

### Equally weighted index of robot-related stocks Investing in companies bringing about the robot revolution

#### Index overview and concept

The Nomura Robot Companies 70 is an equally weighted index made up of 70 stocks representative of companies that engage in robot-related business.

Stocks are selected using quantitative evaluation indicators based on article search results, from among Japanese listed companies (excluding financials) that have been covered in the media in connection with their robot-related businesses, as determined by scanning big data comprising articles and reports from online and TV news, newspapers, magazines, and the like. "Robot" and several related keywords selected with the use of AI are employed in the search for articles.

With robots as its investment theme, the index invests not only in companies that manufacture robots but also in companies that are actively using robots to pursue new businesses. The index mainly comprises companies in the electric appliances & precision instruments and IT & services, others sectors.

The Japanese government developed the New Robot Strategy and has been promoting technological development related to industrial and service robots and growth in these markets. Robots are viewed as a potential driver of growth as they play a key role in both AI (artificial intelligence) and the IoT (internet of things). The aim of the Nomura Robot Companies 70 is to facilitate investment in companies with robot-related businesses.

#### Global Markets Research

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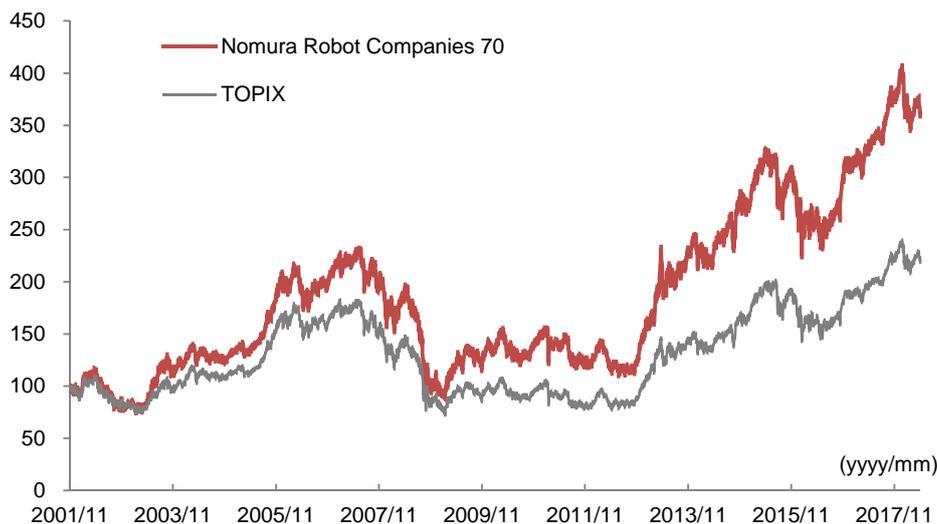
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Fig. 1: Nomura Robot Companies 70: index performance



Note: 30 November 2001 = 100. We did not take transaction costs into account. Analysis is based on historical share prices and does not guarantee future performance.

Source: Nomura

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# 1. Growth in robot-related business

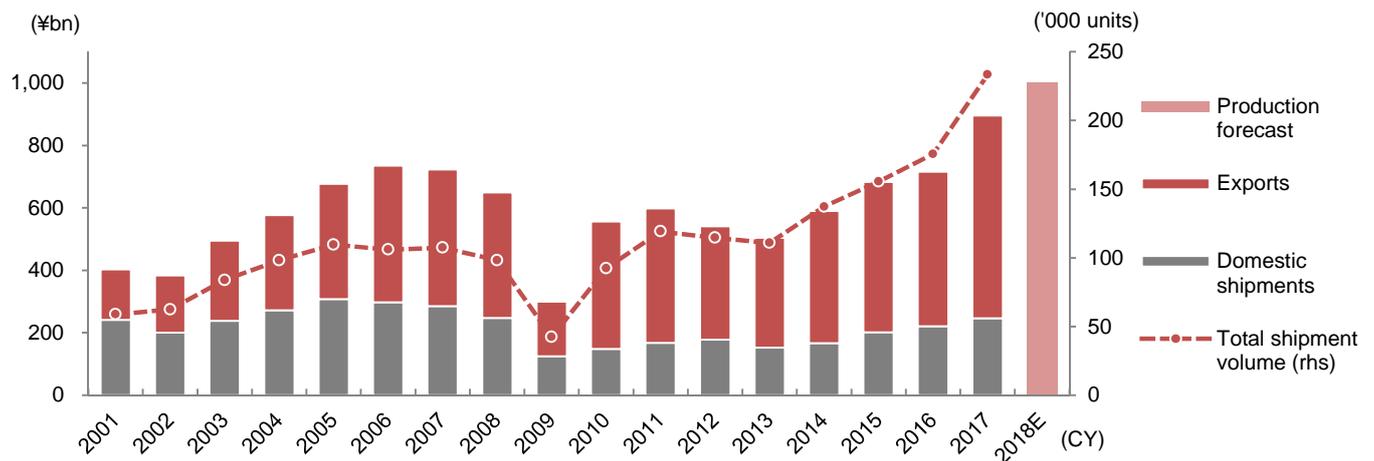
## Production of industrial robots has reached an all-time high

Demand for industrial robots used for factory automation and to save labor, by doing humans' jobs for them, has been growing around the world.

According to the Japan Robot Association (JARA), the value of both orders for and production of industrial robots at Japanese companies reached respective record highs in 2017. The reason for this growth is the rapid increase in Japanese exports of industrial robots to Asia, including China, where the Chinese government has been aggressively promoting automation as part of its state-sponsored "Made in China 2025 strategy". JARA expects the value of robot production by Japanese companies to reach ¥1trn in 2018.

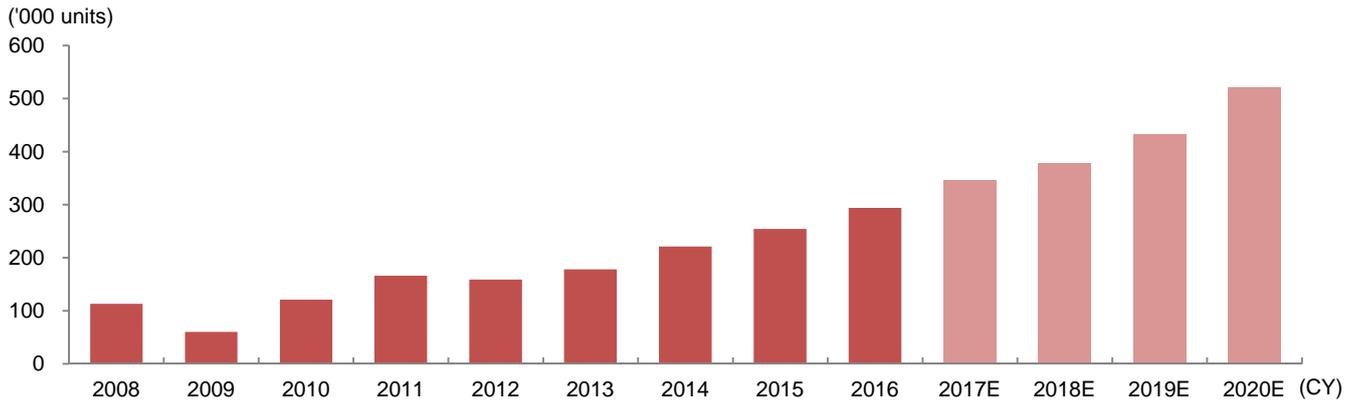
In addition, according to the International Federation of Robotics (IFR), global supply of industrial robots has grown for four straight years, with particularly strong growth in demand for robots in connection with electrical and electronic products. It also estimates average annual growth of 15% through 2020. More than 70% of industrial robots produced in Japan are exported, and these robots account for more than half of global industrial robot supply, by volume. We therefore expect the Japanese industrial robot production market to continue to grow.

