for 2005 and 2015.

[11] Originally a policy goal established in 2006, but affirmed in the 2016 13th Giver Year Plan on National Science, Technology and Innovation.

Figure 44: R&D as % of GDP, 2005 vs. 2015



Source: UNESCO Institute for Statistics, OECD. Note: Instead of 2015 data: 2014 data for Hong Kong, Singapore; 2013 data for Indonesia, Philippines, Australia, Vietnam. Instead of 2005 data: 2004 data for Malaysia, Australia; 2002 data for Vietnam; 2001 data for Indonesia. Blue indicates non-APAC countries.

Figure 45: R&D as % of GDP, summary

	2005	2015	Business R&D as % of GDP, 2015
China	1.31%	2.07%	1.59%
Japan	3.18%	3.28%	2.58%
Korea	2.63%	4.23%	3.28%
Taiwan	2.32%	3.05%	2.38%
Hong Kong	0.77%	0.74%	0.33%
Singapore	2.16%	2.20%	1.34%
Indonesia	0.05%	0.08%	0.02%
Malaysia	0.60%	1.30%	0.67%
Thailand	0.22%	0.63%	0.44%
Philippines	0.11%	0.14%	0.05%
India	0.81%	0.63%	0.27%
Vietnam	0.18%	0.37%	0.19%

Source: UNESCO Institute for Statistics, OECD. Note: Instead of 2015 data: 2014 data for Hong Kong, Singapore; 2013 data for Indonesia, Philippines, Vietnam. Instead of 2005 data: 2004 data for Malaysia; 2002 data for Vietnam; 2001 data for Indonesia.

Figure 46 show the number of R&D employees per 1000 workers again over the same time frame.

Figure 46: R&D personnel per 1,000 employment, summary

	2005	2015
China	1.86	4.88
Japan	14.17	13.85
Korea	9.47	17.44
Taiwan	8.90	12.90
Hong Kong	6.53	7.33
Singapore	12.83	14.02
Malaysia	1.72	5.79
Thailand	0.99	2.26
Philippines	0.29	0.67
India	0.88	1.09
Vietnam	0.26	1.49
Australia	12.07	--
US	7.65	9.03
Germany	13.14	15.17
UK	11.16	13.19
Israel	--	23.37

Source: UNESCO Institute for Statistics, Taiwan Statistical Data Books 2006, 2007& 2016, Blue Book of National Innovation 2016. Note: Instead of 2015 data: 2014 data for Taiwan, Hong Kong, Singapore; 2013 data for Philippines, Vietnam, US; 2012 data for Israel. Instead of 2005 data: 2004 data for Malaysia, Australia; 2002 data for Vietnam. No relevant data available for Indonesia.

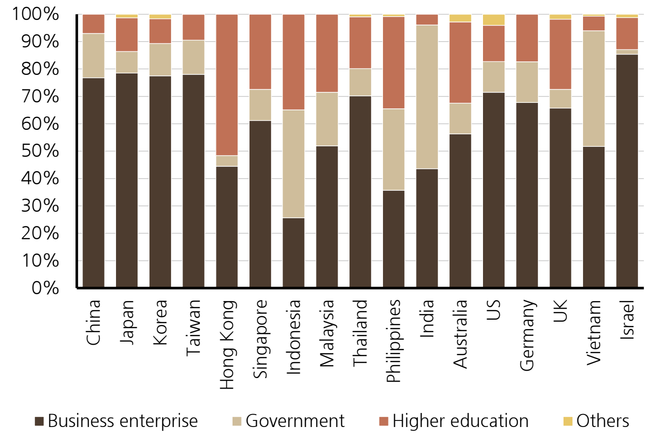
A few points stand out. Firstly, Korea continues to move aggressively up the R&D curve. R&D has been at the heart of Korean government policy since the mid-1960s[12] and this policy remains in force. Japanese R&D spend also remains high, slightly higher than Taiwan the US and Germany. Correlated with this, the number of employees in R&D is also high in north Asia, with China lagging. What also stands out is that R&D in south east Asia and India is very low by comparison to north Asia.

[12] See "Korea's New Techno-Scientific Strategy", J. Uttam, in "Korean Science and Technology in an international Perspective", 2012.

While we don't include it in our scorecard, we also look at the degree to which R&D is performed by the government, higher education or business. Generally, the more advanced countries tend to have a larger share of their R&D being performed by the business sector. In north Asia, the breakdown of spending between these groups is consistent, with around 70% of spending being conducted by businesses, while south Asia (ex Singapore) tends to rely more on government and higher education.

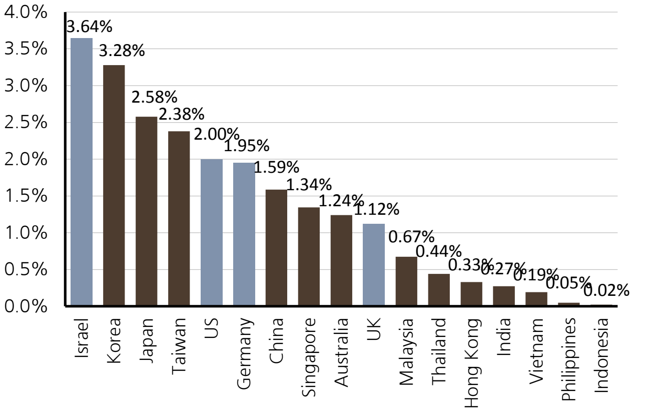
Rather than look at the source of funding, another way to look at the data is to compare business pending on R&D as a% of GDP. This more clearly demonstrates the degree to which north Asian companies are consistently spending more on R&D, even relative to the US, Germany, and the UK. To the extent that this R&D is efficient, it does suggest future sources of competitive advantage, innovation and market share, if not actually profits for these north Asian companies.

Figure 47: R&D spending by segment, 2015



Source: UNESCO Institute for Statistics, OECD. Note: 2014 data for Hong Kong, Singapore; 2013 data for Indonesia, Philippines, Australia.

Figure 48: Business R&D as % of GDP, 2015



Source: UNESCO Institute for Statistics, OECD. Note: 2014 data for Hong Kong, Singapore; 2013 data for Indonesia, Philippines, Australia, Vietnam. Blue indicates non-APAC countries.

We have also been unable to look at a likely further source of support of technological innovation and advancement – defence spending R&D. Historically, it is widely recognised that defence spending has provided many of the major breakthroughs in technology[13]. While the OECD dataset does provide some data – for example the US spends over half of its public R&D on defence, while France, the UK, are over 20%, with South Korea not far behind – the proportion of defence R&D doesn't exist for Israel. Likewise, China is missing from the dataset, though internet sources suggest a figure of perhaps 50% of public R&D may be being spent on defence[14] – in line with US data. It is worth keeping in mind that the antecedents of Huawei – one of China's major Patent filers – are in the defence sector.

