NOMURA

Nomura AI Companies 70

EQUITY QUANTITATIVE RESEARCH

Equally weighted index of AI-related stocks

Stocks selected on basis of searches of TV/online news, newspapers, magazines

Index overview and concept

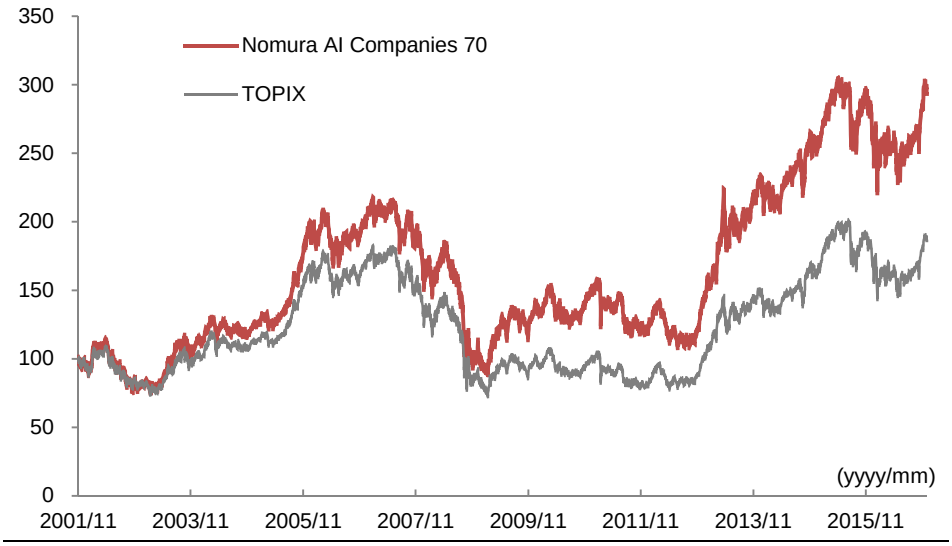
The Nomura AI Companies 70 is an equally weighted index made up of 70 stocks that engage in business related to artificial intelligence (AI).

Stocks are selected by using quantitative evaluation indicators based on article search results, from among listed companies in Japan that are covered in the media in connection with AI-related businesses, as determined by scanning big data comprising articles and reports from online and TV news, newspapers, magazines, and the like. "Artificial intelligence" and several related keywords selected with the use of AI are employed in the article searches.

Sectors that actively use AI, including electric appliances & precision instruments, IT & services, others, automobiles & transportation equipment, machinery, and the like, are at the heart of AI investment themes, and include small and midcap stocks related to AI and robots.

The third AI boom has arrived on the back of strides made in AI technology around the world in the 2010s. In Japan, government and government agencies have been working together to promote R&D and commercialization of AI. AI technology is being applied to business and the Nomura AI Companies 70 was created to make it possible to invest intensively in companies that engage in AI-related business.

Fig. 1: Performance of Nomura AI Companies 70



Note: Data for 30 November 2001 given a value of 100. Analysis is based on historical share prices and does not guarantee future performance.

Source: Nomura

Global Markets Research

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1. Growth in artificial intelligence business

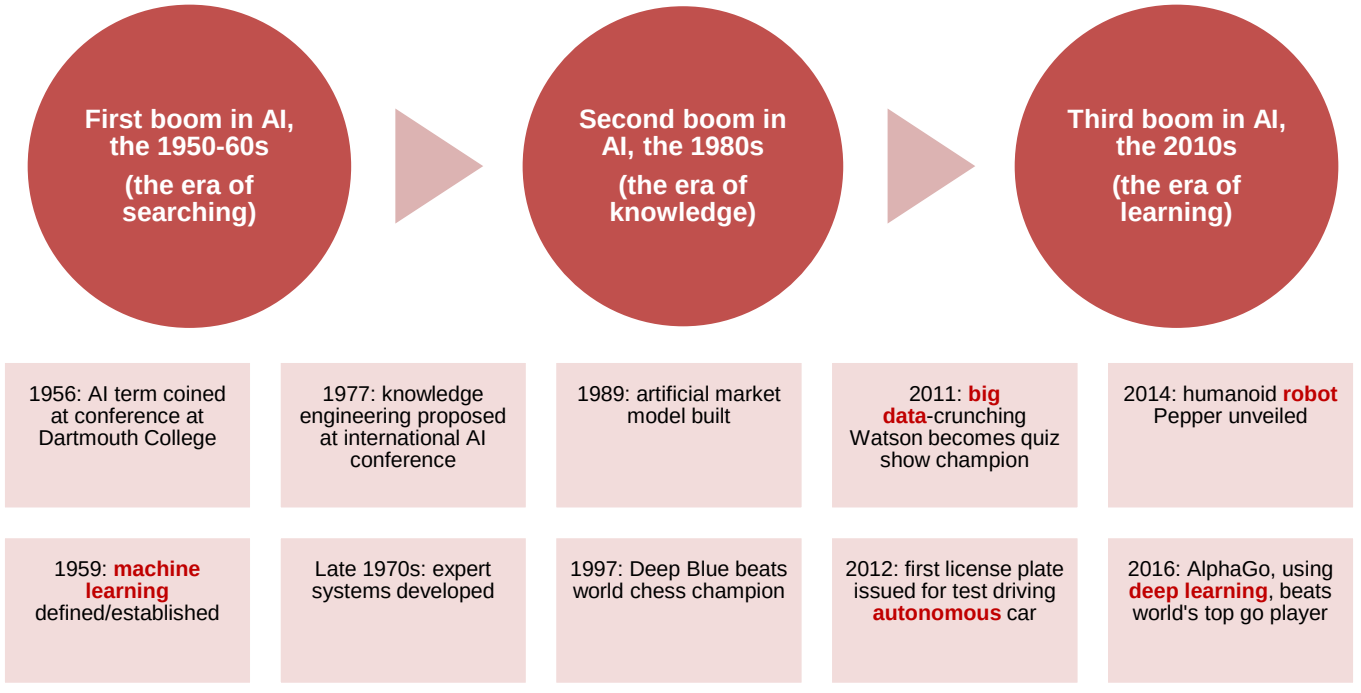
Arrival of third boom in AI

Rapid advances have been made in AI technology in the 2010s, which have been reported by the media. By using AI to learn from big data and the like, decisions and tasks transcending human capacity can be automated and efforts have been made to apply this to various fields of business.

AI was proposed at a conference on the campus of Dartmouth College in the US in 1956, and the ideas for machine learning[1] and the perceptron algorithm (used in the first neural network) were devised and established in the late 1950s. The roots of AI technology used today were formed during the first boom in AI. The second boom in AI arrived along with the spread of databases in the 1980s, following the development of expert systems that make near-expert decisions using the knowledge base of experts. At this time in Japan, a state-sponsored project was under way to research and develop a fifth-generation computer.

