Does the Animal Welfare Kuznets Curve Hypothesis Hold for Japanese Canines?

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Abstract

The purpose of this study was to examine if and how Japanese canine welfare has improved in the past several decades. I had two possible scenarios: A steady and monotonic improvement or an inverted U-shaped welfare change. The difference in these scenarios was attributed to how I supposed that animals' status changed. I included the influence of status on canine welfare in my investigations by using complete domestic dog data from the period when the status of canines changed. I empirically examined which hypothesis was more relevant using four measures: The percentages of 1) stray dogs captured, 2), not-rehomed stray dogs (total data), 3) not-rehomed stray dogs (panel data), and 4) rabies shots. I observed an inverted U-shaped welfare change for the four measures, indicating the existence of an animal welfare Kuznets curve (AWKC). My results suggested that considering important factors, such as status change, multiple statuses, or both may improve the detection of an AWKC.

Keywords

animal welfare, economic development, Kuznets Curve, canine, inverted U-shaped curve

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1. Introduction

In society, animals play various roles that affect their relationships with humans. Animals are broadly categorized into two classifications: wild animals, such as game species, and domestic animals, referring to farm and working animals. Sometimes, they are further classified into more detailed categories, such as "those between wild and domestic animals (community animals and street animals)," "private animals (pets or companion animals)," and "animals used in experiments." From various classifications and categories, different types or positions of animals are determined and used to meet the goals of humans. Hereafter, *status* will describe and reflect components such as animal types, positions, and purposes.

When it comes to the welfare of animals, it is natural to expect that the welfare level of animals bred in homes depends on their status. Besides, economic conditions may be another important determinant of animal welfare. Currently, our knowledge about how an animal's status and economic conditions jointly affect its welfare level is very limited. The existing literature mainly deals with only economic conditions in examining the hypothesis of an inverted U-shaped welfare change, or an animal welfare Kuznets curve (AWKC). As the overview in subsection 2.1. will explain, previous studies have not necessarily provided unique results. This is probably because these studies did not fully consider important effects such as status change.

If one suppose that an animal has a specific status when examining the AWKC hypothesis, then one may suffer from the following issues. First, a *status change issue* may occur if the animal's main status changes over several decades. Second, a *multiple status issue* may exist as the status of some animals can be ambiguous. For example, dogs that mainly serve as working animals may also be pets for their owners. This could apply to large portions of dog owners. In this study, I gathered relatively long-term data that covered all types of dog bred in homes in Japan so that I could consider both the animals' status and the economic conditions. I faced two possible scenarios for changes in Japanese canines' welfare. One is steady and monotonic welfare improvement and the other is an inverted U-shaped welfare change. If the latter scenario is relevant, I can say that not only the economic conditions but also the animals' status should be considered in examining the AWKC hypothesis.

2. Background
2.1. Related Previous Studies

The Kuznets curve (KC) is an empirical rule that was first provided by Simon

Smith Kuznets (Kuznets, 1955). If economic development is placed on the horizontal axis and social inequality on the vertical axis, an inverted U-shaped relationship can be observed. This implies that as a society's economy moves toward a relatively advanced stage, social inequality gets worse. However, as the economy further develops, the inequality diminishes. This famous relationship has been applied in several different fields. Variants of the KC are unique because they put some degradation on the vertical axis such as "environmental degradation" (Grossman and Krueger, 1995), "number of threatened species" (Naidoo and Adamowicz, 2001), "animal welfare degradation" (Frank, 2008), "happiness degradation" (Sulkowski and White, 2016), or "crime" (Buonanno, et al. 2017).

One of the most famous and dominant applications thus far, especially from the 1990s onwards, is the so-called environmental Kuznets curve (EKC) (Grossman and Krueger, 1991, 1995). Applications of the KC hypothesis to animal welfare are relatively new and limited. Frank (2008) conducted one of the earliest and most comprehensive studies that examined several measures and concluded that we may observe the AWKC for some, but not all measures. Since Frank (2008) suggested thatthe AWKC may be closely related to the EKC, some existing studies mention the EKC (Holst and Martens, 2016). Others also considered their studies as coming under the category of EKC studies (Cole and McCoskey, 2013). Kawata (2010a) examined the AWKC hypothesis for Japanese domestic chicken production and concluded that the AWKC existed for three out of four measures examined. Lombardini et al. (2011) examined consumption of Finnish livestock products and suggested that per capita income growth is associated with the deterioration of farm animal welfare. Kennedy (2011) examined the AWKC hypothesis using United States state-level hunting license sales data for between 1963 and 2009 and found an inverted U-shape curve for 21 out of 50 states. Allievi and Vinnari (2012) examined per capita meat consumption from 15 countries in the European Union and concluded that the AWKC exists. Morris (2013) examined cases including European countries and the United States but denied the AWKC hypothesis, yet pointed out that improvement in income equality facilitates animal welfare. Cole and McCoskey (2013) used data on the per capita meat consumption of 150 countries to investigate if an inverted U-shape curve exists. They found a meat-consumption inflection point at an income level of USD $36,375. Finally, Holst and Martens (2016) examined the relationship between the animal protection index and some explanatory variables, including GDP, while mentioning the AWKC hypothesis, using data from nearly 50 countries, but they did not find clear evidence.