Another area that we would like to include, but don't have robust data is for technology transfer. This has been key to the success of innovation north Asian economies – and perhaps explains why 'complex manufacturing economies' like

[13] Most famously in recent times, the internet and GPS but during wars, defence spending in basic research has lifted invention considerably, for example the Manhattan Project. Defence R&D has for example in Israel been a particularly fruitful source of innovation in commercial enterprise in recent times through companies like Rafael Advanced Defense Systems, Elron Electronic Industries and Elbit Systems.

[14] Sun Yuntao and Cong Cao, "Demystifying Central Government R&D Spending in China", 2012, Science, Vol 345, Issue 6200, 2014.

Thailand have failed to prosper in terms of innovation. North Asia typically acquired technology, often through explicit FDI terms, and allowed its companies to learn from, imitate and enhance existing production techniques. Back to our chart Figure 14 on page 15, south Asia appears to have been unable to do this. Technology Transfer is recognised by many as a key ingredient in the capital deepening process.

Figure 49: Aggregate scorecard for research and development

	R&D Expenditure to GDP				Researchers per thousand workers				Total			
	2005		2015		2005		2015		Historical		Current	
	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking
Israel	1.00	1	1.00	1	1.00	1	1.00	1	2.00	1	2.00	1
Korea	0.65	3	0.99	2	0.48	7	0.75	2	1.13	5	1.74	2
Japan	0.79	2	0.77	3	0.73	2	0.59	5	1.51	2	1.36	3
Germany	0.60	5	0.67	5	0.67	3	0.65	3	1.27	3	1.32	4
Taiwan	0.58	6	0.71	4	0.46	9	0.56	7	1.03	7	1.27	5
Singapore	0.54	7	0.52	8	0.66	4	0.60	4	1.19	4	1.12	6
US	0.62	4	0.65	6	0.39	10	0.39	9	1.01	8	1.05	7
UK	0.39	9	0.40	10	0.57	6	0.56	6	0.96	9	0.96	8
Australia	0.46	8	0.52	7	0.62	5	0.38	10	1.08	6	0.90	9
NZ	0.28	11	0.27	12	0.46	8	0.47	8	0.74	10	0.74	10
China	0.32	10	0.48	9	0.10	12	0.21	13	0.42	12	0.69	11
Malaysia	0.15	14	0.30	11	0.09	13	0.25	12	0.24	14	0.55	12
Hong Kong	0.19	13	0.18	13	0.33	11	0.31	11	0.53	11	0.49	13
Thailand	0.05	15	0.15	15	0.05	14	0.10	14	0.11	15	0.24	14
India	0.20	12	0.15	14	0.04	15	0.05	16	0.25	13	0.19	15
Vietnam	0.04	16	0.09	16	0.01	18	0.06	15	0.06	16	0.15	16
Philippines	0.03	17	0.03	17	0.01	17	0.03	17	0.04	17	0.06	17
Indonesia	0.01	18	0.02	18	0.03	16	--	18	0.04	18	0.02	18

Source: OECD, UNESCO, and Global Innovation Index 2016. Note: For Current R&D expenditure numbers, we used 2014 data for Singapore, 2013 data for Philippines, Vietnam, Australia, and New Zealand, and 2012 data for Indonesia. For the same historical numbers, we used 2004 data for Malaysia and Australia, 2002 data for Vietnam, and 2001 data for Indonesia. For Current researcher numbers, we used 2014 data for Hong Kong and Singapore, 2013 data for Philippines, Vietnam, and New Zealand, 2012 data for Israel, and 2010 data for Australia. For the same historical numbers, we used 2004 data for Malaysia and Australia, 2002 data for Vietnam, and 2001 data for Indonesia. For 2005 researchers per thousand workers in Israel, we take average value of other countries divided by their corresponding R&D to GDP, and then times Israel's R&D to GDP.

What does this mean? Asia looks competitive – globally – measured in terms of the amount of R&D spending. Korea is now on par with Israel in R&D, measured as a % of GDP – the highest spender in the world. China is catching up quickly, with spending now higher than in the UK, albeit still 60-70 basis points behind Germany and the US. Ex-Singapore, south Asia lags considerably. India and Malaysia are at least in better shape compared to Indonesia, The Philippines and Thailand.

3. Funding

In the US, the funding model for innovation has often come from venture capital, whereas in east Asia, a major source of capital for innovation has been larger companies like the Chaebol in Korea or the Keiretsu in Japan[15]. We've tried to adjust for this by looking at separate metrics for both venture capital and the cash generated by companies themselves.

Figure 50 shows the Venture Capital funds as a % of GDP. We've used five year trailing data for 2012-2016 for the 'current' data and from 2001 to 2005 for the historic data. The data is based on transactions happening in that country – not

[15] See "National Innovation Systems: An Institutional Perspective', Hoedl & Puck, Springer-Verlag, 2012 and "Institutional Diversity and Innovation: Continuing and Emerging Patterns in Japan and China", Storz & Schaefer, Routledge 2011.

necessarily the origin of the funds. For example, a US VC fund investing US$200m in an Indian company shows up in the India data.

Figure 50: Sum of equity invested to GDP

	2001 - 2005	2012 - 2016	Change
China	0.09%	0.26%	0.16%
Japan	0.01%	0.01%	0.00%
Korea	0.09%	0.04%	-0.05%
Taiwan	0.04%	0.02%	-0.02%
Hong Kong	0.08%	0.04%	-0.04%
Singapore	0.15%	0.22%	0.07%
Malaysia	0.04%	0.04%	0.01%
Thailand	0.03%	0.00%	-0.02%
Philippines	0.02%	0.02%	0.00%
India	0.10%	0.18%	0.08%
Vietnam	0.01%	0.01%	-0.01%
Indonesia	0.01%	0.02%	0.01%
Australia	0.11%	0.02%	-0.08%
US	0.28%	0.29%	0.01%
Germany	0.04%	0.04%	0.01%
UK	0.13%	0.11%	-0.02%
Israel	0.35%	0.32%	-0.03%
New Zealand	0.05%	0.06%	0.01%

Source: Thomson Reuters, World bank

A few things stand out to us. The US and Israel have consistently seen around 30 basis points of GDP being spent by Venture Capital companies. Within Asia, Singapore has consistently had a vibrant share of capital going into investments from venture capitalists. Japan Korea and Taiwan seem to have very underdeveloped markets from venture funding – reflecting in part the role the large companies play in innovation. One of the strongest messages though that comes out is the rate of change that has occurred in China – VC funding as a share of GDP was running at 9 basis points in the five years up to an including 2005. This has soared to 26 basis points, a level not far off the US rate. But even these five year numbers hide a staggering fact: VC funding has grown at a compound rate of 41% since 2012. This is a huge source of support for innovation, and a boon that financial liberalisation has likely provided.

Beyond VC, one of the big drivers of funding in the region is from existing high-tech businesses. In this context, Alibaba, Softbank and Baidu stand out. These companies have spent a combined US$130[16] billion in funding 'start-ups', mainly in the AI/internet space, over the last five years. Not all of this is going into Asia Pacific. In the hardware space as well, the free cash flow (even after dividend payments) of the Tech hardware and Semis companies in Asia Pacific is a further useful source of capital to drive innovation.