The arrival of the third boom in AI came in the 2010s, revolving around deep learning. Much progress has been made in image and audio recognition technology, and innovative products, including self-driving cars and humanoid robots, are close to being realized. AI and related technology traditionally used mostly by IT companies is now being used in myriad industries spanning autos, manufacturing and construction, electric power, pharmaceuticals, and finance. As a result AI business has expanded.

Fig. 2: History of AI



Source: Nomura

[1] Arthur Samuel, known as the father of machine learning, defined machine learning as the field of study that gives computers the ability to learn without being explicitly programmed.

2. Nomura AI Companies 70 stock selection

Quantitatively selected based on results of searches of online and TV news, newspapers, magazines, and other media

The Nomura AI Companies 70 is an equally weighted index made up of 70 stocks of companies covered by the media in connection with business related to AI. It is a theme-specific index enabling focused investment in companies associated with AI, an investment theme that has been gathering interest.

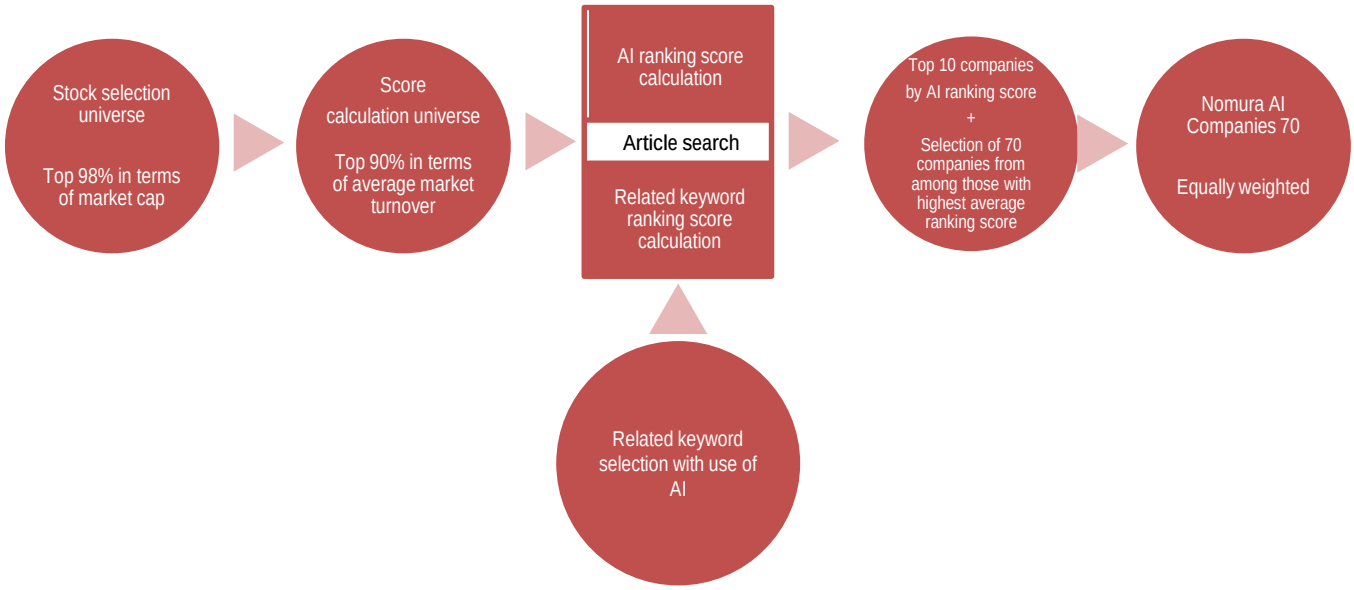
Figure 3 shows the flow of steps involved in selecting stocks. Stocks for inclusion are selected from the score calculation universe of all common stocks listed on exchanges in Japan that are in the top 98% in terms of market cap and in the top 90% in terms of average market turnover. In the interest of investability, stocks with extremely low market caps or low liquidity are not included.

Online and TV news, newspapers, magazines, and other media are searched for the mention of stocks in the score calculation universe. "Artificial intelligence" and several related keywords selected with the use of AI are employed in the search for articles. Ultimately 70 stocks are selected with the use of a quantitative evaluation indicator based on the results of these article searches, which we will describe in more detail later.

The 70 stocks in the index are weighted equally. By making it an equally weighted index, a flat rate of investment is made in not only large cap but also small and midcap AI-related stocks. Keywords related to AI are reviewed annually and published in August. The annual review is carried out on the first business day of December.

We call this stock selection methodology the Nomura AI Thematic Stock Search (NAITS). Thematic stock search can be used for other investment themes by searching articles with related keywords selected with the use of AI.

Fig. 3: Flow for selecting stocks for Nomura AI Companies 70 (Nomura AI Thematic Stock Search)



Source: Nomura

Related keyword selection with use of AI

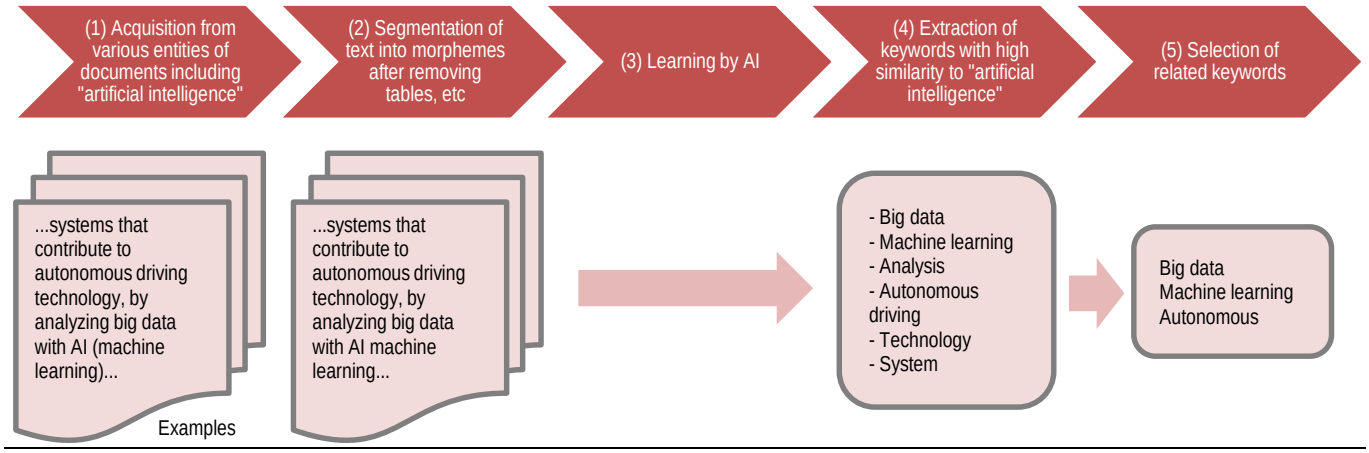
AI-related keywords are selected on the basis of their similarity to AI upon analyzing text in documents related to AI that have been published by government offices and research organizations. As shown in Figure 4, first a broad net is cast to collect documents published by various entities that include "artificial intelligence" and the documents are converted to a text format after removing tables, figures, illustrations, and the like. The text is then segmented into the smallest grammatical units (morphemes) of the language. By using AI to learn the morpheme clusters, words with high similarity to the phrase “artificial intelligence” can be extracted. Ultimately, words are selected that are suitable as keywords in the search of articles in which AI companies have been mentioned.

