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近藤, 章夫 / KONDO, Akio

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Akio KONDO

1. The Background of the Branch Plant Economy

This paper draws on a case study to examine whether efforts to create new innovations will lead to future growth in a regional economy that specializes in manufacturing. The local economy in Japan grew through the decentralization of manufacturing industries from the second half of Japan's rapid economic growth to the early 1980s¹⁾. The biggest driving force of this growth was the electrical and electronics industry with its numerous labor-intensive sectors, and the development of bases for mass production and assembly by companies in multiple locations. Consequently, large and small regional agglomerations were formed all over the country, which affected not only the local labor market but also the regional development of rural areas.

In a regional economy that has undergone decentralized industrialization,

1) According to the Census of Manufacture, the three major metropolitan areas (Tokyo, Osaka, and Nagoya) accounted for 90.7% of value of manufactured goods shipments in 1970, while the other regional areas accounted for only 9.3%. By 1985, the rate in the three major metropolitan areas had fallen to 78.6%, while the rate in other regional areas had risen to 21.4%. In terms of the number of persons employed, other regional areas accounted for 28.8% of the total number of persons employed in 1985, compared to 16.0% in 1970.

an important perspective is the relationship between the location unit and region. The location unit is a concept that considers the organizational characteristics of establishments in multi-site enterprises. The locational hierarchy is one of the characteristics of the electrical and electronics industries. In the locational hierarchy of electrical and electronic companies, plants in each region were systematically linked by the division of labor on both products and processes²⁾. A national production system was formed by integrating affiliated companies, group companies, and subcontractors, which can be seen as an intra-regional division of labor (Kondo, 2017). In other words, the electrical and electronic factories supporting the local economy was positioned as part of the national production system and, since the 1990s, the global production system as well. For this reason, when considering the spillover effects of a factory's location in a rural area, it is essential to consider not only its size and the products it produces, but also its organizational location and function in the production system.

With regard to the organizational hierarchy of the location unit, the contrast between the mother factory and the branch plant has garnered attention. A mother factory is a factory that has important functions such as product design and development, prototyping, and preparation for mass production, and can also provide technical support and deployment to other production factories, such as a branch plant, which is less independent and lacks decision-making power (indirect departments) in sections related to business strategy, investment, and procurement functions. Accordingly, the branch plant economy has been regarded as problematic due to its

2) For the location development of electrical and electronics firms and the formation process of inter-regional division of labor, see Kondo (2007).

limited ability to adapt to changes in the economic environment and for endogenous innovation (Watts, 1981). The reasons for this can be summarized as follows (Miyamoto et al., 1990). (1) The lack of an intra-regional decision-making function and external control limits the intra-regional reinvestment of profits. As a result, the spillover effect is decreased. (2) As it is a regional division of labor within the enterprise, even if there are close links with other regions, developing intra-regional trade links and intra-regional circulation is difficult. (3) Since branch factories often have low-skill, low-wage workplaces and lack knowledge-based workplaces to facilitate research and development, the effect of technology transfer is minimal and the region's ability to create innovation is low.

While this phenomenon was originally observed in the UK in the 1970s, similar cases have been observed in Japan³⁾. In the context of regional development, the issue of exogenous development has been raised, and it has been clarified that the transformation to an endogenous regional economy is challenging due to the constraints of intra-regional linkages and spillover effects. However, it has also been confirmed that there are differences in the stereotypical understanding of the branch plant economy, including but notwithstanding, the sophistication of functions associated with the expansion of factory size, changes in the positioning of factories

3) For the overview of branch plant economy and the trends in UK, Massey (1995) is a useful reference. Phelps (1992) discusses the new development of the branch plant economy in southeast England by combining regional as well as spatially dispersed networks to adapt to flexible production systems. Potter (1995) and Pike (1998) show that England's branch plant economy has a flexible linkage structure and discussed the possibility of linking it to endogenous regional development. In Japan, Yamamoto (1992) discusses the potential for the development of branch plants in Yamagata Prefecture. However, Fujikawa (2001) points out the weakness of the spillover effect in regional agglomerations with branch plants as the main component.