We've used listed companies to assess the funding available for investment: this likely holds back Germany where many innovative 'Mittelstand' companies are simply not listed; and as we've explained, particularly for the internet related companies, their spending is not necessarily all directed to their own country of origin. Nevertheless, this seems to us a broader measure of the cash for innovation in an economy particularly given that in Japan and Korea in particular, much of the innovation has been dominated by the large corporates themselves.

[16] Aggregate value of M&A transactions since 2013 from Thomson Reuters

Figure 51: MSCI IT constituents FCF to GDP

	2006	2016	Change
China	0.01%	0.18%	0.17%
Japan	0.25%	0.26%	0.01%
Korea	0.70%	1.68%	0.98%
Taiwan	1.92%	0.98%	-0.93%
Hong Kong	0.00%	0.02%	0.02%
Singapore	0.00%	0.00%	0.00%
Malaysia	0.00%	0.00%	0.00%
Thailand	0.03%	0.01%	-0.02%
Philippines	0.00%	0.00%	0.00%
India	0.18%	0.23%	0.04%
Vietnam	0.00%	0.00%	0.00%
Indonesia	0.00%	0.00%	0.00%
Australia	0.04%	0.02%	-0.02%
US	0.83%	1.19%	0.36%
Germany	0.11%	0.07%	-0.03%
UK	0.03%	0.02%	-0.01%
Israel	0.31%	0.34%	0.03%
New Zealand	0.00%	0.00%	0.00%

Source: Thomson Reuters, Factset. Note: JD.Com and Softbank added to China and Japan respectively.

Figure 51 shows the FCF/GDP for the Technology sectors to GDP in that country (our definition is operating cash flow minus capex, minus dividends). We've made a few tweaks to the data – for example adding Softbank and JD.Com to the Tech indices for these purposes. The data shows north Asia – particularly Korea, Taiwan, Japan and to a lesser extent China, in a more favourable light.

Figure 52: Aggregate scorecard for funding

	Sum of VC equity invested to GDP				FCF of MSCI IT Index constituents to GDP				Total			
	2001 - 2005		2012 - 2016		2006		2016		Historical		Current	
	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking
US	0.82	2	0.93	2	0.43	2	0.71	2	1.25	1	1.63	1
Israel	1.00	1	1.00	1	0.16	4	0.20	4	1.16	2	1.20	2
Korea	0.27	7	0.13	10	0.36	3	1.00	1	0.64	4	1.13	3
China	0.27	8	0.82	3	0.01	11	0.11	7	0.28	9	0.93	4
India	0.30	6	0.58	5	0.10	6	0.13	6	0.39	6	0.72	5
Singapore	0.44	3	0.71	4	--	13	--	13	0.44	5	0.71	6
Taiwan	0.13	11	0.06	13	1.00	1	0.58	3	1.13	3	0.65	7
UK	0.37	4	0.33	6	0.02	9	0.01	10	0.38	7	0.35	8
Japan	0.02	17	0.04	16	0.13	5	0.16	5	0.16	12	0.20	9
Germany	0.11	12	0.14	8	0.06	7	0.04	8	0.17	11	0.18	10
NZ	0.14	10	0.17	7	--	13	--	13	0.14	13	0.17	11
Malaysia	0.11	13	0.14	9	--	13	--	13	0.11	14	0.14	12
Hong Kong	0.24	9	0.13	11	0.00	12	0.01	11	0.25	10	0.14	13
Australia	0.31	5	0.08	12	0.02	8	0.01	9	0.33	8	0.09	14
Philippines	0.06	15	0.06	14	--	13	--	13	0.06	16	0.06	15
Indonesia	0.02	18	0.05	15	--	13	--	13	0.02	18	0.05	16
Vietnam	0.04	16	0.02	17	--	13	--	13	0.04	17	0.02	17
Thailand	0.07	14	0.01	18	0.01	10	0.01	12	0.09	15	0.02	18

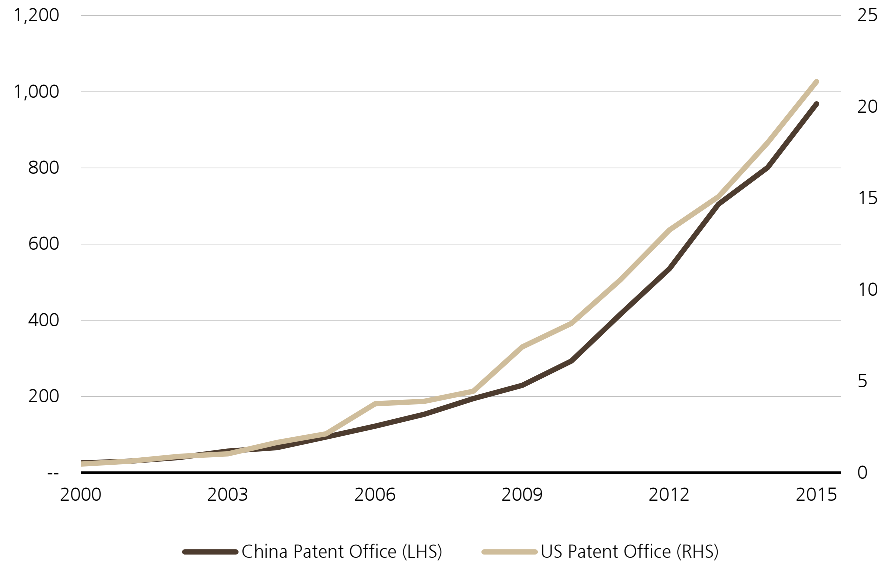
Source: Thomson Reuters, Factset, World Bank

What does this mean? Overall, the US and Israel still stand out as the best places for funding, but once we adjust for corporate funding through our FCF measure, Korea looks better as does Japan. South Asia looks weak on these measures – partly reflecting a low weighting to tech, a handicap to start with. But even on the venture capital score, the provision of funds appears a problem.

4. Patents

To track the output of these three inputs (R&D, Education, capital) to innovation, we've focused on patenting data. We've focused on patents filed and separately granted at the US Patent Office, rather than looking at domestic filed patents. This is because the cost of patent filing is lower in for example China, than at the US Patent Office. As a result, companies filing patents in the US are more likely to be considering the true economic value of an innovation, when considering whether to patent it, than in a lower cost country, where a patent might be granted, but have limited economic value.

Figure 53: Chinese Patent Filed by Location (in thousands)



Source: WIPO, UBS.

There is one drawback to this approach, which is that the percentage of patents filed in the US will naturally tend to have a higher bias toward US companies, just as the EU Patent Office will tend to be dominated by European countries. Another challenge with patent data is that not all companies will file patents, for fear that others will see the line of development taking place.