Related keywords that were initially selected in 2016 are "deep learning," "machine learning," "big data," "internet of things," "robotics," "data mining," "sensing," "cyber security," "robot," and "autonomous driving."

The similarity of each word is shown in the top portion of Figure 5. Similarity shows how close a word is to "artificial intelligence." The closer the numerical representation is to "1," the higher the similarity. Aside from the selected keywords, words with high similarity include "human," "general purpose," "large volume," and others, but these were not selected as they were not deemed to be suitable keywords for searches on articles in which companies are mentioned. Similarity was particularly high for "deep learning" and "machine learning," indicating that these are gathering much attention as core technological drivers of AI.

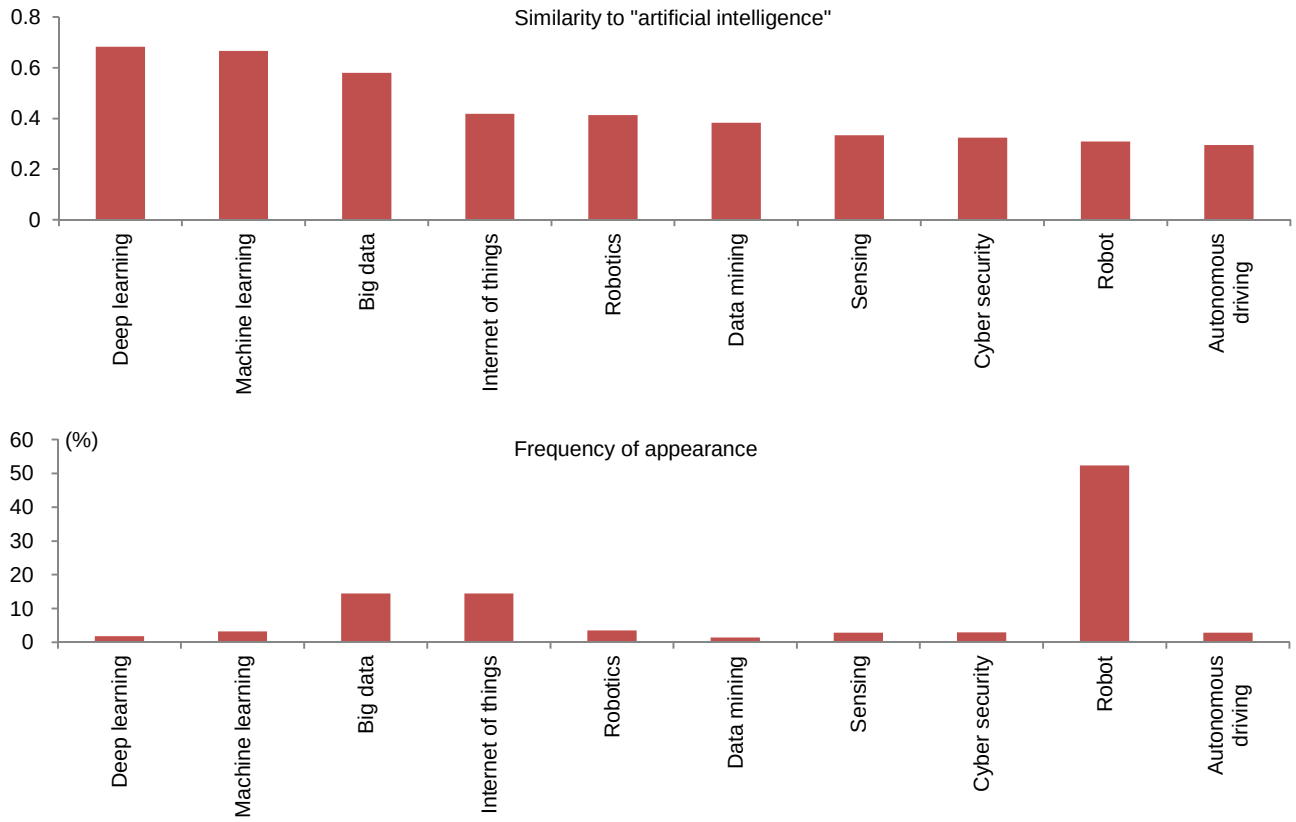
The lower part of Figure 5 breaks down the number of times the keywords were mentioned in documents containing "artificial intelligence." "Robot" appeared most frequently, followed by "big data" and "internet of things." This is based on documents from the five years from April 2011. If we look at documents from the past couple years, we see that keywords other than "robot" have increased in prevalence.

Fig. 4: Extraction of keywords with high similarity to “artificial intelligence” with the use of text analysis



Source: Nomura

Fig. 5: Quantitative indicators for related keywords



Note: Sample period is April 2011 through March 2016.

Source: Nomura, based on documents from government offices and research organizations

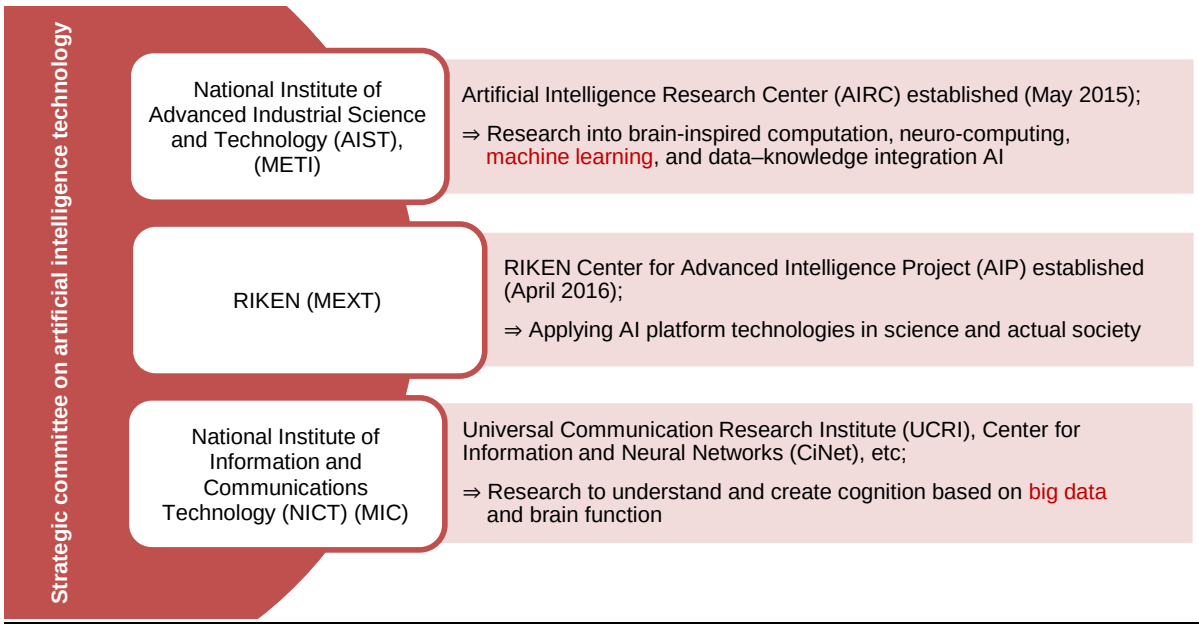
Related keywords found in AI-related policy materials