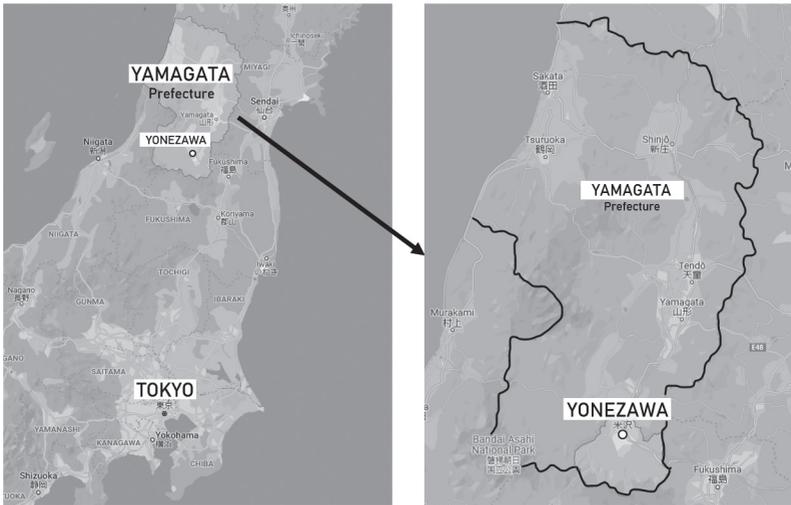
associated with the reorganization of corporate organizations, and the formation of new trade linkages through industry-academia cooperation. Against this backdrop, this paper examines the Yonezawa region of Yamagata Prefecture and discusses the shift from external development through the entry of the electrical and electronics industries to internal development through local innovation, as well as the development potential and challenges of a branch plant economy region⁴⁾.

2. Outline of the Yonezawa Region

The city of Yonezawa in Yamagata Prefecture is located on the border of Fukushima Prefecture in the southernmost part of Yamagata Prefecture (Figure1). The city covers an area of 548.74 km² and the center of the city lies in the Yonezawa Basin at the foot of the Azuma mountain range. Originally a castle town where the Uesugi clan served as successive feudal lords, Yonezawa became a city in 1889 together with Yamagata City to form the capital of Yamagata Prefecture. It was one of the first 39 cities in Japan to become a city. With its history as a castle town, Yonezawa has served as a significant transportation hub since the days of the feudal government. Even today, it is located at the nexus of National Route 13, a major north-south artery running through Yamagata Prefecture between Akita City and Fukushima City, National Route 121 running through the Aizu region of Fukushima Prefecture between Yonezawa City and Mashiko Town in Tochigi Prefecture, as well as National Route 287 leading to Nagai. In terms of railways, the Ou Main Line was established in 1899, ten years after the city was founded. In 1992, the Yamagata Shinkansen was

4) This study is based on Kondo (2014), but this paper is revised with all new figures and tables.

Figure 1. Location of Yonezawa Region, Yamagata Prefecture



Source: Google Map

established as a mini-shinkansen, running directly from Fukushima Station to Yamagata Station via Yonezawa Station, connecting Yonezawa to Tokyo within three hours.

Yamagata Prefecture is roughly divided into the Murayama region, centered on Yamagata City, the Shonai region on the Sea of Japan side, where Sakata City and Tsuruoka City are located; the Mogami region, which stretches along the middle reaches of the Mogami River, and the Okitama region, centered on Yonezawa City. The Okitama region consists of Yonezawa, Nanyo, Nagai, Takahata, Kawanishi, Oguni, Shirataka, and Iide. The total population of the Okitama region is 226,989 (2010 census), second only to the Murayama region (560,000), and the Shonai region (300,000). In terms of urban employment areas, the Okitama area is divided into the Yonezawa urban area (140,000), Nagai urban area (60,000), and

Nanyo urban area (30,000). The Yonezawa urban area comprises Yonezawa City, Kawanishi Town, and Takahata Town, which consists of Nagai City, Oguni Town, Shirataka Town, and Iide Town, while the Nanyo Urban Area is composed only of Nanyo City.

The population of Yonezawa, similar to that of various regional cities, has been declining, with 89,401 people counted in the 2010 census, although the population had remained fairly stable for the previous 40 years. However, this changed in 2000, when it decreased by approximately 6,000 people in 2010 compared to 2000, a decrease of approximately 6% over the previous ten years (Table 2). Similarly, the population structure reflects a decrease of approximately 6% over the last ten years. An analysis of the population structure indicates that the juvenile population (Below 15 years) and the working-age population have been decreasing since their peak in 1970, whereas the proportion of the elderly population (aged 65 and over) has been increasing. In 2010, the proportion of elderly people in the prefecture exceeded 25%, which is higher than the national average, indicating that the population is declining and aging. Yonezawa is the fourth largest city in the prefecture in terms of population size, after Yamagata City (250,000), Tsuruoka City (130,000), and Sakata City (110,000).