**Fig. 2: Japanese robot shipment value/volume and 2018 production forecast**



Note: 2018 production forecast is based on Japan Robot Association data.

Source: Nomura, based on Japan Robot Association and *Nikkei Sangyo Shimbun* data

**Fig. 3: Global industrial robot supply forecasts**

Source: IFR World Robotics 2017

## Government measures aimed at promoting the robot revolution

The Japanese government created the New Robot Strategy in 2015, and has been putting in place measures aimed at realizing a "robot revolution" that will generate new value added, improve convenience, and create wealth, through the use of robots in a wide range of areas from the factory floor to everyday life. The government has also been implementing measures aimed at promoting the fourth industrial revolution<sup>1</sup> since 2016, and measures aimed at the realization of Society 5.0<sup>2</sup> since 2017. Because robots play an important role in both of these sets of measures, they have accounted for a large part of their respective budgets.

In order to realize the "robot revolution", as well as working to boost Japan's ability to create robots, government departments have also set specific strategic targets (key performance indicators) in the five areas of (a) manufacturing, (b) services, (c) long-term care and medical treatment, (d) infrastructure, disaster response, and construction, and (e) agriculture, forestry, fisheries, and food, with the aim of increasing the use of robots.

In manufacturing industries, most of the robots used are industrial robots. In this area, the government's main priority is to encourage the introduction of robots to increase automation in the assembly, processing, and preparation of components, and companies are also training up systems integrators to assist with this. In service industries, the government is encouraging the introduction of robots in the areas of logistics, wholesaling and retailing, and restaurants/hotels, and service robots that provide cleaning, security, and reception desk services, for example, are becoming an increasingly common sight.

In the area of long-term care, the government is promoting the use of robots to help people to walk (personal mobility suits) and to support body movements (power assist suits), while in the area of medical treatment it is encouraging the introduction of robots to assist with surgery. In infrastructure, disaster response, and construction, it is encouraging the use of robots mainly to increase efficiency by moving to unmanned or automated processes, while in agriculture, forestry, and fisheries, robots are increasingly being used to operate tractors automatically, and in the food industry they are being used to improve product quality, for example.

<sup>1</sup> The fourth industrial revolution is the fourth industrial revolution resulting from new technologies such as artificial intelligence (AI), the Internet of Things (IoT), and big data.

<sup>2</sup> Society 5.0 is a new kind of economy/society, following on from hunter-gatherer societies, agricultural societies, industrial societies, and information-based societies.

**Fig. 4: Steps taken in five key areas under the New Robot Strategy**

Manufacturing	Services	Long-term care/ medical treatment	Infrastructure/disaster response/construction	Agriculture/forestry/fisheries industries and food industry
<ul style="list-style-type: none"> <li>• Introduction of robots in labor-intensive areas such as component assembly and processing</li> <li>• Introduction of robots in preparation processes, etc (<b>manipulators</b>, electric <b>actuators</b>, etc)</li> <li>• Training of <b>systems integrators</b> to act as a link between users and manufacturers</li> <li>• Moving towards standardization of robot modules and creation of shared infrastructure (realization of <b>ubiquitous networks</b>)</li> </ul>	<ul style="list-style-type: none"> <li>• Introduction of robots in areas such as logistics, wholesaling and retailing, and restaurants/hotels, etc</li> <li>• Solving problem of labor shortages and improving productivity in service industries</li> <li>• Use of next-generation parts and technologies to automate reception desk services (use of <b>humanoid</b>-type robots, etc)</li> </ul>	<ul style="list-style-type: none"> <li>• Helping people to move from their beds (using <b>power assist suits</b> and <b>muscle suits</b>)</li> <li>• Helping people to walk (using <b>personal mobility suits</b>)</li> <li>• Toilet (excretion) support</li> <li>• Keeping an eye on people suffering from dementia</li> <li>• Bathing support</li> <li>• Increasing uptake of medical equipment such as surgical support robots</li> <li>• Faster assessment of new medical equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Dealing with labor shortages by using robots to save labor and automate processes on construction sites</li> <li>• Using robots to inspect infrastructure and improve the efficiency and sophistication of maintenance/management services</li> <li>• Use of disaster survey robots to speed up the damage assessment process</li> <li>• Full automation of work on landslide sites</li> </ul>	<ul style="list-style-type: none"> <li>• Achieving large-scale low-cost production through use of GPS autonomous driving systems, for example, in agricultural machinery such as tractors</li> <li>• Mechanization/automation of heavy labor through use of <b>assist suits</b> and weeding robots, for example</li> <li>• Saving labor and achieving high-quality production through high-spec environmental control systems and damage detection robots, for example, and big data analysis</li> </ul>

Note: Text highlighted in red indicates robot-related keywords (see later), while text in brackets has been added by the authors of this report.  
 Source: Nomura, based on Robot Revolution Realization Council's "New Robot Strategy", etc

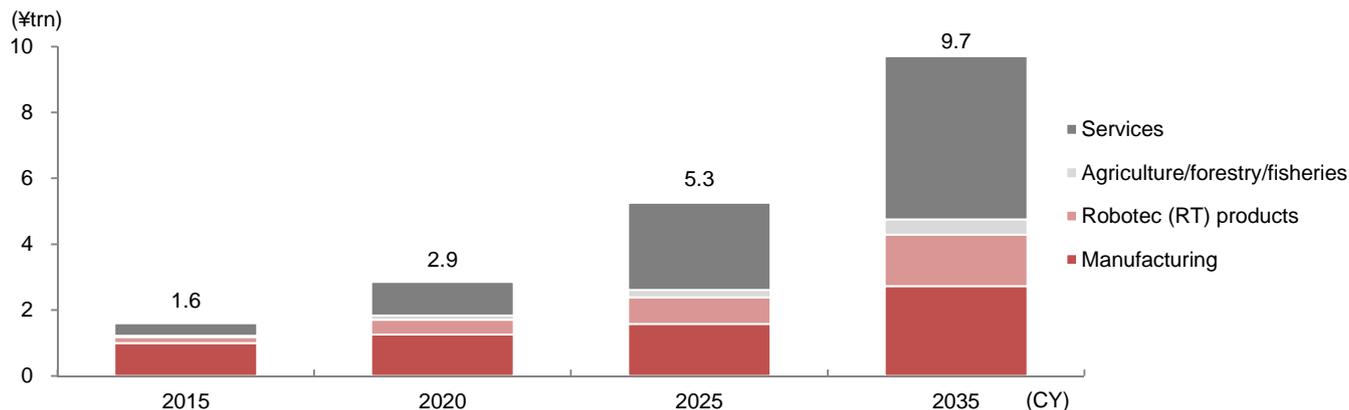
## Increase in robot-related businesses and breakdown of growth