Notwithstanding these drawbacks, we still believe that we can get a sense of the degree of innovation coming from Asia, as well as the degree to which this has changed by measuring the Patent formulation data.

We've looked at two key metrics: one is the cumulative number of patents granted over the last five years. The second is to look at the number of patents filed in the last year. Not all filings lead to grants. But a surge in filing – as for example has happened out of China – should act as a leading indicator of how things will develop. Both metrics have been normalised for the size of the population.

Figure 54: Patents filed at the US Patent Office per million of the population over the last year

	2010	2015	Change
China	6	16	9
Japan	656	679	23
Korea	525	749	223
Taiwan	919	875	(44)
Hong Kong	141	168	27
Singapore	303	331	28
Malaysia	13	15	2
Thailand	2	2	1
Philippines	1	1	0
India	3	6	3
Vietnam	0	0	0
Indonesia	0	0	0
Australia	174	161	(13)
US	780	896	116
Germany	339	365	26
UK	176	204	28
Israel	669	931	262
New Zealand	124	148	25

Source: WIPO, IP5, USPTO

Patents filed data show that Korea, Taiwan the US and Israel leading the charge. If these patents are granted, it suggests these countries will continue to have an edge technologically, measured by their population sizes.

Figure 55 shows the accumulated granted patents over the last five years, on a per population basis.

Figure 55: Cumulative 5 year patent grants at the US Patent Office per million of the population

	2010	2015	Change
China	5	21	16
Japan	1,438	2,006	568
Korea	811	1,459	648
Taiwan	1,455	2,278	823
Hong Kong	240	369	129
Singapore	442	753	311
Malaysia	27	35	8
Thailand	2	5	3
Philippines	1	2	0
India	3	9	6
Vietnam	0	0	0
Indonesia	0	0	0
Australia	318	369	51
US	1,408	2,015	608
Germany	603	905	301
UK	278	433	155
Israel	873	1,721	849
New Zealand	148	254	105

Source: WIPO, IP5, USPTO

This data shows Japan in a slightly better light – that the accumulated knowledge, like in Taiwan, Israel and the US is relatively high.

As we've measured the data on a per capita basis, this does skew the absolute growth rates we're seeing in China, for example. Legitimately, there is a debate whether for the purposes of looking at innovation coming out of a country, should we look at the level of patents in total, not adjusted for population size? Figure 13 on Page 14, shows the data in absolute terms.

Figure 56: Aggregate scorecard for patents

	Patents filed per million population				Cumulative patents granted per million population				Total			
	2010		2015		2010		2015		Historical		Current	
	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking	Score	Ranking
Taiwan	1.00	1	0.94	3	1.00	1	1.00	1	2.00	1	1.94	1
US	0.85	2	0.96	2	0.97	3	0.88	2	1.82	2	1.85	2
Israel	0.73	3	1.00	1	0.60	4	0.76	4	1.33	4	1.76	3
Japan	0.71	4	0.73	5	0.99	2	0.88	3	1.70	3	1.61	4
Korea	0.57	5	0.80	4	0.56	5	0.64	5	1.13	5	1.44	5
Germany	0.37	6	0.39	6	0.41	6	0.40	6	0.78	6	0.79	6
Singapore	0.33	7	0.36	7	0.30	7	0.33	7	0.63	7	0.69	7
UK	0.19	8	0.22	8	0.19	9	0.19	8	0.38	9	0.41	8
Hong Kong	0.15	10	0.18	9	0.16	10	0.16	9	0.32	10	0.34	9
Australia	0.19	9	0.17	10	0.22	8	0.16	10	0.41	8	0.33	10
NZ	0.13	11	0.16	11	0.10	11	0.11	11	0.24	11	0.27	11
Malaysia	0.01	12	0.02	13	0.02	12	0.02	12	0.03	12	0.03	12
China	0.01	13	0.02	12	0.00	13	0.01	13	0.01	13	0.03	13
India	0.00	14	0.01	14	0.00	14	0.00	14	0.01	14	0.01	14
Thailand	0.00	15	0.00	15	0.00	15	0.00	15	0.00	15	0.00	15
Philippines	0.00	16	0.00	16	0.00	16	0.00	16	0.00	16	0.00	16
Vietnam	0.00	17	0.00	17	0.00	18	0.00	18	0.00	18	0.00	17
Indonesia	0.00	18	0.00	18	0.00	17	0.00	17	0.00	17	0.00	18

Source: WIPO, IP5, USPTO

What does this mean? Taiwan, the US, Israel, Japan and Korea are in a league of their own when it comes to the overall levels of patents granted. This has remained consistent back to 2005. South Asia (ex Singapore) lags badly. Because we've normalised the data for China by population score, this is one area that China also lags considerably at the moment.

Historical overall scorecard

Finally, Figure 57 shows the overall scorecard for historically purposes. Generally, we've tried to use data from 2005. In some cases, as we've shown in the four sections on Education, R&D, Patents and Funding, we've had to use less aged data, where it doesn’t exist. Also, there are some data points that don't exist back in time for certain countries.

Figure 57: Country scorecard (historical)