Table 1 Yonezawa's Demographic Trends

	1960	1970	1980	1990	2000	2010
Below 15 years population	28,555	21,683	19,915	16,952	14,139	11,577
Working age population	63,263	63,751	62,817	63,215	61,233	54,346
Above 65 years population	5,173	7,330	10,091	14,591	20,022	22,898
Total Population	96,991	92,764	92,823	94,760	95,396	89,401
Below 15 years (%)	29.4	23.4	21.5	17.9	14.8	13.0
Working age (%)	65.2	68.7	67.7	66.7	64.2	61.2
Above 65 years (%)	5.3	7.9	10.9	15.4	21.0	25.8
Sum	100.0	100.0	100.0	100.0	100.0	100.0

Source: National Census

3. A Brief History of Industrial Structure in Yonezawa Region

In Yonezawa region, textiles have long been a major industry. In 1767, the 10th lord of the Yonezawa domain, Uesugi Harunori (Takayama after retiring), introduced silk weaving from Ojiya to Echigo (Niigata Prefecture), which was an advanced area at that time, as a measure to promote industry and rebuild the domain's finances. Yonezawa's textile industry, known as "rice weaving," was characterized by yarn dyeing using natural dyes from plants and trees, also gave rise to many related processes such as silk production, design, dyeing, and weaving. Following a period of high economic growth, the demand for small widths, an industry mainstay, decreased due to the influx of cheap imports, ultimately leading to the gradual decline of the industry. In response to the Westernization of clothing, wide widths have been the mainstay of the industry since the 1980s; however, the decline has since become more prominent.

In place of the textile industry, the machinery industry, particularly the electrical and electronics industry, has transpired into a major industry in the Yonezawa area since the late 1970s. This change in industrial structure is attributable to the growth of factories in the rural areas, as well as the creation of industrial parks throughout the country as part of industrial decentralization policy; thereby actively attracting companies to the area. More specifically, the Yonezawa-Hachimanbara Industrial Park was the first core industrial park in Japan to be created by the Japan Regional Development Corporation (now the Organization for Small & Medium Enterprises and Regional Innovation, JAPAN) under the Industrial Relocation Promotion Act, while three agro-industrial parks were created in Yonezawa Minami, Kubota and Higashi-matsubara. In these inland industrial parks, many major electrical and electronic manufacturers from

Tokyo set up their affiliated companies. As a result, a branch plant economy of the electrical and electronic industries was formed, which has since supported the economy of the Yonezawa region.

In the 1980s, the Yonezawa Electric Industry Association and the Yonezawa Electronic Equipment and Machinery Industry Promotion Council were established to promote interactions between local companies that had developed from sparse factories and companies that were attracted from outside the region. This multi-layered network of private companies began to attract national attention. In the 1990s, the number of employees in the region began to decline along with the decline in domestic production caused by the overseas expansion of the electrical and electronics industries. In the midst of this situation, the Yonezawa region, led by Junji Kido of Yamagata University's Faculty of Engineering, came to national prominence for its research and development on OLEDs. By the 2000s, it had evolved into the focal point of Yamagata Prefecture's "OLED Valley" Plan. As a pioneering example of regional innovation, the Yonezawa region is actively engaged in industry-government-academia collaboration for the practical application of next-generation technologies and is backed by the regional concentration of the electrical and electronics industries.

4. From External Development to Internal Development

4.1 Changes in the Composition of Regional industries and the Current Situation

Looking at the population by industry in Yonezawa, the weight of the secondary industry is higher than that of the whole country, and the regional economy is centered on the manufacturing industry. However, the decline in the number of workers in the secondary sector was

particularly large, from 23,069 in 2000 to 16,952 in 2010, a decrease of approximately 26.5% over the last ten years. Looking at the ratio of population by industry, the ratio of the secondary industry exceeded 40% in 1980 and reached 44.2% in 1990, but after peaking there, it has decreased to 36.2% in the following 20 years.