As discussed above, we selected our related keywords based on documents related to AI that have been published by government offices and research organizations. In this section, we discuss how these keywords are used in actual policy materials.

The government and its various agencies are all working together to promote accelerated R&D into AI and to make it into a viable industry. A strategic committee for AI technology was established on the prime minister's orders in April 2016, and METI, the Ministry of Internal Affairs and Communications (MIC), and the Ministry of Education, Culture, Sports, Science and Technology (MEXT) are now prepared to work together on AI R&D and innovation policy. As part of these efforts, RIKEN in April 2016 launched the RIKEN Center for Advanced Intelligence Project with a subsidy for the Advanced Integrated Intelligence Platform Project (AIP), which is meant to integrate AI with big data, IoT, and cybersecurity. The high similarity shown in Figure 5 for "big data," "internet of things," and "cyber security" may reflect the influence of the AIP in particular.

As shown in Figure 6, the National Institute of Advanced Industrial Science and Technology's Artificial Intelligence Research Center, RIKEN's Center for Advanced Intelligence Project, and the R&D institutions under the National Institute of Information and Communications Technology are working together to promote partnerships between universities, industry, and government for research into AI technology, and to develop businesses in this field.

Fig. 6: AI efforts by the national government, government agencies, and research institutions



Source: Nomura, based on documents from government offices and research organizations

The government's Council on Investments for the Future met in September 2016 to direct the government's growth strategies, with the aim of creating ¥30trn in value-added by 2020 by promoting a fourth[2] industrial revolution in the corporate sector. This fourth industrial revolution is envisioned as a transformation that would allow for the development of new goods and services by connecting all manner of things to the internet and by using AI to analyze the mass of data thus generated. As can be seen in Figure 7, the use of AI, IoT, big data, and robots gives rise to numerous examples of innovation in a wide range of business domains.

"Data mining" refers to techniques used to analyze big data to extract useful information, and is thus quite similar to machine learning as a technology. "Sensing" is a technology to collect quantitative data using a variety of sensors, and is an essential technology for autonomous driving. This technology is also used for remote sensing, used in remote operation.

Fig. 7: Actual uses of technological innovations in society

Health, medical, and nursing care	Mobility, transportation	Manufacturing	Energy, construction
• Creation and analysis of electronic medical charts and invoices • Use of ICT for preventive medicine, independence support, remote treatment, and nursing care robots • Diagnosis using AI, sensors, and robots	• Autonomous driving • Autonomous driving and convoying for trucks on expressways • Early implementation of drone deliveries • Logistics revolution to overcome personnel shortages	• Smart manufacturing • Prediction and early detection of abnormalities using IoT, big data, and AI • Cyber security in an IoT society	• Visibility of energy consumption • Widespread adoption of smart meters and home energy management systems (HEMS) • Productivity revolution at construction sites • Use of ICT to promote spread of "i-Construction"

Source: Nomura, based on the priority agenda in the second round of materials from the Economic Revitalization Headquarters' Council on Investments for the Future

[2] The fourth industrial revolution indicates changes in industrial structure, following on from the first industrial revolution (in the 18th century), which involved the use of the steam engine, the second industrial revolution (in the second half of the 19th century), in which electric power was used to enable mass production, and the third industrial revolution (in the second half of the 20th century), which involved automation via the use of computers.

Stock selection using Nomura AI Thematic Stock Search (NAITS)

Stocks for inclusion in the Nomura AI Companies 70 are selected using quantitative indicators based on the results of searches for articles that include the phrase “artificial intelligence” and related keywords. Essentially, companies that are the subject of a large number of articles related to AI are selected for the index. We set out the stock selection process in more detail below.

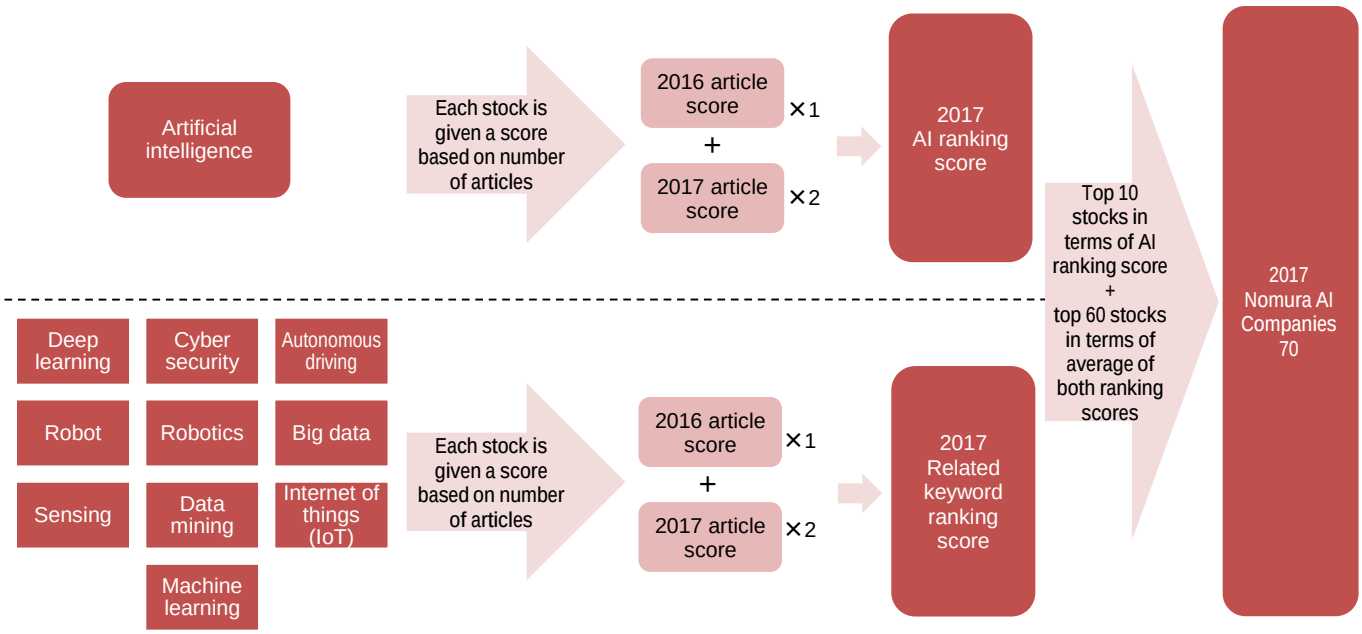
As we have already explained, the universe of stocks eligible for score calculation for the Nomura AI Companies 70 comprises the stocks that are in both the top 98% of stocks listed on Japanese stock exchanges in terms of free-float-adjusted market cap and the top 90% of stocks listed on Japanese stock exchanges in terms of average daily market turnover over the past 60 days. The AI ranking score and related keyword ranking score are then calculated for each of the stocks in the score calculation universe.