Based on its estimates of domestic production volumes through 2035, METI and Japan's New Energy and Industrial Technology Development Organization (NEDO) forecast that the Japanese industrial robot market as a whole, including both industrial and service robots, will grow to ¥2.9trn in 2020 and ¥9.7trn in 2035 (Figure 5). It expects particularly rapid growth in services.

Figure 6 shows the average of the breakdowns of forecasts for different years for five areas in which the government is encouraging the introduction of robots, as discussed above. Industrial robots and robots related to automobiles and electrical machinery account for nearly half of the forecast market, but market growth is expected from the use of robots in the areas of consumer electronics/housing facilities/maintenance-related and logistics-related services, and long-term care/medical treatment and the agriculture/forestry/fisheries industries too.

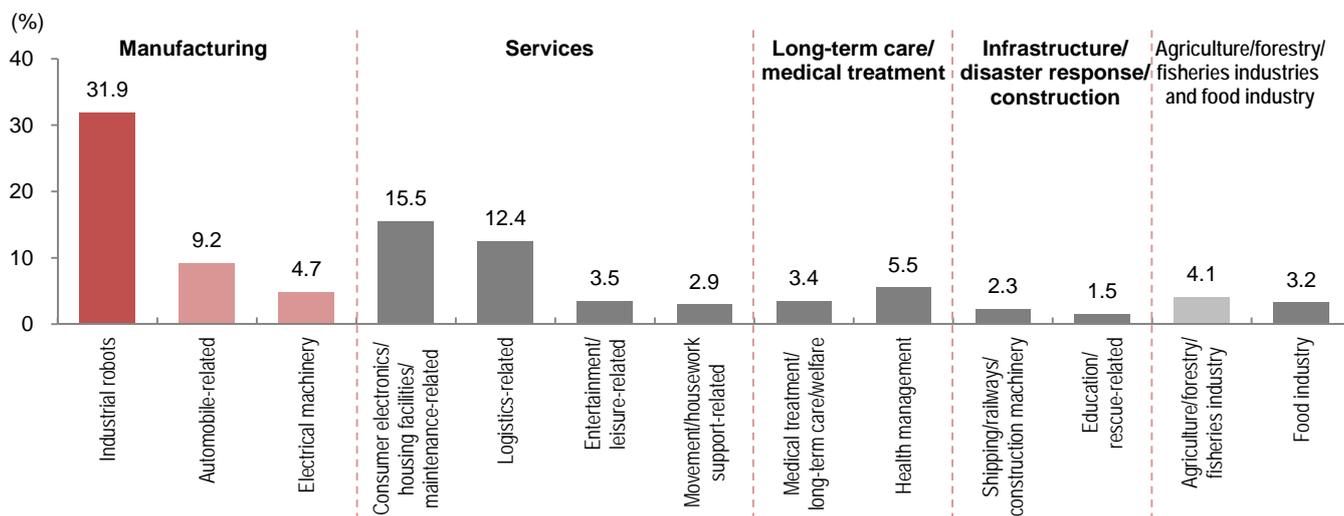
When considering investment in robot-related businesses, it might be possible to invest in companies that are likely to achieve growth as a result of expansion of the robot market by considering the allocation of funds not just to manufacturing industries but also to other industries that use robots.

**Fig. 5: Robot industry market size forecasts through 2035**



Source: Nomura, based on METI/New Energy and Industrial Technology Development Organization (NEDO) 2010 data

**Fig. 6: Breakdown of robot industry market forecasts, by area**



Note: Shows average breakdown, by area, of robot industry forecasts for 2015, 2020, 2025, and 2035.

Source: Nomura, based on METI/New Energy and Industrial Technology Development Organization (NEDO) 2010 data

## 2. Nomura Robot Companies 70 stock selection

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

The Nomura Robot Companies 70 is an equally weighted index made up of 70 stocks of companies covered by the media in connection with business related to robots. Financial sectors<sup>3</sup> are excluded from the index, however. It is a theme-specific index enabling focused investment in companies associated with robots, uptake of which has been proceeding apace in the manufacturing and service industries.

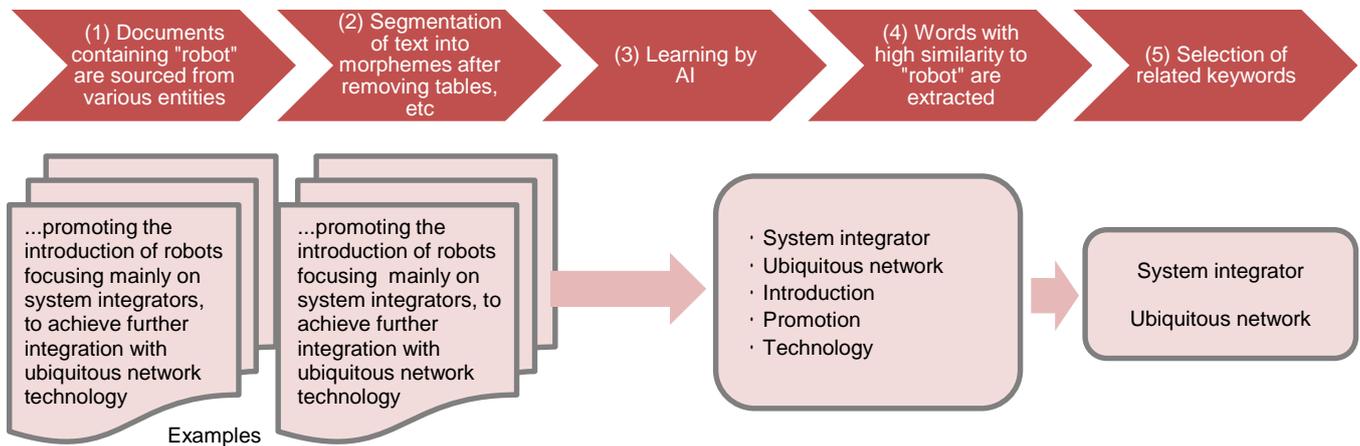
The stock selection process uses the results of searches for articles in online and TV news, newspapers, magazines, and other media. "Robot" and several related keywords selected with the use of AI are employed to search for articles.