	R&D						Education									Funding						Patents						Summary	
	R&D / GDP	Score	Rank	Res. / kwks	Score	Rank	QS Ranking	Score	Rank	H Score	Score	Rank	STEM / kPOP	Score	Rank	5yrs VC / GDP	Score	Rank	IT FCF / GDP	Score	Rank	Filing / mcapita	Score	Rank	Aggr / mcapita	Score	Rank	UBS Score	Overall Rank
Australia	1.85	0.46	8	12.07	0.62	5	84.03	0.85	3	272	0.34	5	2.25	0.44	6	0.11%	0.31	5	0.04%	0.02	8	173.8	0.19	9	318.5	0.22	8	1.45	9
China	1.31	0.32	10	1.86	0.10	12	74.86	0.76	8	161	0.20	7	0.36	0.07	16	0.09%	0.27	8	0.01%	0.01	11	6.1	0.01	13	5.2	0.00	13	0.70	12
Germany	2.42	0.60	5	13.14	0.67	3	74.93	0.76	7	408	0.51	3	0.70	0.14	12	0.04%	0.11	12	0.11%	0.06	7	338.9	0.37	6	603.5	0.41	6	1.58	6
Hong Kong	0.77	0.19	13	6.53	0.33	11	83.82	0.85	4	135	0.17	12	1.78	0.35	7	0.08%	0.24	9	0.00%	0.00	12	141.1	0.15	10	239.8	0.16	10	1.00	10
India	0.81	0.20	12	0.88	0.04	15	44.78	0.45	13	146	0.18	10	--	--	18	0.10%	0.30	6	0.18%	0.10	6	3.2	0.00	14	2.9	0.00	14	0.53	14
Indonesia	0.05	0.01	18	0.56	0.03	16	13.58	0.14	16	52	0.07	17	0.66	0.13	13	0.01%	0.02	18	--	--	13	0.1	0.00	18	0.1	0.00	17	0.14	16
Israel	4.04	1.00	1	19.52	1.00	1	51.08	0.52	12	235	0.30	6	4.12	0.81	4	0.35%	1.00	1	0.31%	0.16	4	669.1	0.73	3	872.5	0.60	4	2.79	1
Japan	3.18	0.79	2	14.17	0.73	2	81.69	0.83	6	372	0.47	4	5.11	1.00	1	0.01%	0.02	17	0.25%	0.13	5	656.1	0.71	4	1,438.2	0.99	2	2.45	4
Korea	2.63	0.65	3	9.47	0.48	7	73.58	0.74	9	161	0.20	7	4.22	0.83	3	0.09%	0.27	7	0.70%	0.36	3	525.5	0.57	5	810.9	0.56	5	2.04	5
Malaysia	0.60	0.15	14	1.72	0.09	13	44.25	0.45	14	56	0.07	16	3.07	0.60	5	0.04%	0.11	13	--	--	13	13.0	0.01	12	27.4	0.02	12	0.56	13
New Zealand	1.12	0.28	11	9.02	0.46	8	58.41	0.59	10	151	0.19	9	1.64	0.32	8	0.05%	0.14	10	--	--	13	123.7	0.13	11	148.4	0.10	11	0.92	11
Philippines	0.11	0.03	17	0.29	0.01	17	11.48	0.12	17	58	0.07	15	0.35	0.07	17	0.02%	0.06	15	--	--	13	0.9	0.00	16	1.4	0.00	16	0.14	17
Singapore	2.16	0.54	7	12.83	0.66	4	82.47	0.83	5	114	0.14	13	1.10	0.22	10	0.15%	0.44	3	--	--	13	303.3	0.33	7	441.8	0.30	7	1.53	7
Taiwan	2.32	0.58	6	8.94	0.46	9	54.62	0.55	11	139	0.18	11	4.46	0.87	2	0.04%	0.13	11	1.92%	1.00	1	918.8	1.00	1	1,455.3	1.00	1	2.61	3
Thailand	0.22	0.05	15	0.99	0.05	14	30.25	0.31	15	84	0.11	14	0.59	0.11	14	0.03%	0.07	14	0.03%	0.01	10	1.7	0.00	15	2.1	0.00	15	0.27	15
UK	1.57	0.39	9	11.16	0.57	6	99.01	1.00	1	465	0.59	2	1.47	0.29	9	0.13%	0.37	4	0.03%	0.02	9	175.9	0.19	8	278.1	0.19	9	1.49	8
US	2.50	0.62	4	7.65	0.39	10	98.88	1.00	2	793	1.00	1	1.05	0.20	11	0.28%	0.82	2	0.83%	0.43	2	779.5	0.85	2	1,407.9	0.97	3	2.77	2
Vietnam	0.18	0.04	16	0.26	0.01	18	--	--	18	52	0.07	17	0.47	0.09	15	0.01%	0.04	16	--	--	13	0.1	0.00	17	0.0	0.00	18	0.10	18

Source: UNESCO Institute for Statics, OECD, QS World University Rankings, Scorpus, Commission on higher education of Philippines, Indonesia Ministry of National Education, National Statistics (Taiwan), Thomson Reuters, Factset, CEIC, WIPO, IP5, UBSPTO, The Central Bureau of Statistics (Israel)

Valuation Method and Risk Statement

Although there are many uncertainties with equity investing, generally economic and policy surprises pose the most consistent and continuous risks. Economic growth can be volatile, leading to earnings uncertainty. Inflation volatility can likewise lead to interest rate uncertainty. The direction and level of policy rates has a substantial impact upon equity valuations.

Required Disclosures

This report has been prepared by UBS Securities Asia Limited, an affiliate of UBS AG. UBS AG, its subsidiaries, branches and affiliates are referred to herein as UBS.

For information on the ways in which UBS manages conflicts and maintains independence of its research product; historical performance information; and certain additional disclosures concerning UBS research recommendations, please visit www.ubs.com/disclosures. The figures contained in performance charts refer to the past; past performance is not a reliable indicator of future results. Additional information will be made available upon request. UBS Securities Co. Limited is licensed to conduct securities investment consultancy businesses by the China Securities Regulatory Commission. UBS acts or may act as principal in the debt securities (or in related derivatives) that may be the subject of this report. This recommendation was finalized on: 24 September 2017 01:22 PM GMT.

Analyst Certification: Each research analyst primarily responsible for the content of this research report, in whole or in part, certifies that with respect to each security or issuer that the analyst covered in this report: (1) all of the views expressed accurately reflect his or her personal views about those securities or issuers and were prepared in an independent manner, including with respect to UBS, and (2) no part of his or her compensation was, is, or will be, directly or indirectly, related to the specific recommendations or views expressed by that research analyst in the research report.

UBS Investment Research: Global Equity Rating Definitions

12-Month Rating	Definition	Coverage[1]	IB Services[2]
Buy	FSR is > 6% above the MRA.	45%	28%
Neutral	FSR is between -6% and 6% of the MRA.	38%	27%
Sell	FSR is > 6% below the MRA.	17%	11%
Short-Term Rating	**Definition**	**Coverage[3]**	**IB Services[4]**
Buy	Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%
Sell	Stock price expected to fall within three months from the time the rating was assigned because of a specific catalyst or event.	<1%	<1%

Source: UBS. Rating allocations are as of 30 June 2017.
1:Percentage of companies under coverage globally within the 12-month rating category.
2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.
3:Percentage of companies under coverage globally within the Short-Term rating category.
4:Percentage of companies within the Short-Term rating category for which investment banking (IB) services were provided within the past 12 months.

KEY DEFINITIONS:Forecast Stock Return (FSR) is defined as expected percentage price appreciation plus gross dividend yield over the next 12 months. **Market Return Assumption (MRA)** is defined as the one-year local market interest rate plus 5% (a proxy for, and not a forecast of, the equity risk premium). **Under Review (UR)** Stocks may be flagged as UR by the analyst, indicating that the stock's price target and/or rating are subject to possible change in the near term, usually in response to an event that may affect the investment case or valuation. **Short-Term Ratings** reflect the expected near-term (up to three months) performance of the stock and do not reflect any change in the fundamental view or investment case. **Equity Price Targets** have an investment horizon of 12 months.

EXCEPTIONS AND SPECIAL CASES:UK and European Investment Fund ratings and definitions are: Buy: Positive on factors such as structure, management, performance record, discount; **Neutral:** Neutral on factors such as structure, management, performance record, discount; **Sell:** Negative on factors such as structure, management, performance record, discount. **Core Banding Exceptions (CBE):** Exceptions to the standard +/-6% bands may be granted by the Investment Review Committee (IRC). Factors considered by the IRC include the stock's volatility and the credit spread of the respective company's debt. As a result, stocks deemed to be very high or low risk may be subject to higher or lower bands as they relate to the rating. When such exceptions apply, they will be identified in the Company Disclosures table in the relevant research piece.