The industrial transition of Yonezawa City according to the industrial statistics table is shown in Table 2. The number of business establishments peaked at 614 in 1971, while the number of employees increased up until

Table 2 Changes of Manufacturing Industries in Yonezawa Region

	1960	1971	1980	1990	2000	2010	
Number of establishments	Food and Beverages	34	45	52	51	41	39
	Textile products	441	385	280	203	123	69
	Lumber and wood products	63	74	62	41	29	23
	Chemical	0	3	5	22	23	16
	Fabricated metal products	9	17	24	32	28	31
	General-purpose machinery	18	12	32	36	51	42
	Electrical and Electronics	3	26	62	93	67	34
	Transportation equipment	0	4	2	5	4	3
	Others	34	48	63	66	44	30
	Total	602	614	582	549	410	287
Number of persons employed	Food and Beverages	582	707	729	797	719	799
	Textile products	8,390	6,131	4,406	3,631	1,992	1,214
	Lumber and wood products	766	1,163	1,025	873	619	385
	Chemical	6	0	50	670	584	623
	Fabricated metal products	438	240	362	811	837	1,293
	General-purpose machinery	679	812	1,018	1,338	1,872	1,945
	Electrical and Electronics	784	2,425	4,177	8,011	6,748	5,433
	Transportation equipment	0	68	0	67	57	45
	Others	1,124	2,591	1,860	1,425	1,376	1,187
	Total	12,769	14,137	13,627	17,623	14,804	12,924
Value of manufactured goods shipments(million yen)	Food and Beverages	1,462	3,289	6,775	10,260	11,728	14,849
	Textile products	5,497	16,500	29,509	33,163	20,868	10,631
	Lumber and wood products	465	4,048	10,294	12,838	10,029	6,177
	Chemical	2	0	212	16,983	18,876	13,435
	Fabricated metal products	365	498	4,594	13,404	16,725	44,717
	General-purpose machinery	475	1,570	7,353	25,297	42,770	35,196
	Electrical and Electronics	717	10,625	57,518	243,533	500,004	639,533
	Transportation equipment	0	79	0	741	665	483
	Others	913	6,955	18,249	17,143	40,086	54,914
	Total	9,895	43,564	134,503	373,362	661,750	819,935

Source: Census of Manufacture

1990 before slowly decreasing. However, the value of shipments of manufactured goods has been steadily increasing and reached approximately 820 billion yen in 2010. Considering the number of establishments and employees, it is reasonable to surmise that the number of employees per establishment and the size of manufactured product shipments have increased, and that the regional “oligopoly” of a few major electrical and electronic manufacturers in the local economy has occurred.

Regarding the specialization coefficients for the Okitama area (Yonezawa City, Nagai City, Nanyo City, Takahata Town, Kawanishi Town, Oguni Town, Shirataka Town, and Iide Town), the information and communications machinery and equipment manufacturing industry has the highest specialization coefficient at 4.59, followed by electronic components and device manufacturing at 4.58, non-ferrous metal manufacturing at 4.27, and electrical machinery and equipment manufacturing at 3.5. The specialization coefficient of the electrical machinery and electronics industry supporting the region is high. In addition, the textile industry, which was once a major industry, still has a specialization coefficient above three, indicating that the textile industry in Yonezawa has a continuing history and the industries of the Yonezawa region are based on a tradition of manufacturing. This demonstrates that the industries in the Yonezawa region are founded on a manufacturing tradition. Observing Yonezawa’s industry by sector indicates that the manufacture of electrical machinery and equipment is dominant, and that the growth in manufactured goods shipments since 1980 can be attributed to the introduction of electrical machinery when several major electrical and electronic manufacturers started expanding the scale of production.

4.2 Industrial Parks and Location of Major Firms

The center of industry in Yonezawa is the Yonezawa Hachimanbara Core Industrial Park, which has been in the market since 1978 and is ranked first in Yamagata Prefecture and fourth in Tohoku in terms of the value of manufactured goods shipped by industrial parks. The total area of the industrial park is 384 ha, of which 153 ha are occupied by factories. Major companies with more than 200 employees include Tohoku Pioneer Corporation, SUMCO Corporation, Saxa Techno Corporation (formerly Tamura Electric), AGC Display Glass Yonezawa Corporation (a wholly owned subsidiary of Asahi Glass), Yonezawa Electric Wire Corporation (a foreign company involved in semiconductors), and NEC Corporation (a wholly owned subsidiary of NEC). (foreign capital related to semiconductors) and others.