### Related keywords are selected using AI

Robot-related keywords are selected for their similarity to the word "robot" based on analysis of text in documents related to robots that have been published by government offices and research organizations. As shown in Figure 7, first a broad net is cast to collect documents published by various entities that include the word "robot" 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 word "robot" can be extracted. Ultimately, words are selected that are suitable as keywords to search articles in which robot-related companies have been mentioned.

The first related keywords selected in 2017 are "robo," "system integrator," "muscle suit," "assist suit," "power assist," "humanoid," "manipulation," "ubiquitous network," "manipulator," "personal mobility," "actuator," and "robotics."<sup>4</sup>

Fig. 7: Extraction of keywords with high similarity to "robot" with the use of text analysis

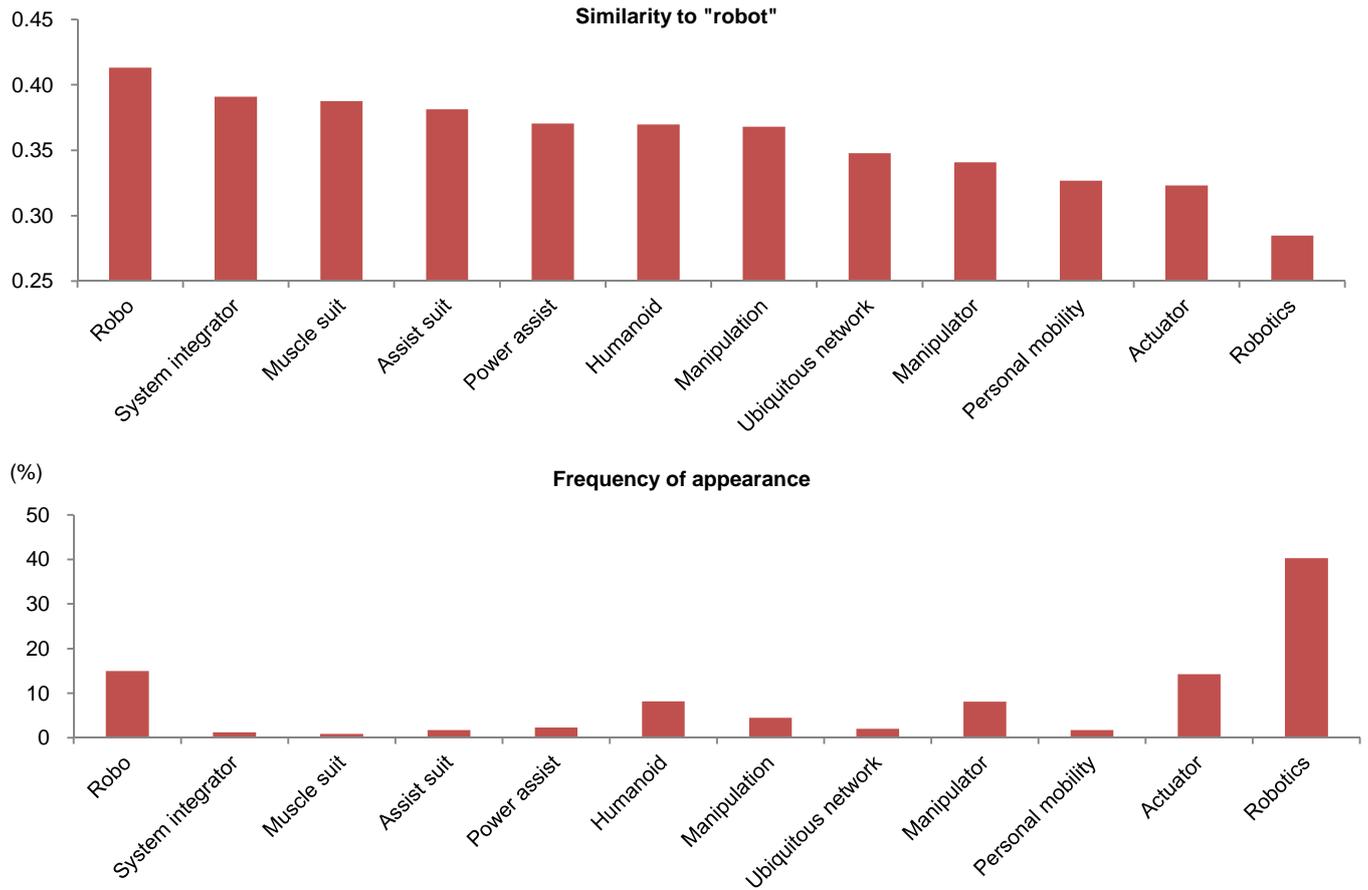


Source: Nomura

<sup>3</sup> "Financial sectors are stocks in the "banks", "securities and commodities futures", "insurance", and "other financing business" sectors (based on the Tokyo Stock Exchange's 33 sector classifications).

<sup>4</sup> Allowance is made for minor variations in how the Japanese equivalents of some of the terms written in katakana are spelled.

**Fig. 8: Quantitative indicators for related keywords**



Note: Shows data for April 2012 through December 2017.  
 Source: Nomura, based on government and think tank data

The similarity of each term is shown in the top portion of Figure 8. Similarity shows how close a word is to "robot"; the closer to 1, the greater the similarity. The word "robot" is in widespread use, and compared with more specialized terms, related keywords tend to show lower levels of similarity.

The lower part of Figure 8 breaks down the number of times the keywords were mentioned in documents containing "robot." "Robotics" and "robo" appeared most frequently, followed by "actuator" and "manipulator."

"Actuators" are devices that convert energy or electric signals into mechanical or physical motion. "Manipulators" are devices used to perform actions similar to those carried out by the human hand, and are also known as robotic arms. Both are used mainly in the manufacturing domain. "Humanoid" is used to describe an external appearance or movements similar to those of humans, and the term is used particularly frequently in the context of service robots. Although they occurred less frequently, the terms "muscle suit," "assist suit," and "power assist" have been in the spotlight in the logistics and long-term care fields, and there is a wide expectation that related devices will lessen the physical toll associated with, for example, lifting and lowering freight items, or helping a care receiver get out of bed.

## Stock selection using Nomura AI Thematic Stock Search (NAITS)

Figure 9 shows the flow of steps involved in selecting stocks. Here we give a simplified overview of the rules. Please refer to the [Nomura Robot Companies 70 index rulebook](#) for a more detailed description of the stock selection process.

Stocks for inclusion are selected from the score calculation universe of common stocks (excluding the financials sector) 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.