As described above, a limited number of studies treated varied species in different categories from several countries. These studies focused on measures such as

the number of slaughters, per capita meat consumption, and hunting license sales, among others. Holst and Martens (2016) indicated that these different measures may be categorized into those concerning "animal well-being" and those concerning "animal protection policies."

The number of existing animal welfare studies that treat pets in their examinations is still limited. One of the existing studies that is most relevant to this study is that by Stavisky et al. (2012). Although they did not apply the KC hypothesis in their investigations, their study dealt with data similar to mine. In the United Kingdom, a large number of pet dogs and cats become unowned and pass through rescue shelters. More than 10% of them are euthanized. The authors further concluded that an investigation into the reasons why pets became unowned was required so that appropriate interventions could be developed.

2.2. Hypotheses

Historically, dogs bred in homes had several statuses including domestic animals, pets, and companion animals. In past eras, they were bred in homes mainly for industrial or pragmatic purposes such as hunting dogs, shepherd's dog, and watchdogs. Sometimes, they were also treated as pets. The term "companion animal" appeared in academic literature as early as the late 1970s and early 1980s (Foley, et al. 1979; MacDonald, 1979; Gilbert, 1982; Borchelt, 1983). More citizens have become concerned for animals' welfare (George et al. 2016) and have bred dogs as companion animals in recent decades.

When considering this shift in animals' status in households, there are two possible scenarios concerning changes in the animals' welfare level. In the first scenario, I suppose that, along with animals' status change, our attitude toward animals kept in homes has changed gradually but steadily and has monotonically improved. Roughly speaking, animals in homes were historically just domestic animals kept for some utilitarian purpose, especially in agrarian societies. In recent centuries, more people have started to keep pets. For example, Kellert and Westervelt (1983) examined 10 attitudes toward animals between 1900 and 1976. They found that utilitarian attitudes decreased while humanistic attitudes kept a relatively high rank in the U.S. In the past few decades, people have sometimes clearly distinguished between companion animals and pets. The conditions of pets are better than those of domestic animals. However, pets are still treated as belongings rather than as friends, family members, or children for some owners, which is the way that companion animals are treated (Berryman,1985; Holbrook, 2008; Kubinyi, et al. 2009; Payne, et al. 2015). If the above inference is appropriate, we may observe a monotonic improvement in animal welfare along with a status change and economic developments.

We may expect that animals' welfare has decreased until recently because they are now treated more as pets than domestic animals. This is because the value of pets for owners may fluctuate much more than that of domestic animals with a utilitarian purpose. The facts that pets have been housed in rescue shelters worldwide may be an indicator that some owners lose the motivation to support their pets. The more that owners regard animals kept in homes as companion animals rather than pets, the higher the welfare level. If this expectation is correct, we would observe an AWKC that describes an inverted U-shaped welfare change.

The purpose of this study is to empirically examine which hypothesis is more relevant using data on Japanese dogs from over the past several decades. By so doing, I examine if the AWKC hypothesis holds. Because the study's topic is animal welfare and there are a limited number of wild dogs in Japan, I included dogs bred in homes and excluded wild canines from my examinations.

3. Materials and Methods
3.1. Data

I selected dogs for my investigation not only because their status in homes has gradually changed over time, but also because they have been one of the most popular animals kept in homes worldwide for a long time. Dogs have been bred as pets for around 12,000 years (Clutton-Brock, 1995) and were found to be the most liked animals by nationwide surveys conducted in the United States in 1978 and 2014 (George et al., 2016). Besides, statistics such as dog registrations and records of rabies shots for dogs are available in Japan from more than 50 years ago. I used data from a series of statistical surveys conducted by the Ministry of Health, Labour and Welfare (MHLW). The title of the statistical surveys is *Report on Public Health Administration and Services* (MHLW, 1965–2016; hereafter referred to as the "Report"). The Report provides statistics on dogs bred in homes in one-year units up until 1997 and in units of one fiscal year after 2005. The available data differ depending on the year or fiscal year (Table 1). Data on house dogs between April 1997 and December 2004 at the prefectural level (hereafter, "panel data") are not available in the Report. However, data between FY1997 and FY2004 in total numbers (hereafter, "total data") are available from the MHLW (2018). For the sake of simplicity, moving forward, I omit the FY notation. Note that some of the data for 2010 from some parts of Iwate, Miyagi, and Fukushima prefectures were not included in the Report due to the Great East Japan Earthquake (MHLW, 2016).