First, the AI ranking score is calculated for every stock. The number of articles in the past two years containing both the stock's ticker code and the phrase "artificial intelligence" is calculated for every stock once a year, and the total AI article score is obtained by doubling the figure for the most recent year. Each stock's ranking in terms of total AI article score is its AI ranking score, with rankings in ascending order starting with the stock with the highest number of articles.

Next, to calculate each stock’s related keyword ranking score, the number of articles containing the stock's ticker code and a related keyword but not the phrase "artificial intelligence" is calculated in the same way as for the AI ranking score. Each stock's ranking in terms of total related keyword article score is its keyword ranking score, with rankings in ascending order starting with the stock with the highest number of articles.

The top 10 stocks in terms of AI ranking score and the top 60 stocks in terms of the average of AI ranking score and keyword ranking score, ranked in ascending order, are selected as the constituent stocks of the Nomura AI Companies 70. The above is a simplified version of the stock selection process. Refer to the Nomura AI Companies 70 index rulebook for a more detailed description of the stock selection process.

Fig. 8: Stock selection process using NAITS (2017)



Source: Nomura

3. Nomura AI Companies 70: performance and industry/style mix

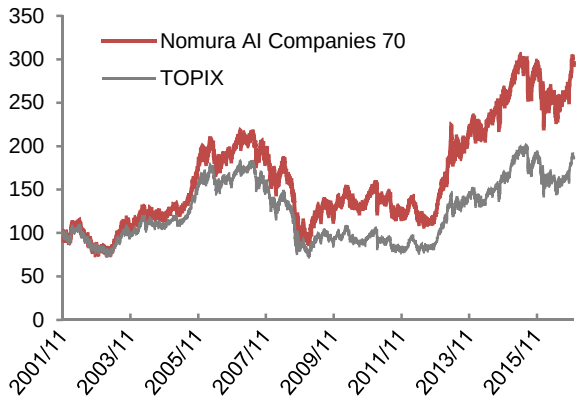
Outperforming TOPIX

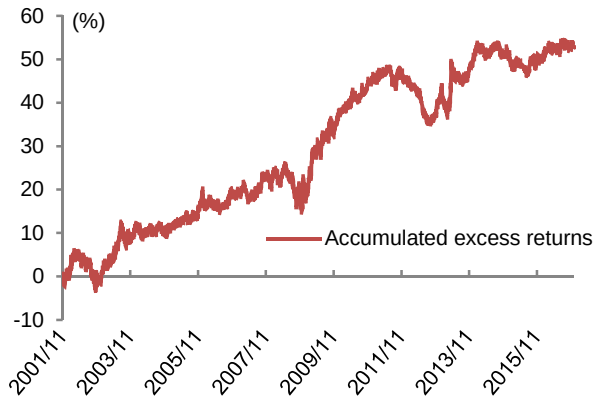
Figure 9 shows the performance of the Nomura AI Companies 70. Over the past 15 years (since 2001), the roughly 9.9% average annual return of the index has surpassed the 3.5% average of the TOPIX. The total excess return was 52.8%.

While the strong performance likely owes primarily to industry and size factors, we think that the number of news reports could have been a share price-lifting factor too, with investor attention stoked by a high volume of media reports. We cover this in more detail later in this report, but we think the TOPIX-beating performance was driven by concentrated investment at a set weight (1/70th each) in a cluster of small/midcap AI- and robot-related stocks that were frequently mentioned in online and TV news reports, newspapers, and magazines.

The average beta[3] was 1.02, showing sensitivity to the market average that was similar to (or slightly higher than) the TOPIX.

Fig. 9: Index performance: Nomura AI Companies 70





	Nomura AI Companies 70	TOPIX
Average return (%)	9.92	6.61
Standard deviation (%)	23.48	22.20
Sharp ratio	0.38	0.25
Max draw dow n (%)	59.10	60.15
Excess returns (%)	3.51	—
Information ratio	0.65	—

Note: Sample period is November 2001 through December 2016. 30 November 2001 = 100. Annualized based on daily results. TOPIX includes dividends, excludes effects of dividend taxation. For the Nomura AI Companies 70, calculation of excess return and information ratio is dividend inclusive to match conditions for TOPIX. Others calculated from indices that are net of dividend tax. Transactions costs have not been taken into account. Analysis is based on historical share prices and does not guarantee future performance.

Source: Nomura

[3] Beta is average of figures for November 2003 to December 2016, with those figures calculated from two years' weekly data for the TOPIX (dividend inclusive) and the Nomura AI Companies 70 (dividend inclusive).