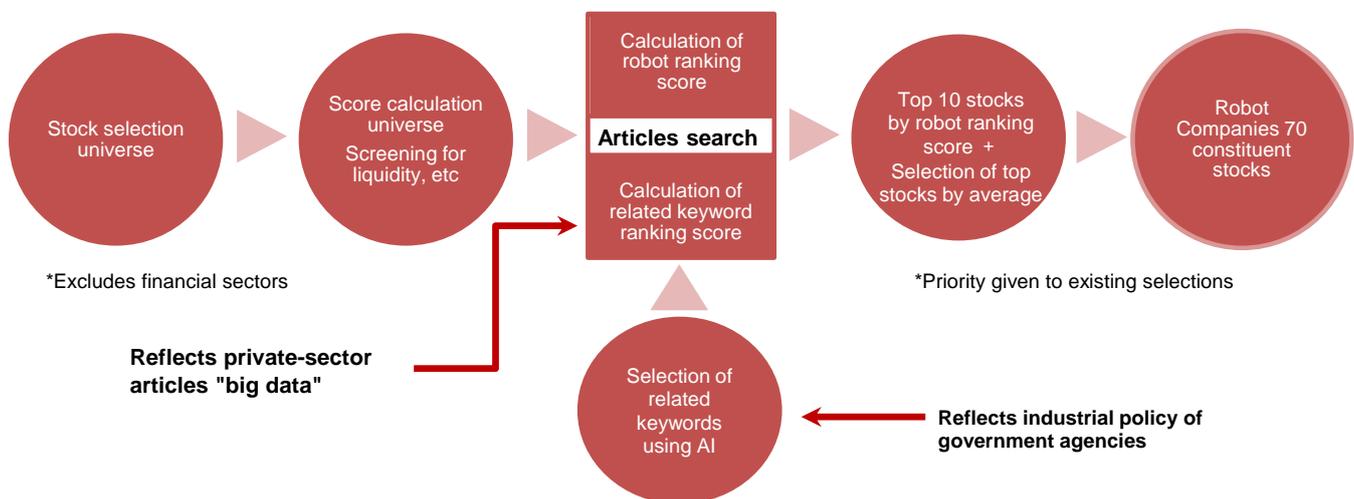
Online and TV news, newspapers, magazines, and other media are searched for the mention of stocks in the score calculation universe. "Robot" and several related keywords selected with the use of AI are employed to search for articles.

First, the robot 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 term "robot" is calculated for every stock once a year, and the total robot article score is obtained by doubling the figure for the most recent year. Each stock's ranking in terms of total article score is its robot ranking score, with rankings in ascending order starting with the stock with the highest number of articles.

Next, the number of articles containing the stock's ticker code and related keywords but not the term "robot" is calculated in the same way as for the robot 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.

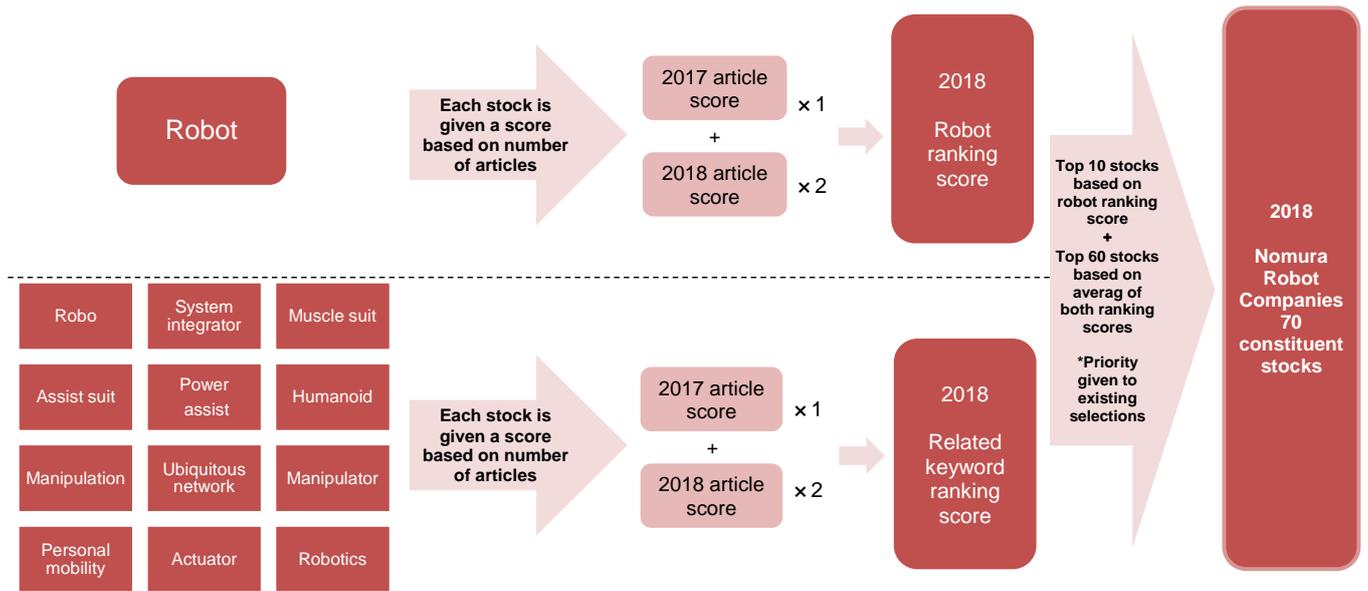
Finally, the top 10 stocks in terms of robot ranking score and the top 60 stocks in terms of the average of robot ranking score and keyword ranking score, ranked in ascending order, are selected as the constituent stocks of the Nomura Robot Companies 70.

**Fig. 9: Nomura Robot Companies 70 stock selection flow diagram**



Source: Nomura

**Fig. 10: Flow chart showing article search and stock selection for the Nomura Robot Companies 70 Index (2018)**



Source: Nomura

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

We call this stock selection methodology the Nomura AI Thematic Stock Search (NAITS). By using private sector article big data, while also reflecting government agencies' industrial policies, it is possible to select as investment targets companies that are attracting attention on many fronts.

Although "robot" is the investment theme in this report, thematic stock search can be used for other investment themes as well by searching articles with related keywords selected using AI. Yamanaka/Onishi (2017a, 2017b) describe stock selection carried out using AI and Abenomics as the investment themes. In Matsuura/Motomura/Fujita/Yamanaka/Onishi (2017a, 2017b, 2017c) stock selection was based on the investment themes of working practice reforms, healthy life expectancy, human resource investment, and education, and in Suimon/Yamanaka/Onishi (2017), stock selection was based on the investment theme of the fourth industrial revolution. For working practice reforms, a large proportion of stocks were in the electrical machinery and construction sectors, while for fourth industrial revolution, a large proportion of stocks selected came from the electrical machinery and information & communication sectors. Another advantage of this methodology is that it makes it possible to ascertain quantitatively and over time which companies and sectors see spillover effects of macro policy or important keywords.