I used prefectural income data between 1965 and 2015 provided by the Cabinet Office (Cabinet Office, 2018 a, b, c, d). I converted prefectural nominal per capita income into real income using prefectural total expenditure deflators that were also available from

the Cabinet Office (2018 a, b, c, d). I also used the Japanese population when calculating the number of dogs per person in subsection 4.1 (MIAC, 2018b).

I clarify the meaning of some terms that specify dogs' conditions in Figure 1.

Table 1. Available Data (Total Data (T) and Prefectural (Panel) Data (P))

Period	Number of registered dogs	Number of rabies shot cards issued	Number of stray dogs captured	Number of rehomed dogs
	(1)	(2)	(3)	(4)
1960.1–1960.12	T	T	T	T
1965.1–1972.12	T, P	T*	T, P	T, P
1973.1–1996.12	T, P	T, P	T, P	T, P
1997.1–2005.3	T	T	T	T
2005.4–2017.3	T, P	T, P	T, P	T, P

Note: Data are available in one-year units until 1997 and in units of one fiscal year after 1997 (both types are available in 1997). Data with "*" are available only for 1965 and 1970.

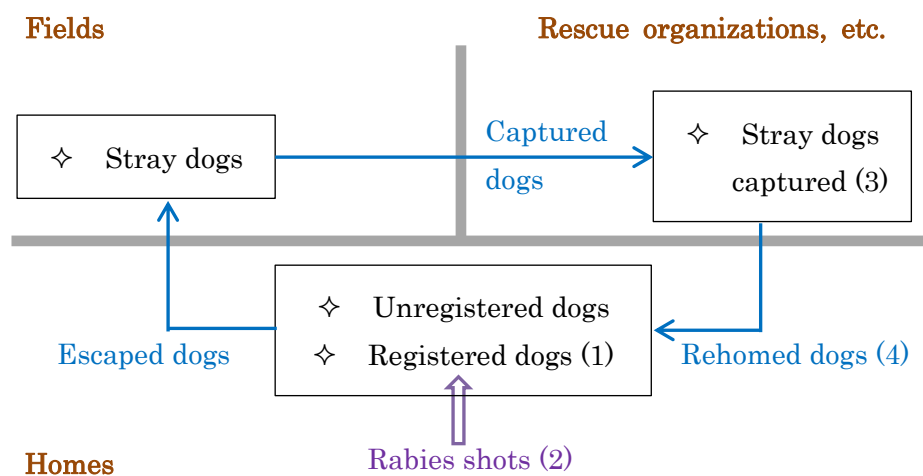Source: MHLW (1965–2016)

Figure 1. Dogs' Conditions in Homes, Fields, and Organizations
Note: Digits (1) to (4) correspond to those in Table 1.

3.2. Methods

I examined the following four cases: (1) the percentage of stray dogs captured (subsection 4.2.), (2) the percentage of not-rehomed stray dogs using total data (subsection 4.3.), (3) the percentage of rabies shots (subsection 4.4.), and (4) the percentage of not-rehomed stray dogs using panel data (subsection 4.5.). Although I also examined cases (1) and (3) using panel data, I could not find any clear tendencies: I report only the results for the total data below.

While I showed the results of cases (1) to (4) graphically, I also applied ordinary least squares (OLS) regression to case (4). Because the AWKU is an inverted U-shaped curve, I estimated using a quadratic function. The signs for the coefficient of quadratic and linear terms should be negative and positive, respectively.

4. Results

4.1. Status Change of Dogs in Homes

As suggested above, the status of Japanese dogs bred in homes may have changed over the past several decades. Two supporting pieces of evidence of such a status change will now be presented. First, I checked dogs' position based on either or both their economic or social changes in Japan. After World War II, the Japanese economy gradually recovered. The Economic White Paper of 1956 insisted that the Japanese economy would "no longer be termed postwar." Around the same time, the Japanese economy started to experience high economic growth periods, which facilitated large-scale farming. For example, the average number of pigs per farming household was 1.7 between 1930 and 1959. However, this figure increased exponentially to 2.4 heads in 1960, 14.3 heads in 1970, 272.3 heads in 1990, and 1,095 in 2005 (MIAC, 2018a). This fact suggests that Japanese society transitioned from a rather agrarian society to a more modern industrial society after the 1960s. According to the above shift, we may infer that dogs' position in houses has changed from domestic animals to other statuses.