Research analysts contributing to this report who are employed by any non-US affiliate of UBS Securities LLC are not registered/qualified as research analysts with FINRA. Such analysts may not be associated persons of UBS Securities LLC and therefore are not subject to the FINRA restrictions on communications with a subject company, public appearances, and trading securities held by a research analyst account. The name of each affiliate and analyst employed by that affiliate contributing to this report, if any, follows.

UBS AG Hong Kong Branch: Niall MacLeod; Matthew Gilman; Yankun Hou; Mark Leung. **UBS AG, Singapore Branch:** Edward Teather. **UBS Securities Co. Limited:** Ting Gao.

Unless otherwise indicated, please refer to the Valuation and Risk sections within the body of this report. For a complete set of disclosure statements associated with the companies discussed in this report, including information on valuation and risk, please contact UBS Securities LLC, 1285 Avenue of Americas, New York, NY 10019, USA, Attention: Investment Research.

Global Disclaimer

This document has been prepared by UBS Securities Asia Limited, an affiliate of UBS AG. UBS AG, its subsidiaries, branches and affiliates are referred to herein as UBS.

Global Research is provided to our clients through UBS Neo, in certain instances, UBS.com and any other system, or distribution method specifically identified in one or more communications distributed through UBS Neo or UBS.com as an approved means for distributing Global Research (each a "System"). It may also be made available through third party vendors and distributed by UBS and/or third parties via e-mail or alternative electronic means. The level and types of services provided by Global Research to a client may vary depending upon various factors such as a client's individual preferences as to the frequency and manner of receiving communications, a client's risk profile and investment focus and perspective (e.g., market wide, sector specific, long-term, short-term, etc.), the size and scope of the overall client relationship with UBS and legal and regulatory constraints.

All Global Research is available on UBS Neo. Please contact your UBS sales representative if you wish to discuss your access to UBS Neo.

When you receive Global Research through a System, your access and/or use of such Global Research is subject to this Global Research Disclaimer and to the terms of use governing the applicable System.

When you receive Global Research via a third party vendor, e-mail or other electronic means, your use shall be subject to this Global Research Disclaimer and to UBS's Terms of Use/Disclaimer (http://www.ubs.com/global/en/legalinfo2/disclaimer.html). By accessing and/or using Global Research in this manner, you are indicating that you have read and agree to be bound by our Terms of Use/Disclaimer. In addition, you consent to UBS processing your personal data and using cookies in accordance with our Privacy Statement (http://www.ubs.com/global/en/legalinfo2/privacy.html) and cookie notice (http://www.ubs.com/global/en/homepage/cookies/cookie-management.html).

If you receive Global Research, whether through a System or by any other means, you agree that you shall not copy, revise, amend, create a derivative work, transfer to any third party, or in any way commercially exploit any UBS research provided via Global Research or otherwise, and that you shall not extract data from any research or estimates provided to you via Global Research or otherwise, without the prior written consent of UBS.

This document is for distribution only as may be permitted by law. It is not directed to, or intended for distribution to or use by, any person or entity who is a citizen or resident of or located in any locality, state, country or other jurisdiction where such distribution, publication, availability or use would be contrary to law or regulation or would subject UBS to any registration or licensing requirement within such jurisdiction. It is published solely for information purposes; it is not an advertisement nor is it a solicitation or an offer to buy or sell any financial instruments or to participate in any particular trading strategy. No representation or warranty, either expressed or implied, is provided in relation to the accuracy, completeness or reliability of the information contained in any materials to which this document relates (the "Information"), except with respect to Information concerning UBS. The Information is not intended to be a complete statement or summary of the securities, markets or developments referred to in the document. UBS does not undertake to update or keep current the Information. Any opinions expressed in this document may change without notice and may differ or be contrary to opinions expressed by other business areas or groups, personnel or other representative of UBS. Any statements contained in this report attributed to a third party represent UBS's interpretation of the data, information and/or opinions provided by that third party either publicly or through a subscription service, and such use and interpretation have not been reviewed by the third party.

This document is a general communication and is educational in nature. Nothing in this document constitutes a representation that any investment strategy or recommendation is suitable or appropriate to an investor's individual circumstances or otherwise constitutes a personal recommendation. By providing this document, none of UBS or its representatives has any responsibility or authority to provide or have provided investment advice in a fiduciary capacity or otherwise. Investments involve risks, and investors should exercise prudence and their own judgement in making their investment decisions. None of UBS or its representatives is suggesting that the recipient or any other person take a specific course of action or any action at all. By receiving this document, the recipient acknowledges and agrees with the intended purpose described above and further disclaims any expectation or belief that the information constitutes investment advice to the recipient or otherwise purports to meet the investment objectives of the recipient. The financial instruments described in the document may not be eligible for sale in all jurisdictions or to certain categories of investors. Options, derivative products and futures are not suitable for all investors, and trading in these instruments is considered risky. Mortgage and asset-backed securities may involve a high degree of risk and may be highly volatile in response to fluctuations in interest rates or other market conditions. Foreign currency rates of exchange may adversely affect the value, price or income of any security or related instrument referred to in the document. For investment advice, trade execution or other enquiries, clients should contact their local sales representative.

The value of any investment or income may go down as well as up, and investors may not get back the full (or any) amount invested. Past performance is not necessarily a guide to future performance. Neither UBS nor any of its directors, employees or agents accepts any liability for any loss (including investment loss) or damage arising out of the use of all or any of the Information.

Any prices stated in this document are for information purposes only and do not represent valuations for individual securities or other financial instruments. There is no representation that any transaction can or could have been effected at those prices, and any prices do not necessarily reflect UBS's internal books and records or theoretical model-based valuations and may be based on certain assumptions. Different assumptions by UBS or any other source may yield substantially different results.

This document and the Information are produced by UBS as part of its research function and are provided to you solely for general background information. UBS has no regard to the specific investment objectives, financial situation or particular needs of any specific recipient. In no circumstances may this document or any of the Information be used for any of the following purposes:

(i) valuation or accounting purposes;

(ii) to determine the amounts due or payable, the price or the value of any financial instrument or financial contract; or

(iii) to measure the performance of any financial instrument.

By receiving this document and the Information you will be deemed to represent and warrant to UBS that you will not use this document or any of the Information for any of the above purposes or otherwise rely upon this document or any of the Information. Prior to making any investment or financial decisions, any recipient of this document or the information should seek individualized advice from his or her personal financial, legal, tax and other professional advisors that takes into account all the particular facts and circumstances of his or her investment objectives.

UBS has policies and procedures, which include, without limitation, independence policies and permanent information barriers, that are intended, and upon which UBS relies, to manage potential conflicts of interest and control the flow of information within divisions of UBS and among its subsidiaries, branches and affiliates. For further information on the ways in which UBS manages conflicts and maintains independence of its research products, historical performance information and certain additional disclosures concerning UBS research recommendations, please visit www.ubs.com/disclosures.