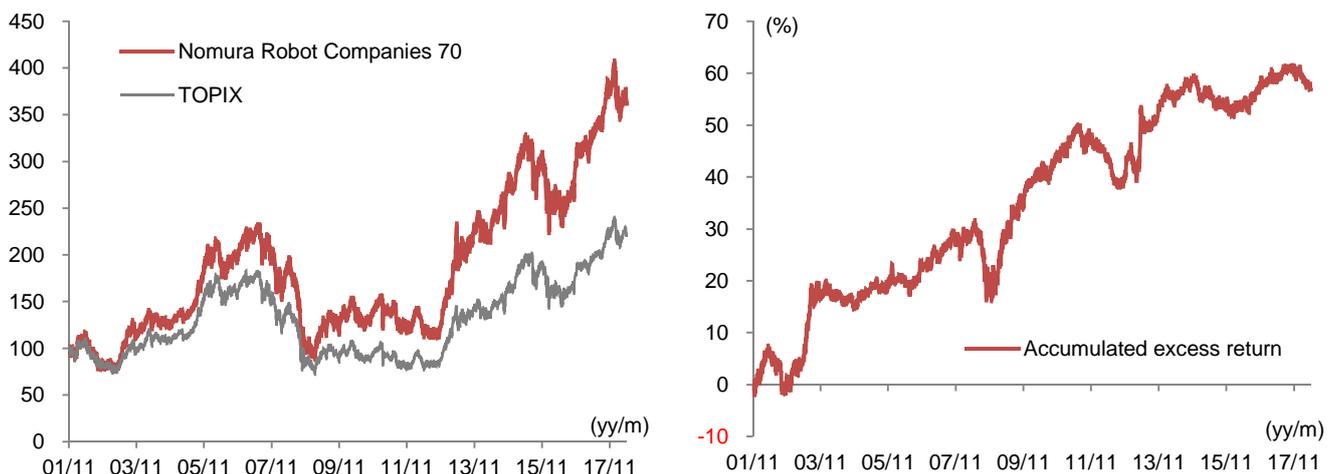
### 3. Nomura Robot Companies 70 performance and industry/style mix characteristics

#### Outperforming TOPIX

Figure 11 shows the performance of the Nomura Robot Companies 70. Since the base date for the index in 2001, the average annual return of the index has been 9.8%, and excess returns (versus the TOPIX) were 3.6%. Risk is slightly higher than for the benchmark and the beta average<sup>5</sup> was 1.05.

We think the high return was driven mainly by industry and size factors owing to investment at a set weight (1/70th each) in a cluster of robot-related stocks that were frequently mentioned in news reports, newspapers, and magazines. As we discuss later, the high sensitivity to overseas economies because of the high overseas export weighting for robots was also a factor behind high returns and high risk. 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, and that this contributed to strong performance.

Fig. 11: Index performance: Nomura Robot Companies 70



	Nomura Robot Companies 70	TOPIX
Average return (%)	9.84	6.33
Standard deviation (%)	20.00	17.36
Sharpe ratio	0.49	0.36
Maximum drawdown (%)	58.75	56.23
Excess return (%)	3.62	-
IR (information ratio)	0.63	-

Note: Shows data for November 2001 through May 2018. 30 November 2001 = 100. Annualized based on monthly results. Uses dividend-inclusive indices, does not take into account effects of dividend taxation. 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 various materials

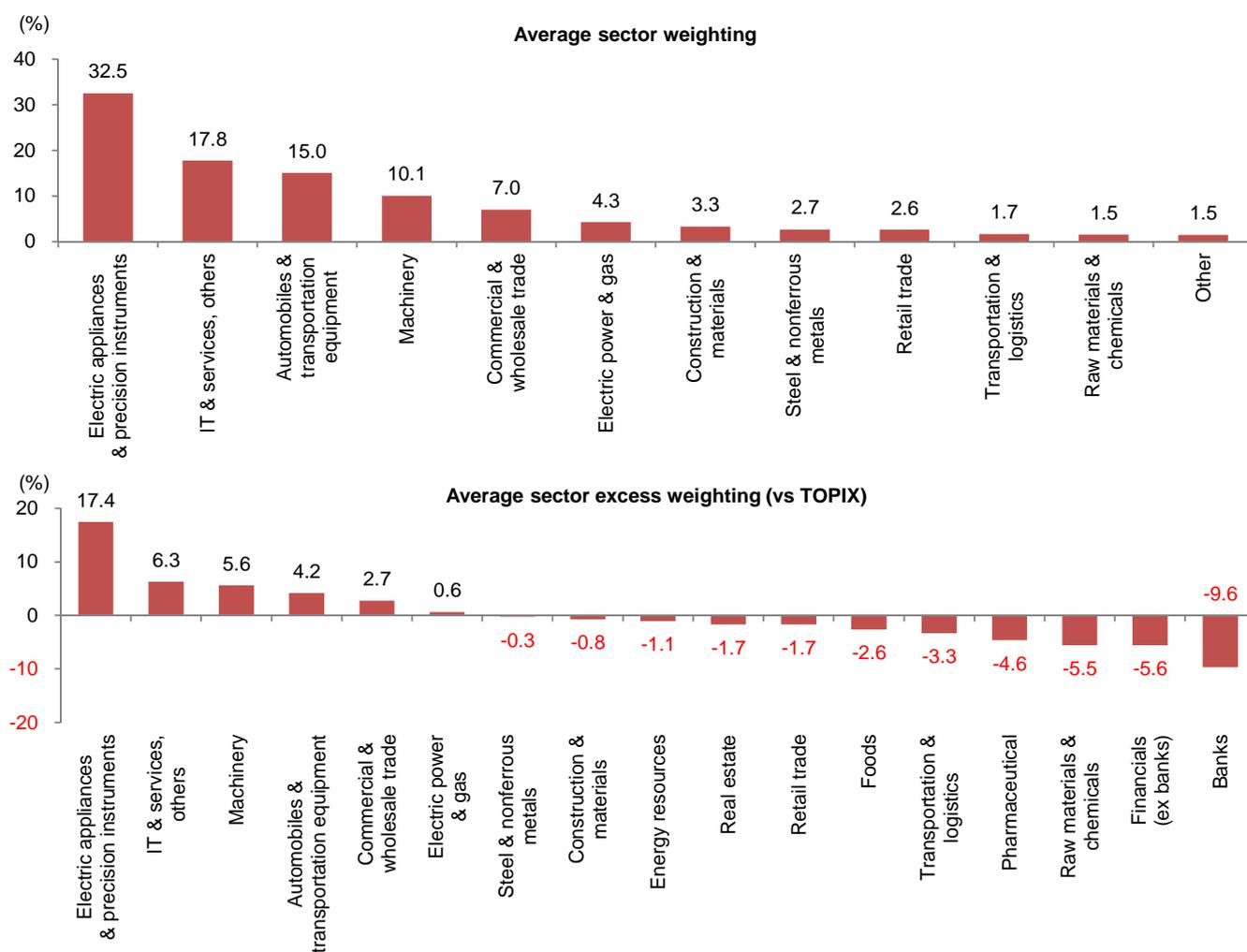
<sup>5</sup> Beta calculated from weekly data (past 104 weeks) for TOPIX dividend-inclusive share price index and Nomura Robot Companies 70 dividend inclusive share price index, showing the average for December 2003 through May 2018.