Next, I checked trends in the number of dogs registered between 1960 and 2016 (Figure 2). Here, I used data (1) in Table 1. I also checked trends in the number of dogs per person, which was calculated by dividing data (1) in Table 1 by the population size in MIAC (2018b) between 1960 and 2016. The tendency of both lines seemed to be almost the same, as shown in Figure 1. Therefore, I did not distinguish between these two lines when addressing them. It is possible to discern two or three periods between the 1960s and 2010s. The most obvious change may have happened in 1995, because I observed almost linear trends and a convex upward shape before and after 1995, respectively. I could further divide the first half of the periods between the 1960s and 1995. It is less obvious, but we can observe a convex upward shape and rather linear trends before and

after 1980. Based on these observations, it is possible to distinguish three periods: (1) before 1980, (2) 1980 to 1995, and (3) after 1995.
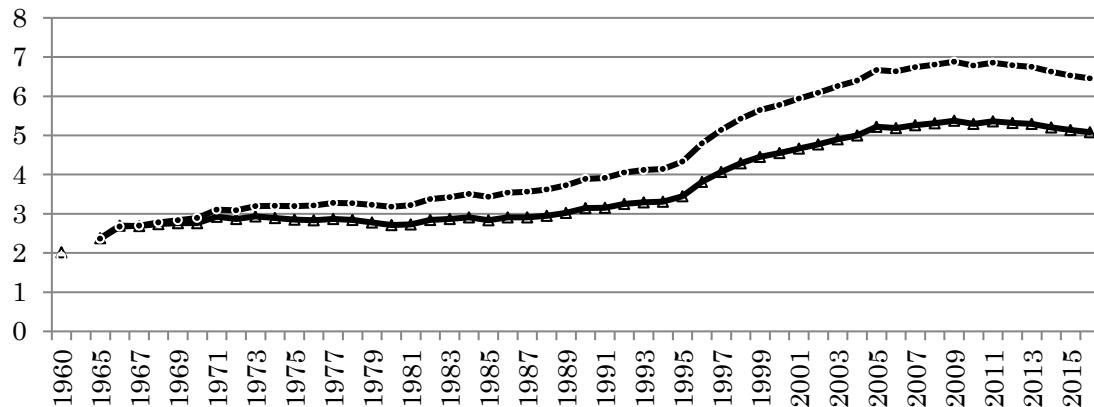

Figure 2. The Number of Dogs Registered (unit: million dogs) and the Number of Dogs per Person (unit: heads/100 people)
Source: MIAC (2018b)

Currently, I have no solid evidence that the trend changes in around 1980 and 1995 corresponded to the status changes from domestic animals to pets and companion animals. Moreover, whether a dog is categorized as a domestic dog or pet largely depends on the owner's perception, so it is not easy to verify if and when trend changes happened. Note that despite the above limitations, I could fully consider status change issues because I used the Report, which covers complete dog data.

4.2. Percentage of Stray Dogs Captured

In Figure 3, I show the relationship between "stray dogs captured" and "per capita income." I calculated the values by dividing (3) by (1) in Table 1. The threshold per capita income was between 500 and 1,000 thousand yen. I observed an inverted U-shaped relationship.

4.3. Percentage of Not-Rehomed Stray Dogs (Total Data)

To calculate the percentage of not-rehomed stray dogs, I divided (4) by (3) in Table 1 and then translated them into reversed figures. For example, 45% was translated into 55% to obtain the number of "not-rehomed stray dogs." Then, I used "not-rehomed stray dogs" for the vertical axis and "per capita income" for the horizontal axis in Figure 4. The threshold per capita income was about 1,500 to 2,000 thousand yen. I observed a clear inverted U-shaped relationship.
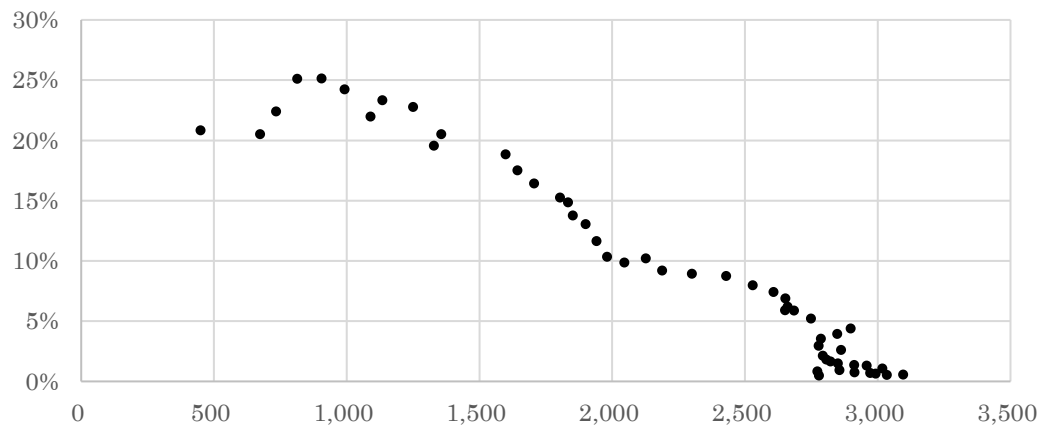
Figure 3. Relationship between Stray Dogs Captured (Vertical Axis) and Per Capita Income (Horizontal Axis: In Thousand Yen)