Research will initiate, update and cease coverage solely at the discretion of UBS Research Management, which will also have sole discretion on the timing and frequency of any published research product. The analysis contained in this document is based on numerous assumptions. All material information in relation to published research reports, such as valuation methodology, risk statements, underlying assumptions (including sensitivity analysis of those assumptions), ratings history etc. as required by the Market Abuse Regulation, can be found on NEO. Different assumptions could result in materially different results.

The analyst(s) responsible for the preparation of this document may interact with trading desk personnel, sales personnel and other parties for the purpose of gathering, applying and interpreting market information. UBS relies on information barriers to control the flow of information contained in one or more areas within UBS into other areas, units, groups or affiliates of UBS. The compensation of the analyst who prepared this document is determined exclusively by research management and senior management (not including investment banking). Analyst compensation is not based on investment banking revenues; however, compensation may relate to the revenues of UBS and/or its divisions as a whole, of which investment banking, sales and trading are a part, and UBS's subsidiaries, branches and affiliates as a whole.

For financial instruments admitted to trading on an EU regulated market: UBS AG, its affiliates or subsidiaries (excluding UBS Securities LLC) acts as a market maker or liquidity provider (in accordance with the interpretation of these terms in the UK) in the financial instruments of the issuer save that where the activity of liquidity provider is carried out in accordance with the definition given to it by the laws and regulations of any other EU jurisdictions, such information is separately disclosed in this document. For financial instruments admitted to trading on a non-EU regulated market: UBS may act as a market maker save that where this activity is carried out in the US in accordance with the definition given to it by the relevant laws and regulations, such activity will be specifically disclosed in this document. UBS may have issued a warrant the value of which is based on one or more of the financial instruments referred to in the document. UBS and its affiliates and employees may have long or short positions, trade as principal and buy and sell in instruments or derivatives identified herein; such transactions or positions may be inconsistent with the opinions expressed in this document.