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

Figure 12 shows the average sector composition of the Nomura Robot Companies 70. The top chart shows average sector weights at the time of the periodic reconfigurations carried out from 2001 through 2017, based on TOPIX-17 Series sectors. The bottom chart shows the average excess weight for each sector in the index calculated by subtracting the industry weight for each year from its weight in the TOPIX.

As we are talking about robot-related stocks, the (excess) weighting of electric appliances & precision instruments, IT & services, others, automobiles & transportation equipment and machinery was quite large during this period, but the weighting of commercial & wholesale trade, where robots are mainly used in the services field, also exceeded that in the TOPIX. There were no constituent stocks in the pharmaceuticals and energy resources sectors in the past, and financial-related sectors were excluded based on the rules<sup>6</sup>, so these sectors were therefore underweight.

**Fig. 12: Average sector composition of Nomura Robot Companies 70**



Note: Shows average sector weights as of the periodic reconfiguration date (the first business day of December) each year from 2001 through 2017. Sectors based on TOPIX-17 sectors.

Source: Nomura, based on various sources

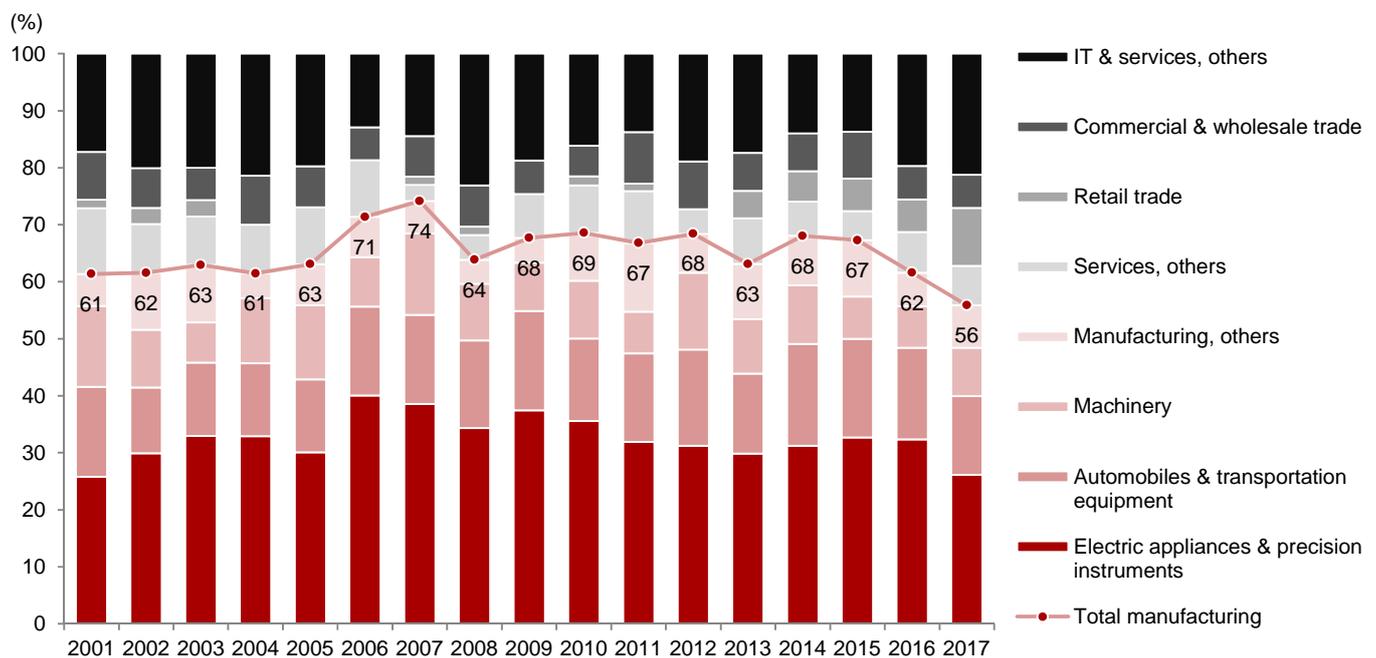
<sup>6</sup> With "robots" as the investment theme, even if financial sectors were not excluded based on the rules, the sector would have been underweight in the past as only a small proportion of financial sector stocks were selected for the theme by nature.

## Gradual increase in weighting of services-related sectors

Figure 13 shows the sector breakdown of the Nomura Robot Companies 70 index. The four types of red or pink shading indicate manufacturing-related sectors while the four types of black or grey shading mainly indicate services-related sectors. In the past, manufacturing-related sectors used to account for around 60% of robot-related sectors, but in recent years the percentage of services-related companies in the index has increased gradually, rising above 40% in 2017. The market forecasts issued by METI and NEDO that we referred to earlier indicate expectations for market growth in services-related areas, and we see this as a natural reflection of business expansion.

Recently, there has been a particularly sharp increase in the retail trade sector's weighting in the index. Retailers have been improving efficiency by using robots to manage their products and introducing unmanned outlets, for example, and they have also been introducing cleaning robots and humanoid-type reception robots. Companies operating service robot-related businesses have been attracting attention.

**Fig. 13: Sector composition of Nomura Robot Companies 70**



Note: Shows average sector weighting on periodic reconfiguration date (the first business day of December) every year. Sectors based on TOPIX-17 sectors. "Manufacturing, others" comprises the construction & materials, steel & nonferrous metals, and raw materials & chemicals sectors. "Services, others" comprises the transportation & logistics, electric power & gas, foods, and real estate sectors.