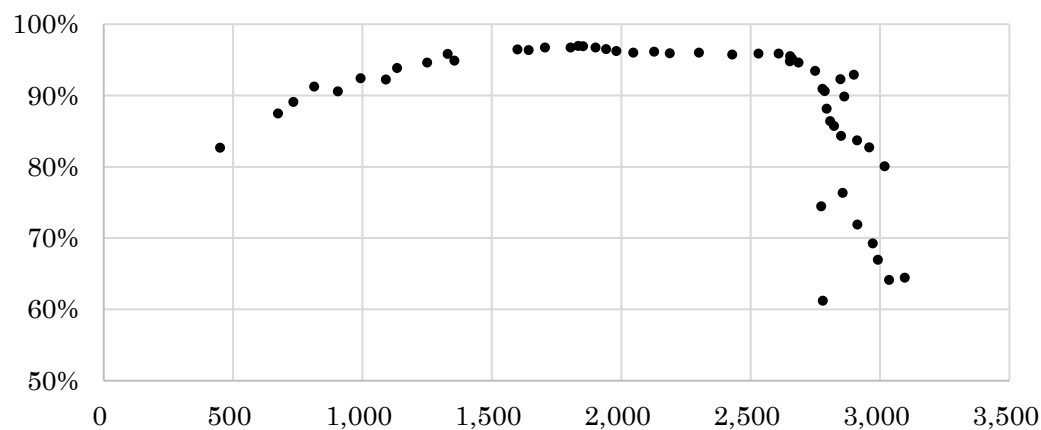Source: MHLW (1965–2016) and Cabinet Office (2018 a, b, c, d)

Figure 4. Relationship between Not-rehomed Dogs (Vertical Axis) and Per Capita Income (Horizontal Axis: In Thousand Yen)

Source: MHLW (1965–2016) and Cabinet Office (2018 a, b, c, d)

4.4. Percentage of Rabies Shots

In Figure 5, I show the relationship between "dogs that received rabies shots" and "per capita income." I calculated the values by dividing (2) by (1) in Table 1. Note that the number of rabies shots per year changed institutionally in 1985 from twice per year to once. Interpreting this result was not easy. Although it was illegal not to give your dog a rabies shot, because human rabies was eradicated in Japan in 1957 (Takahashi-Omoe, Omoe, and Okabe, 2008), there could have been a decrease in the percentage of rabies shots due to owners' desire to reduce the discomfort accompanying injections for dogs. The threshold per capita income could be around 2,000 thousand yen. I observed
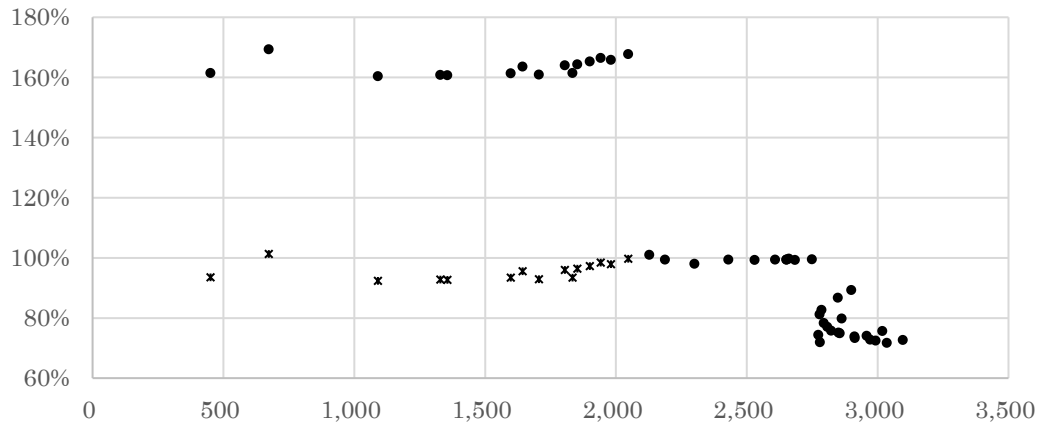
an inverted U-shaped relationship for this case.

Figure 5. Relationship between Rabies Shots (Vertical Axis) and Per Capita Income (Horizontal Axis: In Thousand Yen)
Note: Data were not available from 1961 to 1972, except for 1965 and 1970. The circle points show the original data, while the asterisks are adjusted values with the value in 1984 set at 100%.
Source: MHLW (1965–2016) and Cabinet Office (2018 a, b, c, d)

4.5. Percentage of Not-Rehomed Stray Dogs (Panel Data)

I show the relationship between "not-rehomed stray dogs" and "prefectural per capita income" in Figure 6. I applied a similar procedure as that of subsection 4.3 when calculating the value of "not-rehomed stray dogs." I also used the per capita income of each prefecture between 1965 and 2015 (Cabinet Office, 2018 a, b, c, d) and observed an inverted U-shaped relationship graphically.