United Kingdom and the rest of Europe: Except as otherwise specified herein, this material is distributed by UBS Limited to persons who are eligible counterparties or professional clients. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. **France:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities France S.A. UBS Securities France S.A. is regulated by the ACPR (Autorité de Contrôle Prudentiel et de Résolution) and the Autorité des Marchés Financiers (AMF). Where an analyst of UBS Securities France S.A. has contributed to this document, the document is also deemed to have been prepared by UBS Securities France S.A. **Germany:** Prepared by UBS Limited and distributed by UBS Limited and UBS Europe SE. UBS Europe SE is regulated by the Bundesanstalt fur Finanzdienstleistungsaufsicht (BaFin). **Spain:** Prepared by UBS Limited and distributed by UBS Limited and UBS Securities España SV, SA. UBS Securities España SV, SA is regulated by the Comisión Nacional del Mercado de Valores (CNMV). **Turkey:** Distributed by UBS Limited. No information in this document is provided for the purpose of offering, marketing and sale by any means of any capital market instruments and services in the Republic of Turkey. Therefore, this document may not be considered as an offer made or to be made to residents of the Republic of Turkey. UBS Limited is not licensed by the Turkish Capital Market Board under the provisions of the Capital Market Law (Law No. 6362). Accordingly, neither this document nor any other offering material related to the instruments/services may be utilized in connection with providing any capital market services to persons within the Republic of Turkey without the prior approval of the Capital Market Board. However, according to article 15 (d) (ii) of the Decree No. 32, there is no restriction on the purchase or sale of the securities abroad by residents of the Republic of Turkey. **Poland:** Distributed by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce regulated by the Polish Financial Supervision Authority. Where an analyst of UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce has contributed to this document, the document is also deemed to have been prepared by UBS Limited (spolka z ograniczona odpowiedzialnoscia) Oddzial w Polsce. **Russia:** Prepared and distributed by UBS Bank (OOO). **Switzerland:** Distributed by UBS AG to persons who are institutional investors only. UBS AG is regulated by the Swiss Financial Market Supervisory Authority (FINMA). **Italy:** Prepared by UBS Limited and distributed by UBS Limited and UBS Limited, Italy Branch. Where an analyst of UBS Limited, Italy Branch has contributed to this document, the document is also deemed to have been prepared by UBS Limited, Italy Branch. **South Africa:** Distributed by UBS South Africa (Pty) Limited (Registration No. 1995/011140/07), an authorised user of the JSE and an authorised Financial Services Provider (FSP 7328). **Israel:** This material is distributed by UBS Limited. UBS Limited is authorised by the Prudential Regulation Authority and regulated by the Financial Conduct Authority and the Prudential Regulation Authority. UBS Securities Israel Ltd is a licensed Investment Marketer that is supervised by the Israel Securities Authority (ISA). UBS Limited and its affiliates incorporated outside Israel are not licensed under the Israeli Advisory Law. UBS Limited is not covered by insurance as required from a licensee under the Israeli Advisory Law. UBS may engage among others in issuance of Financial Assets or in distribution of Financial Assets of other issuers for fees or other benefits. UBS Limited and its affiliates may prefer various Financial Assets to which they have or may have Affiliation (as such term is defined under the Israeli Advisory Law). Nothing in this Material should be considered as investment advice under the Israeli Advisory Law. This Material is being issued only to and/or is directed only at persons who are Eligible Clients within the meaning of the Israeli Advisory Law, and this material must not be relied on or acted upon by any other persons. **Saudi Arabia:** This document has been issued by UBS AG (and/or any of its subsidiaries, branches or affiliates), a public company limited by shares, incorporated in Switzerland with its registered offices at Aeschenvorstadt 1, CH-4051 Basel and Bahnhofstrasse 45, CH-8001 Zurich. This publication has been approved by UBS Saudi Arabia (a subsidiary of UBS AG), a Saudi closed joint stock company incorporated in the Kingdom of Saudi Arabia under commercial register number 1010257812 having its registered office at Tatweer Towers, P.O. Box 75724, Riyadh 11588, Kingdom of Saudi Arabia. UBS Saudi Arabia is authorized and regulated by the Capital Market Authority to conduct securities business under license number 08113-37. **UAE / Dubai:** The information distributed by UBS AG Dubai Branch is only intended for Professional Clients and/or Market Counterparties, as classified under the DFSA rulebook. No other person should act upon this material/communication. The information is not for further distribution within the United Arab Emirates. UBS AG Dubai Branch is regulated by the DFSA in the DIFC. UBS is not licensed to provide banking services in the UAE by the Central Bank of the UAE, nor is it licensed by the UAE Securities and Commodities Authority. **United States:** Distributed to US persons by either UBS Securities LLC or by UBS Financial Services Inc., subsidiaries of UBS AG; or by a group, subsidiary or affiliate of UBS AG that is not registered as a US broker-dealer (a **'non-US affiliate'**) to major US institutional investors only. UBS Securities LLC or UBS Financial Services Inc. accepts responsibility for the content of a document prepared by another non-US affiliate when distributed to US persons by UBS Securities LLC or UBS Financial Services Inc. All transactions by a US person in the securities mentioned in this document must be effected through UBS Securities LLC or UBS Financial Services Inc., and not through a non-US affiliate. UBS Securities LLC is not acting as a municipal advisor to any municipal entity or obligated person within the meaning of Section 15B of the Securities Exchange Act (the "Municipal Advisor Rule"), and the opinions or views contained herein are not intended to be, and do not constitute, advice within the meaning of the Municipal Advisor Rule. **Canada:** Distributed by UBS Securities Canada Inc., a registered investment dealer in Canada and a Member-Canadian Investor Protection Fund, or by another affiliate of UBS AG that is registered to conduct business in Canada or is otherwise exempt from registration. **Mexico:** This report has been distributed and prepared by UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, an entity that is part of UBS Grupo Financiero, S.A. de C.V. and is an affiliate of UBS AG. This document is intended for distribution to institutional or sophisticated investors only. Research reports only reflect the views of the analysts responsible for the reports. Analysts do not receive any compensation from persons or entities different from UBS Casa de Bolsa, S.A. de C.V., UBS Grupo Financiero, or different from entities belonging to the same financial group or business group of such. For Spanish translations of applicable disclosures, please see www.ubs.com/disclosures. **Brazil:** Except as otherwise specified herein, this material is prepared by UBS Brasil CCTVM S.A. to persons who are eligible investors residing in Brazil, which are considered to be: (i) financial institutions, (ii) insurance firms and investment capital companies, (iii) supplementary pension entities, (iv) entities that hold financial investments higher than R$300,000.00 and that confirm the status of qualified investors in written, (v) investment funds, (vi) securities portfolio managers and securities consultants duly authorized by Comissão de Valores Mobiliários (CVM), regarding their own investments, and (vii) social security systems created by the Federal Government, States, and Municipalities. **Hong Kong:** Distributed by UBS Securities Asia Limited and/or UBS AG, Hong Kong Branch. **Singapore:** Distributed by UBS Securities Pte. Ltd. [MCI (P) 007/09/2016 and Co. Reg. No.: 198500648C] or UBS AG, Singapore Branch. Please contact UBS Securities Pte. Ltd., an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110); or UBS AG, Singapore Branch, an exempt financial adviser under the Singapore Financial Advisers Act (Cap. 110) and a wholesale bank licensed under the Singapore Banking Act (Cap. 19) regulated by the Monetary Authority of Singapore, in respect of any matters arising from, or in connection with, the analysis or document. The recipients of this document represent and warrant that they are accredited and institutional investors as defined in the Securities and Futures Act (Cap. 289). **Japan:** Distributed by UBS Securities Japan Co., Ltd. to professional investors (except as otherwise permitted). Where this document has been prepared by UBS Securities Japan Co., Ltd., UBS Securities Japan Co., Ltd. is the author, publisher and distributor of the document. Distributed by UBS AG, Tokyo Branch to Professional Investors (except as otherwise permitted) in relation to foreign exchange and other banking businesses when relevant. **Australia:** Clients of UBS AG: Distributed by UBS AG (ABN 47 088 129 613 and holder of Australian Financial Services License No. 231087). Clients of UBS Securities Australia Ltd: Distributed by UBS Securities Australia Ltd (ABN 62 008 586 481 and holder of Australian Financial Services License No. 231098). This Document contains general information and/or general advice only and does not constitute personal financial product advice. As such, the Information in this document has been prepared without taking into account any investor's objectives, financial situation or needs, and investors should, before acting on the Information, consider the appropriateness of the Information, having regard to their objectives, financial situation and needs. If the Information contained in this document relates to the acquisition, or potential acquisition of a particular financial product by a 'Retail' client as defined by section 761G of the Corporations Act 2001 where a Product Disclosure Statement would be required, the retail client should obtain and consider the Product Disclosure Statement relating to the product before making any decision about whether to acquire the product. The UBS Securities Australia Limited Financial Services Guide is available at: www.ubs.com/ecs-research-fsg. **New Zealand:** Distributed by UBS New Zealand Ltd. UBS New Zealand Ltd is not a registered bank in New Zealand. You are being provided with this UBS publication or material because you have indicated to UBS that you are a "wholesale client" within the meaning of section 5C of the Financial Advisers Act 2008 of New Zealand (Permitted Client). This publication or material is not intended for clients who are not Permitted Clients (non-permitted Clients). If you are a non-permitted Client you must not rely on this publication or material. If despite this warning you nevertheless rely on this publication or material, you hereby (i) acknowledge that you may not rely on the content of this publication or material and that any recommendations or opinions in such this publication or material are not made or provided to you, and (ii) to the maximum extent permitted by law (a) indemnify UBS and its associates or related entities (and their respective Directors, officers, agents and Advisors) (each a 'Relevant Person') for any loss, damage, liability or claim any of them may incur or suffer as a result of, or in connection with, your unauthorised reliance on this publication or material and (b) waive any rights or remedies you may have against any Relevant Person for (or in respect of) any loss, damage, liability or claim you may incur or suffer as a result of, or in connection with, your unauthorised reliance on this publication or material. **Korea:** Distributed in Korea by UBS Securities Pte. Ltd., Seoul Branch. This document may have been edited or contributed to from time to time by affiliates of UBS Securities Pte. Ltd., Seoul Branch. This material is intended for professional/institutional clients only and not for distribution to any retail clients. **Malaysia:** This material is authorized to be distributed in Malaysia by UBS Securities Malaysia Sdn. Bhd (Capital Markets Services License No.: CMSL/A0063/2007). This material is intended for professional/institutional clients only and not for distribution to any retail clients. **India:** Distributed by UBS Securities India Private Ltd. (Corporate Identity Number U67120MH1996PTC097299) 2/F, 2 North Avenue, Maker Maxity, Bandra Kurla Complex, Bandra (East), Mumbai (India) 400051. Phone: +912261556000. It provides brokerage services bearing SEBI Registration Numbers: NSE (Capital Market Segment): INB230951431, NSE (F&O Segment) INF230951431, NSE (Currency Derivatives Segment) INE230951431, BSE (Capital Market Segment) INB010951437; merchant banking services bearing SEBI Registration Number: INM000010809 and Research Analyst services bearing SEBI Registration Number: INH000001204. UBS AG, its affiliates or subsidiaries may have debt holdings or positions in the subject Indian company/companies. Within the past 12 months, UBS AG, its affiliates or subsidiaries may have received compensation for non-investment banking securities-related services and/or non-securities services from the subject Indian company/companies. The subject company/companies may have been a client/clients of UBS AG, its affiliates or subsidiaries during the 12 months preceding the date of distribution of the research report with respect to investment banking and/or non-investment banking securities-related services and/or non-securities services. With regard to information on associates, please refer to the Annual Report at: http://www.ubs.com/global/en/about_ubs/investor_relations/annualreporting.html

The disclosures contained in research documents produced by UBS Limited shall be governed by and construed in accordance with English law.