Source: Nomura

## Index is weighted towards small- and mid-cap stocks

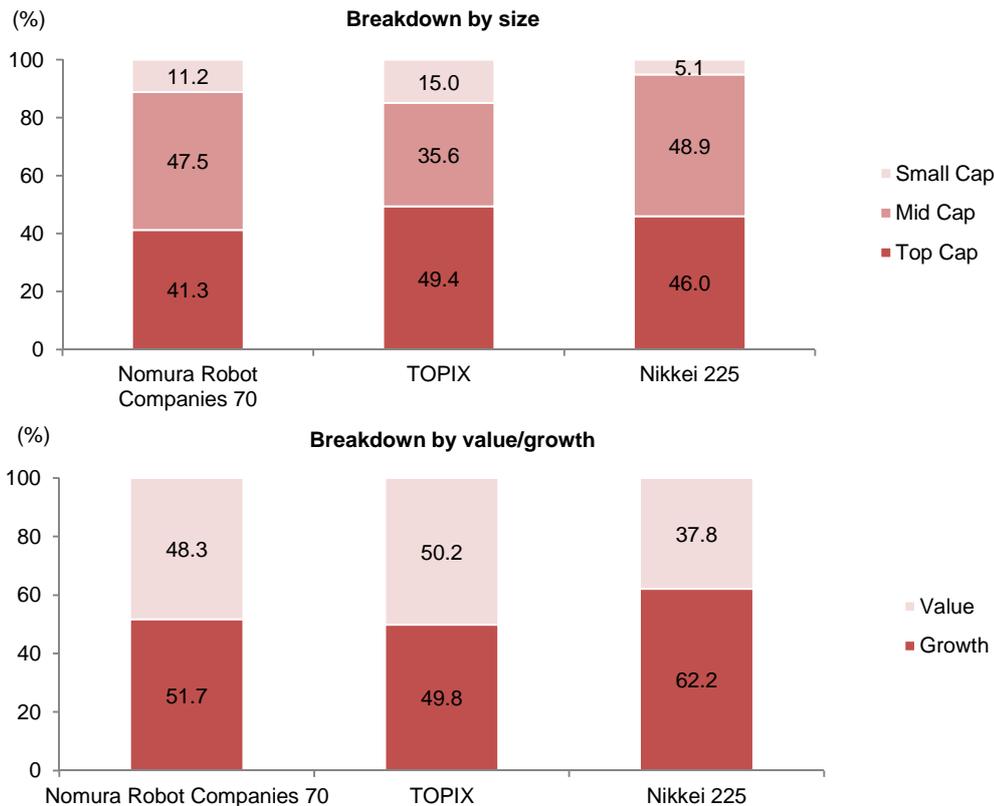
We then looked at the average composition of the Nomura Robot Companies 70 index in terms of style from 2001 through 2017 in order to investigate the style of the stocks making up the index.

As Figure 14 shows, compared to the TOPIX, the Nomura Robot Companies 70 index is weighted towards small-cap and mid-cap stocks. Over the period of our analysis, the average percentage of the Nomura Robot Companies 70 index accounted for by small-cap and mid-cap stocks was around 8ppt higher than the equivalent percentage in the TOPIX and around 5ppt higher than the equivalent percentage in the Nikkei 225.

Meanwhile, when we looked at the composition of the index in terms of value and growth, we found that, over the period of our analysis, the percentage of the Nomura Robot

Companies 70 index accounted for by growth stocks was on average around 2ppt higher than the equivalent percentage in the TOPIX, but this is not a large difference.

**Fig. 14: Composition of Nomura Robot Companies 70 by style**



Note: Analysis covers period from November 2001 through May 2018. We classified stocks of each index in terms of styles by Russell/Nomura Japan Equity Indexes and then calculating the total weighing for each style with use of each index composition. We then calculated the average of the monthly figures, for each style.

Source: Nomura

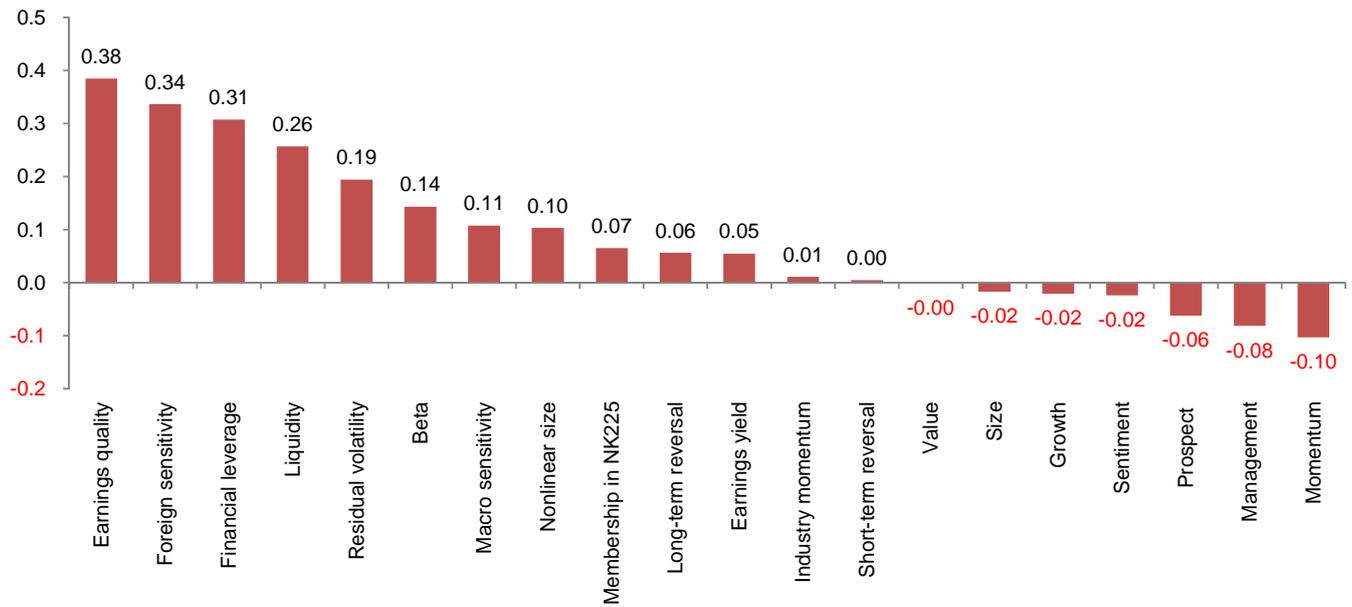
## High exposure to earnings quality, sensitivity to overseas economy

In order to identify the source of returns (risk factors) for the Nomura Robot Companies 70, we looked at average excess factor exposure (versus TOPIX) in the period from 2001 through 2017.

With exposure to earnings quality and sensitivity to the overseas economy particularly high, we can see that a large proportion of investment was into companies where cash income accounted for a large proportion of profits and companies with a high weighting of overseas sales and high forex sensitivity. As we noted at the beginning of this report, the overseas export ratio is generally high for Japan's industrial robots, and we need to be aware of the relatively large overseas economy-related risk for these companies that are constituent stocks of the Nomura Robot Companies 70, but we also think that they were the source of high returns when economic conditions were good in the past.

Size nonlinearity excess exposure is positive, consistent with mid caps accounting for a large proportion of stock holdings, but the impact was small compared to other risk factors.

**Fig. 15: Nomura Robot Companies 70 excess factor exposure (vs TOPIX)**



Note: Sample period is 2001-17. Shows average exposure on periodic reconfiguration date (the first business day of December) every year.  
 Source: Nomura, based on MSCI Barra

## Reference materials

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# Appendix A-1

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As at 31 March 2018.

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