To obtain more solid results, I conducted two more analyses. First, I calculated the average percentage of not-rehomed dogs for several per capita income classes: They were 89.3% (500–999 thousand yen), 93.5% (1,000–1,499), 95.6% (1,500–1,999), 90.3% (2,000–2,499), 80.2% (2,500–2,999), 74.1% (3,000–3,499), 66.2% (3,500–3,999), and 43.6% (4,000–). The threshold per capita income class was the between 1,500–1,999 thousand yen class (Table 2).

Table 2. The Threshold per Capita Income (In Thousand Yen)

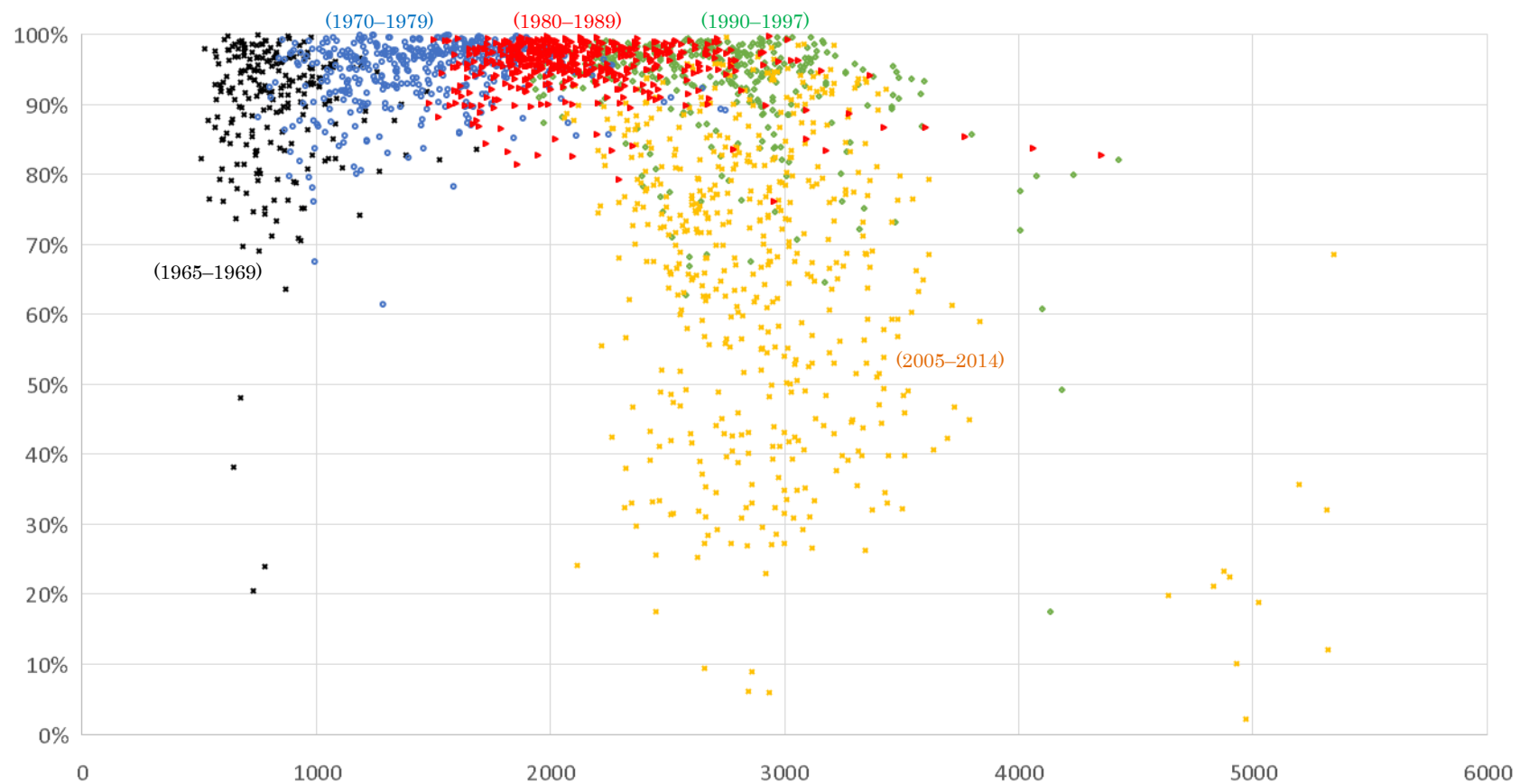|	Case (1)	Case (2)	Case (3)	Case (4)
Total data	500–1,000	1,500–2,000	2,000	1,500–1,999 class
Panel data				1,285