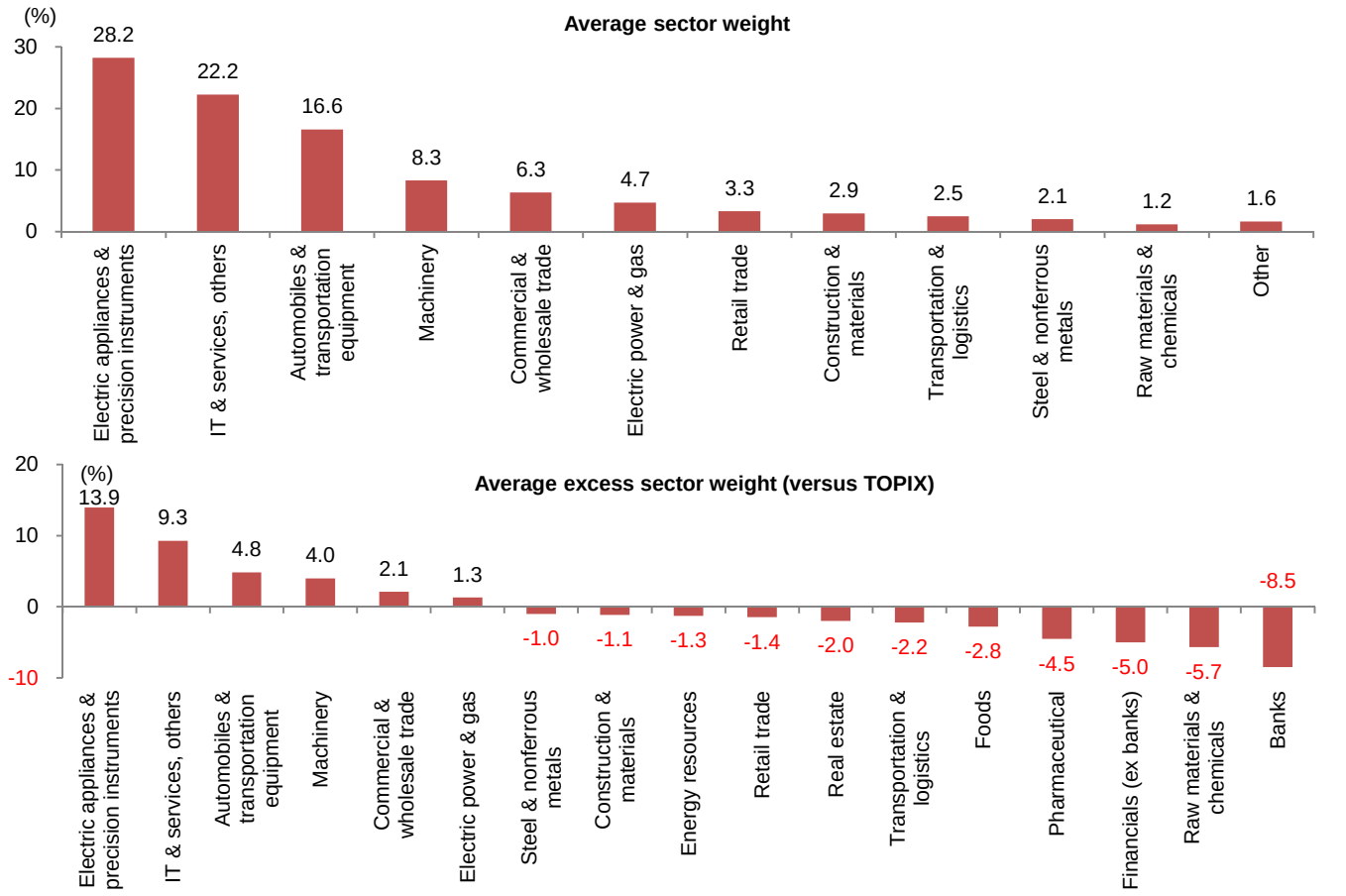
Index centered around electric appliances & precision instruments and IT & services sectors

Figure 10 shows the average sector composition of the Nomura AI Companies 70. The top chart shows average sector weights at the time of the periodic reconfigurations carried out from 2001 through 2016, based on TOPIX-17 Series sectors. The bottom chart shows the average excess weight for each sector in the index versus its weight in the TOPIX.

It is clear from the bottom chart that the electric appliances & precision instruments, IT & services, others, automobiles & transportation equipment, and machinery sectors have had particularly large excess weights, on average. One way of interpreting this is to say that the sectors for which the development of AI-related technology has led directly to improvements in operational efficiency or innovations have had high weights in the index. At the same time, the pharmaceutical, financials (including banks), and raw materials & chemical sectors have on average been underweight versus the TOPIX. AI is currently used in a wide range of sectors, but we think that its uptake in these sectors was relatively low in the past.

Below, we look at the ways in which AI and related technologies are being used in the various sectors.

Fig. 10: Sector composition of Nomura AI Companies 70



Note: Shows average sector weights as of the periodic reconfiguration date (the first business day of December) each year from 2001 through 2016

Source: Nomura

Electric appliances & precision instruments and IT & services, others
More and more PCs and smartphones are now able to offer the appropriate service automatically on the basis of voice input recognition. Dialog with humanoid robots is also being put to practical use, and products that use AI are becoming increasingly familiar in both the home and the workplace. All the major electronics manufacturers have launched plans aimed at substantially increasing their numbers of AI engineers from 2017 onward, and this is likely to be the sector that accounts for the majority of AI-related business from now on.

In the field of medical equipment, automatic diagnosis using medical image analysis technologies such as X-rays and the automatic proposal of treatment methods based on automatic diagnosis are now being put to practical use. Healthcare robots fall into the categories of long-term care support robots that provide support for activities such as moving around and bathing, independence support robots that assist in walking and rehabilitation, for example, and, most importantly, communications robots able, thanks to the application of AI technology, to engage in conversation and communicate with the user. Demand for all three categories of healthcare robot is growing as Japanese society ages.

Meanwhile, as a wide range of data, including confidential and personal data, is now being exchanged frequently, the problems of data leaks and hacking have also surfaced, and data security is regarded as a high priority. In October 2016, METI launched a national qualification system, called the IT Security Support Provider System, to encourage companies to hire experts who will be responsible for in-house cyber security.

AI and related technologies have started to be used in the field of crime prevention too. Products such as smart doorbells that are able to detect and provide notification of visitors, smart doorknobs that can lock and unlock doors, and smart alerts that detect and provide notification of intruders and other abnormalities are emerging as new types of consumer electronics for residential use. Demand is also growing for biometric authentication technologies such as face recognition and fingerprint recognition, and for equipment that uses these technologies, and AI is increasingly being used to help improve security.

Automobiles & transportation equipment, transportation & logistics
Autonomous driving is a keyword for these two sectors. Progress has been made in the development of image recognition and spatial recognition. Autonomous driving vehicles that use sensing technologies and 3D mapping to recognize external data have been developed, and in some countries such vehicles are already being tested on public roads. Companies have been taking advantage of their respective areas of strength to develop technologies ranging from quasi-autonomous driving aided both by the driver and infrastructure installed on the roads to fully automated driving. Substantial progress has also been made in the development of individual technologies such as automatic braking and automatic parking.

In the transportation & logistics sector, companies are looking into new types of services such as delivery using unmanned taxis and drones, and trucks installed with 3D printers that can carry out manufacturing and transportation at the same time.

Machinery and construction & materials
Companies in these two sectors are making use of IoT and ICT. There have been proposals for smart factories (fully automated factories) and smart construction, and attempts have also been made to use ICT to control all onsite operations. Measurement and transportation using driverless dump trucks, self-driving tractors, and drones are examples of moves toward automation and greater efficiency in these sectors.

Other sectors

In the retail trade sector, self-checkout systems are becoming increasingly common, and completely unmanned stores are also being looked into. The idea is that the use of omnichannel retailing that links together all the sales and distribution channels (bricks-and-mortar stores, the internet, and mobile phones, for example) will enable retailers to attract new customers and reduce their personnel expenses.

In the electric power & gas sector, progress is being made in the installation of smart meters with telecommunications functionalities and EMS (energy management systems) with energy-saving functionalities, and the creation of smart grids that incorporate both types of products is leading to greater efficiency in the sector and more appropriate energy usage overall.