Another industrial park is the “Yonezawa Office Arcadia,” which has sold 10 of its 42 districts as of 2013. However, in the Office Arcadia project, which aims to improve the functioning of regional cities across Japan, conspicuous vacant plots are not limited only to the Yonezawa area, suggesting that the concentration of knowledge work in regional cities is not progressing.

In the electrical and electronics industry in the Yonezawa area, the influence of the local “Big 6” companies was significant. These were Yonezawa Electric Wire, Tamura Electric (now Saxa Techno), NEC Yonezawa (now NEC Personal Products and NEC Embedded Products), Meiden Telecom (now Siward Technology), Hitachi Yonezawa (Renesas Northern Japan Semiconductor Yonezawa Plant), and Tohoku Pioneer. As can be seen from the name change of these six companies, the investment relationship has changed since the 1990s due to the deteriorating

performance and restructuring of the parent company. In addition to these six companies, several of the “large companies” located in the region were branch plants with their headquarters and administrative functions located outside the region, and the spillover effects on subsidiaries and subcontractors, as well as the development of inter-firm relations within the region were limited⁵⁾. In the Yonezawa region, where such a branch plant economy is a basic characteristic, the OLED Valley concept has attracted attention since the beginning of the 2000s as a movement aiming for a breakthrough in the development of next-generation industries based on OLED technology.

4.3 The OLED Valley Concept and the Yonezawa Model

In 2003, Yamagata Prefecture launched the “OLED Valley Initiative”⁶⁾. The catalyst for the OLED Valley Initiative was the development of the world’s first OLED white lighting by Professor Junji Kido and his colleagues at Yamagata University’s Faculty of Engineering. The prefectural government subsidized the Organic Electronics Research Institute, which was established in Yonezawa City where Yamagata University’s Faculty of Engineering is located, with a grant of approximately 5 billion yen over a seven-year period from November 2003 to March 2010. Even though the Organic Electronics Research Institute has played a major role in the research and development of elemental technologies, there were still calls

5) For example, NEC Yamagata (now Renesas Yamagata Semiconductor), also in Yamagata Prefecture, expanded in 1964 and was the first NEC plant to do so. NEC is representative of the intra-regional division of labor model, and many of these “local NECs” companies specialize in manufacturing subsidiaries to take advantage of low-cost labor. There are also branch plants and satellite factories of “local NECs” in the vicinity, and a group of NEC-affiliated cooperative factories were also found in the Yonezawa region.

6) Nozawa (2012) provides a detailed summary of the history of industry-government-academia collaboration and the challenges of regional innovation, with a focus on OLEDs.

from local industries for Yamagata Prefecture to provide support up to the point of practical application. Later in April 2013, it was reorganized as the Organic Electronics Innovation Promotion Center within the Yonezawa Office Arcadia to strengthen cooperation with Yamagata University.

In the Yonezawa region, the network of private companies, including the Yonezawa Electric Industry Association, is more multilayered than in other regions; after the establishment of the Organic Electronics Research Institute, it functioned as an effective intermediary for industry-academia-government collaboration, particularly with the Faculty of Engineering at Yamagata University. For example, in May 2008, Lumiotec was established with investment from Mitsubishi Heavy Industries, ROHM, Toppan Printing, and other companies that had been conducting joint research with the aim of commercializing the research results of the Organic Electronics Laboratory⁷⁾. In June 2009, Prof. Kido and a local company, Takahata Electronics, established a university-launched venture company, Organic Lighting, to establish the Yonezawa Model, which promotes the development and production of elemental technologies for OLED lighting in the region. As of 2013, there were 85 members, 75 from within the prefecture and 40% from the Okitama area, and there are high expectations for OLEDs in the region. The OLED lighting market has not yet been fully developed, and most companies, including Tohoku Pioneer, which has been producing OLED panels for car audio since 1997, as well as Lumiotec and

7) Lumiotec's capital was 1.4 billion yen at the time of its establishment (including 700 million yen in capital reserves), but it has continued to increase its capital every year in order to become debt-free, reaching 3.17 billion yen (6.35 billion yen in capital) as of February 2013. The company has five shareholders: Mitsubishi Heavy Industries (51%), Rohm (34%), Toppan Printing (9%), Mitsui (5%), and Junji Kido (less than 1%). The average age of the company's employees is 42, consisting of 42 males and 13 females. 26 employees are hired locally, and although the company's workforce is small, it is one of the reasons why the company is expected to actively recruit locally.