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Figure 6. Relationship Between Not-rehomed Dogs (Vertical Axis) and Per Capita Income (Horizontal Axis: In Thousand Yen)
Source: MHLW (1965–2016) and Cabinet Office (2018a, b, c, d)

Second, I applied OLS to these data. The result was as follows:

$$Y = -0.286X^2 + 4.09X - 13.7$$
$$[-20.02] \quad [19.40] \quad [-17.61]$$
$$\text{adj } R^2 = 0.258 \quad n = 2,010$$

Here, Y was not-rehomed stray dogs (in %), and X was prefectural per capita income (after taking the natural log). The t-values are provided in brackets. All parameters were statistically significant at the 1% level. The sign conditions were satisfied since the coefficient of the quadratic and linear terms were negative and positive, respectively. The estimation result indicated that an inverted U-shaped relationship held. By using estimated parameter values, I could calculate the threshold per capita income at 1,285 thousand yen (Table 2).

5. Discussion and Conclusion

In my examination, I posed two scenarios for canine welfare improvement: either a steady and monotonic improvement or an inverted U-shaped improvement. To detect which was more relevant, I examined changes in Japanese canine welfare levels for four cases with animals' status change in mind. I found an inverted U-shaped relationship for all cases with different thresholds of per capita income.

Let us compare the results on the different threshold per capita incomes. The classes were 500–1,000 thousand yen, 1,500–2,000 thousand yen, around 2,000 thousand yen, and 1,500–1,999 thousand yen for cases (1) to (4), respectively. Here, case (1) was the percentage of stray dogs captured, which was followed by both cases (2), the percentage of not-rehomed stray dogs (total data), and (3), the percentage of not-rehomed stray dogs (panel data); the last one was case (4), the percentage of rabies shots. The order of the threshold per capita incomes/income ranges seems reasonable when considering the dogs' conditions, as described in Figure 1.

I observed a trend change in around 1995, as shown in Figure 2. One of the possible reasons for this is the influence of Siberian husky breeding, which became a fad during the 1990s in Japan. It is noteworthy that, based on the Trade Statistics of Japan (Ministry of Finance, 2018), imports of dogs in 1995 were more than double (226,845 kg) those of the former and later years. The average between 1991 and 2000 was 102,126 kg.[1]

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[1] I used figures that appeared in the following report issued by the Ministry of the Environment (accessed March 23, 2018)
https://www.env.go.jp/nature/dobutsu/aigo/2_data/pamph/rep_h1503.html

I also observed clear changes in tendency, as seen in Figures 3 to 6: Points almost vertically declined when per capita income was around 3,000 thousand yen. Most of these points were those of the years after 1995. One possible reason for this change could be the influence of the economic recession, which made dog owners feel the relatively large economic burden of breeding dogs. The fact that the percentage of rabies shots decreased (as shown in Figure 5) after 1995 may reflect this economic burden to some extent. Takahashi-Omoe, Omoe, and Okabe (2008) point out that the last incidence of human rabies in Japan was in 1957, with the exceptions of imported cases in 1970 (one person) and 2006 (two people). Under such circumstances, it is natural that Japanese people have less fear of the dire consequences of rabies and are more concerned about the expense of rabies shots. Moreover, as dogs were treated more as pets and companion animals rather than domestic animals during the economic development period, they were fed pet food rather than human food waste and had more opportunities to visit veterinarians, which also enhanced the cost of keeping dogs. When considering the fact that the Japanese economy has experienced a prolonged recession after the collapse of the bubble economy in the early 1990s, it is reasonable to observe changes in around 1995.[2]

As stated in subsection 4.1., I used complete dog data from a period of more than half a century, which enabled me to implicitly but fully consider animals' status issues. Both a status change and multiple status issues were experienced by Japanese canines after the 1960s, as explained in subsection 4.1. Existing studies that addressed welfare improvements normally selected specific types of animal for investigation, such as livestock (Miranda-de la Lama et al., 2017), laboratory-housed animals (Hall, et al. 2017), free-ranging animals (Morters et al. 2014; Demirbas and Pereira, 2017), sheltered animals (Passantino et al. 2014), and pets (Morris and Steffler, 2011). The status of animals in categories such as livestock on large farms and laboratory-housed animals may not change; however, animals bred in homes such as livestock on smaller farms, free-ranging animals, sheltered animals, and pets may have multiple statuses and their main status should have changed over time.

The KC hypothesis and its variants are empirical rather than solid theoretical rules. The background factors that the AWKC hypothesis holds as true are not necessarily shown clearly in existing studies. My results implied that to ensure the existence of the KC, we should carefully examine the components that simultaneously create an inverted U-shaped relationship. The results of this study indicated that a status change could be an

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[2] To avoid the criticism that I should have used per capita income on the horizontal axis, I did not mention it in the main text, but I examined cases where I put time series data on the horizontal axis rather than per capita income. I observed smoother changes for all four cases. For more detail, see Appendix.

important factor for animals bred in homes, such as canines.