In new drug research and development, AI is being used in experiments (clinical trials) that take time and effort in particular, thus making the search for potential new drugs more efficient.

In the financial sector, including banks, fintech, which brings together finance and IT, is attracting attention, and electronic settlement in particular is becoming increasingly common. Robo-advisors that suggest and manage portfolios automatically on the basis of investors' preferences and risk tolerance, and blockchain technology, exemplified by bitcoin, are also being used more and more.

In food-related industries, progress is being made in standardizing the technologies used in touch, taste, and smell sensors, for example, and it now appears that Japanese technologies might become the global standard in this area. Progress is also being made in improving the efficiency of food manufacturing processes via the use of robot hands and other types of industrial robot.

In the retailing, pharmaceutical, and financial sectors, AI is beginning to be used in humanoid robots for customer service use, and for the purpose of answering questions, for example in call centers. These sectors in the past had low weights in the Nomura AI Companies 70, but their index weights might rise if there is an increase in news or newspaper reports, for example, about the use of AI in these sectors.

Fig. 11: Examples of use of AI and automation, and keywords, by sector

Electric appliances & precision instruments IT & services, others	Automobiles & transportation equipment Transportation & logistics	Machinery sector Construction & materials sector	Other sectors

• Voice input in information devices
• 5G
• Humanoid robot
• Healthcare robot
• Medical image analysis
• Automatic diagnosis
• Cyber security
	• Autonomous driving
	  • Quasi-autonomous driving
	  • Fully autonomous driving
	• Automatic braking
	• Automatic parking
		• Smart factory (fully automated factory)
		• Smart construction (use of ICT)
		• Project risk management
			• Omnichannel

• Smart refrigerator • Smart cleaning robot	• Sensing technology • 3D mapping	• Unmanned dump truck • Self-driving tractor • Measurement/ transportation by drone	• Smart grid • Smart meter • EMS (energy management system)
• Smart doorbell (visitor detection) • Smart doorknob (locking and unlocking door) • Smart alert (detection of abnormalities)	• Unmanned taxi • Truck installed with 3D printer • Delivery by drone		• New drug development • FinTech • Robo-advisor • Blockchain • Touch sensor • Taste sensor • Smell sensor • Robot hand

Source: Nomura

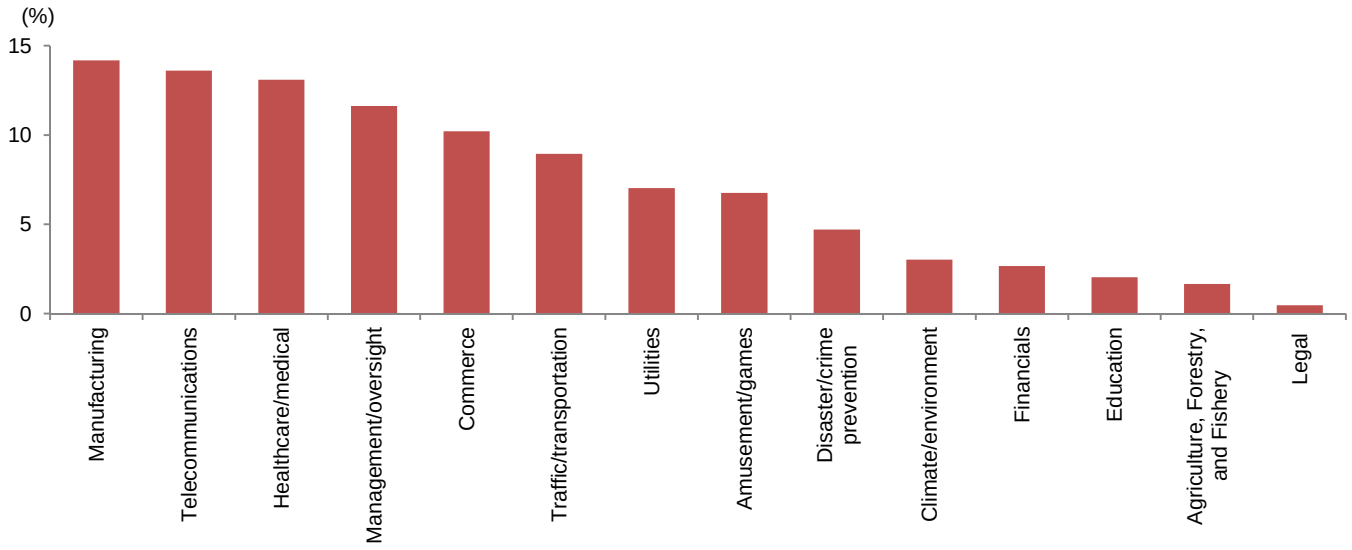
Areas in which AI technology is being used, based on number of patent applications

The electric appliances & precision instruments, IT & services, other, and automobiles & transportation equipment sectors have had high weights in the Nomura AI Companies 70, and these sectors also appear to be important as far as we can tell from a breakdown of the areas in which patent applications involving the use of AI have been filed.

Figure 12 shows the breakdown of Japanese, US, European, Chinese, and South Korean patent applications involving the use of AI technology, by area in which the technology is to be applied, based on Japan Patent Office data. The categories are public sector (traffic/transportation, telecommunications, utilities, climate/environment, and disaster/crime prevention), industrial (finance, manufacturing, agriculture, forestry, and fishery, legal, commerce, management/oversight), lifestyle (amusement/games, healthcare/medical, education), general, and other. Areas of application with a particularly high number of patent applications are manufacturing, telecommunications, healthcare/medical, management/oversight, and commerce, and while there are some differences in terms of categorization these are largely the same as the sectors with high weights in the Nomura AI Companies 70. These can thus be said to be the areas that are likely to see a direct boost from the development of AI technologies.

In terms of the technology on which the patent applications are based, Japan Patent Office data indicate that machine learning and neural networks account for 30-40% of patent applications in the areas of manufacturing, telecommunications, healthcare/medical, management/oversight, and commerce, and more than 60% in the area of robots (based on another categorization composed of robots, cars and healthcare). The importance of "machine learning" and "deep learning," which have been selected as related keywords for the Nomura AI Companies 70 stock selection process, is also clear from the number of patent applications.

Fig. 12: Sector breakdown based on number of global AI-related patent applications



Note: Based on number of patent applications in Japan, US, Europe, China, and South Korea that claimed priority in 2008-12. Sector breakdown in terms of area of application excludes "general" and "other."