OLED Lighting, have yet to make sufficient profits. In such a budding market, the medium- to long-term effects of public support from the government and prefectures are significant.

Among the industry-academia-government initiatives for the commercialization of OLEDs, Lumiotec has attracted particular attention. This could be attributable to the fact that it is a local venture formed on the basis of local research and development. Moreover, it is the world's first company specializing in OLED lighting¹⁰). The "EL" in OLED stands for electroluminescence, a substance (luminous material) or structure that glows when an electric current is passed through it. Compared to LEDs, OLED lighting is a surface light source (LEDs are a point light source); therefore, it generates less heat and does not flicker like fluorescent lighting. They also have high color rendering properties, as they are close to the spectrum of sunlight, making them easy on the eyes.

The first feature of the Lumiotec system is the cross-industrial collaboration that leverages the strengths of the four main companies. Mitsubishi Heavy Industries will provide manufacturing equipment using the high-efficiency continuous vacuum deposition technology developed at its Hiroshima plant, which will develop devices using its OLED device manufacturing technology that is suitable for lighting. Toppan Printing will finish the panels after deposition using its advanced light extraction technology, while Mitsui will provide marketing support. The core of the system is a large, highly efficient, high-speed linear evaporation source in-line deposition system with an annual production capacity of 60,000 units (equivalent to a 150 mm square panel) in an 8-hour operation. The device structure uses the multi photon emission (MPE) method to achieve both high brightness and long lifespan. MPE patents have been applied for and registered in the following countries and regions: Japan, Europe, the USA,

Korea, Taiwan, and China.

However, OLED lighting applications are still limited to a few regions and have not yet reached a sufficient scale for regional innovation. The challenge is the cost of production, which is approximately ten times more expensive than LEDs. The demand is still low and market expansion is still awaited. The ripple effect of production activities in this region is also limited. Nonetheless, the entry of Lumiotec, a company symbolic of the “OLED Valley Concept” and the “Yonezawa Model,” has had a significant “emergent” effect on companies in the region. For example, the movement of local inns, organizations, and companies to introduce OLED lighting without regarding cost was largely inspired by Lumiotec’s hard work. Thus, industry-academia-government collaboration has the potential to have a significant ripple effect in the medium to long term by involving the local community.

5. Prospects and Challenges for the Regional Economies

Yonezawa’s specialties are sometimes referred to as the “ABCs”: A stands for Fuji apples from Tateyama; B stands for Yonezawa beef, one of Japan’s three largest Wagyu cattle; and C stands for Yonezawa carp, which was introduced to compensate for the lack of protein. In the Yonezawa region, where these ancient traditions are still alive, the question is whether DE will become the mainstay of the region in modern times, following ABC. Electrical and electronic branch factories have been established since the 1970s. The Yonezawa region has been developing exogenously since then with electrical and electronic branch plants moving into the region. After that, as the electrical and electronics industries have been restructured and downsized across the country, industry-

government-academia collaboration has progressed towards new innovations originating in the region, while also leveraging the strengths of the local resources that have accumulated. Industry-government-academia collaboration has succeeded in developing certain products and creating new industries such as the university-launched start-ups Lumiotec and Organic Lighting. Supportive networks such as OELD Yamagata are also features of the Yonezawa region.

Nevertheless, the Yonezawa region is still dominated by the electrical and electronics industries, and the OLED Valley Initiative, which is expected to be the driving force behind the region's internal development, has only just begun. The OLED market for displays is finally up and running, but the market for OLED lighting is still in its infancy. Lumiotec, the world's first company specializing in this field, is dependent on investment from its parent company. Notably, the procurement of materials for panel orders is still only taking place on a small scale in the region. In order to commercialize such advanced elemental technologies, the cooperation and public support of companies both inside and outside the region is essential. To commercialize the internal seeds of the Yonezawa region, it is important to bridge the gap between R&D and market development. In addition to the scale of public support, there are additional difficulties in terms of cost-effectiveness. In the case of Yamagata Prefecture, subsidies totaling 5 billion yen over seven years were discontinued. It is now up to industry, government, and universities to figure out how best to create a "domino effect" regionally by leveraging the strengths of the pre-existing regional resources.

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