Source: Nomura, based on Japan Patent Office data

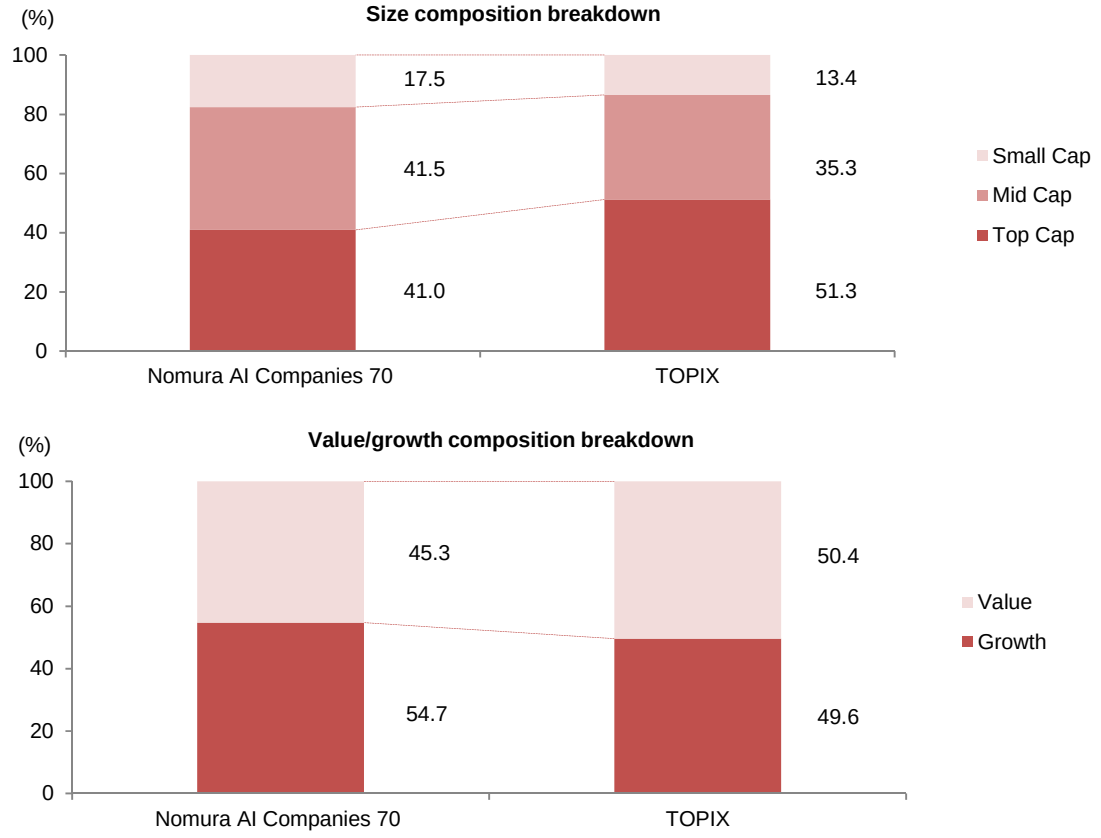
Small caps, midcaps, and growth stocks tend to account for a large share of the index

We looked at the average breakdown of the Nomura AI Companies 70 from 2001 to 2016 by investment style and company size.

Figure 13 shows that the index had a higher weighting of small and midcap stocks than the TOPIX, with the average weighting about 10ppt higher than for the TOPIX during this period. We think the index had excess returns attributable to size factors as it invested at a higher rate than the TOPIX in AI-related small and midcaps.

The index had a higher weighting of growth stocks than the TOPIX, with the average weighting about 5ppt higher than for the TOPIX during this period. This shows to us that the index tended to include AI-related companies expected to see high growth.

Fig. 13: Investment style and company size composition of Nomura AI Companies 70



Note: Sample period is 2001-16. We took the average of monthly composition breakdowns that we calculated by multiplying the number of stocks in style indexes of the Russell/Nomura Japan Equity Indexes by composition weightings.

Source: Nomura

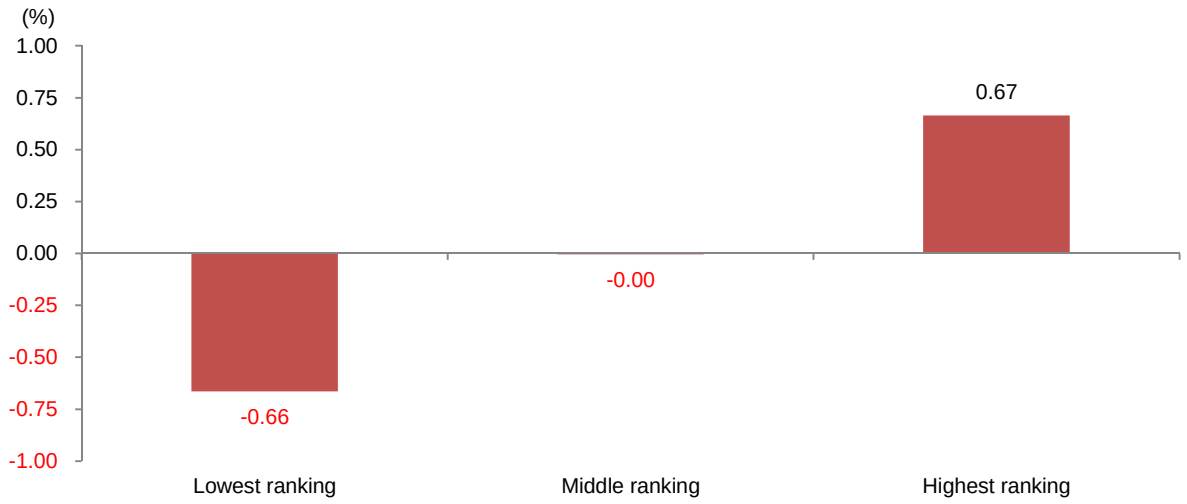
Returns tend to be higher the larger the number of articles with "artificial intelligence" and related keywords

Finally, we look at the relationship between the number of articles and excess returns. As of the date of periodic reconfigurations from 2001 to 2016, we divided constituent stocks into tertiles according to the number of articles related to each stock. We then calculated excess returns over the next year for each tertile. The averages for the sample period are shown in Figure 14.

Companies referenced in a large number of articles containing "artificial intelligence" and related keywords belong to the tertile with the highest number of articles, and companies included in the Nomura AI Companies 70 generally belong to this tertile. The tertile with the largest number of articles had the highest average excess returns and the tertile with the smallest number of articles tended to have the lowest average excess returns.

The larger the number of articles, the more the company's reputation and visibility improved via mass media coverage and the more interested investors became in the company and bought shares, and the more, on average, we think this could lead to higher share prices, even for relatively long investments of a year.

Fig. 14: Excess return averages by tertile based on number of article rankings



Note: Sample period is December 2001 through December 2016. Once a year the stock universe is divided into tertiles according to the number of articles for the past two years as of December (the number of articles for the most recent year is doubled) and after calculating excess returns for one year, the average of all years is taken. The universe is the top 98% of listed stocks in terms of market cap and the benchmark assumes all stocks in the universe are owned with an equal weighting. We did not take transaction costs into account. Analysis is based on historical share prices and does not guarantee future performance.

Source: Nomura, based on Nikkei Media Marketing data

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