Finally, I will present some issues that should be examined in future studies. When considering the fact that Japan is rapidly advancing into an aging society, it is important to consider not only dog owners' attitudes, but also the feasibility of owners' caring for their pets or companion animals. Against the background of a falling birth rate and aging population, citizens require more pets or companion animals to alleviate the isolation created by having fewer children (22). On the other hand, both economic and physical restrictions such as the limited income of aged people, a decrease in physical performance, or the death of pet owners because of old age may increase the number of unowned animals in the future. I did not detect any such tendencies in my data. However, this possibility may change my conclusions and should be considered in future studies.

References

1. Allievi, F., & Vinnari, M. (2012) Investigating the existence of an 'Animal Kuznets curve' in the EU-15 countries. In: Potthast T, Meisch S, ed. Climate change and sustainable development: Ethical perspectives on land use and food production, Wageningen Academic Publishers, 468–474.

2. Berryman, J. C., Howells, K., & Lloyd-Evans, M. (1985) Pet owner attitudes to pets and people: A psychological study. Veterinary Record 117, 659–661.

3. Borchelt, P.L. (1983) Aggressive behavior of dogs kept as companion animals: Classification and influence of sex, reproductive status and breed. Applied Animal Ethology 10(1–2), 45–61.

4. Buonanno, P., Fergusson, L., & Vargas, J.F. (2017) The crime Kuznets curve. Journal of Quantitative Criminology 33(4), 753–782.

5. Cabinet Office (2018a) Prefectural accounts between 1955 and 1974 (68SNA), available at:
    http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/files_kenmin.html
    (Accessed February 22, 2018).

6. Cabinet Office (2018b) Prefectural accounts between 1975 and 1999 (68SNA), available at:
    http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/files_kenmin.html
    (Accessed February 22, 2018).

7. Cabinet Office (2018c) Prefectural accounts between 2001 and 2014 (93SNA), available at:
    http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/files_kenmin.html
    (Accessed February 22, 2018).

8. Cabinet Office (2018d) Prefectural accounts between 2006 and 2015 (08SNA), available at: http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/contents/main_h27.html (Accessed November 5, 2018).

9. Cole, J.R. & McCoskey, S. (2013) Does global meat consumption follow an environmental Kuznets curve? Sustainability: Science, Practice and Policy 9(2), 26–36.

10. Clutton-Brock, J. (1995) Origins of the dog: domestication and early history. In James Serpell, ed. The domestic dog: its evolution, behaviour and interactions with people. Cambridge University Press, 7–20.

11. Demirbas, Y.S., Safak, E., Emre, B., Piskin, İ., Ozturk, H., & Pereira, G.D.G. (2017) Rehabilitation program for urban free-ranging dogs in a shelter environment can improve behavior and welfare. Journal of Veterinary Behavior: Clinical Applications and Research 18, 1–6.

12. Foley, C.W., Lasley, J.F., & Osweiler, G.D. (1979) Abnormalities of companion animals: Analysis of heritability. Iowa State University Press.

13. Frank, J. (2008) Is there an "animal welfare Kuznets curve?" Ecological Economics 66(2–3), 478–491.

14. George, K.A., Slagle, K.M., Wilson, R.S., Moeller, S.J., & Bruskotter, J.T. (2016) Changes in attitudes toward animals in the United States from 1978 to 2014. Biological Conservation 201, 237–242.

15. Gilbert, F.F. (1982) Public attitudes toward urban wildlife: A pilot study in Guelph, Ontario. Wildlife Society Bulletin 10(3), 245–253.

16. Grossman, G.M. & Krueger, A.B. (1991) Environmental impacts of a North American Free Trade Agreement. NBER Working Papers No. 3914.

17. Grossman, G.M., & Krueger, A.B. (1995) Economic growth and the environment. Quarterly Journal of Economics 110(2), 353–377.

18. Hall, L.E.M.S, Robinson, S., Finch, J., & Buchanan-Smith, H.M. (2017) The influence of facility and home pen design on the welfare of the laboratory-housed dog. Journal of Pharmacological and Toxicological Methods 83, 21–29.

19. Holbrook, M.B. (2008) Pets and people: Companions in commerce? Journal of Business Research 61, 546–552.

20. Holst, A. & Martens, P. (2016) Determinants of animal protection policy: A cross-country empirical study. Politics and Animals 2(1), 1–14.

21. Kawata, Y. (2010a) Animal welfare Kuznets curve in Japan: The case of domestic chicken. The 14th Animal Science Congress of the Asian-Australasian Association

of Animal Production Societies Proceedings 3, 557–561.

22. Kawata, Y. (2010b) Can dogs alleviate the desolation created by having fewer children? An empirical study in the Japanese context. The Internet Journal of Veterinary Medicine 8(1).

23. Kellert, S.R., & Westervelt, M.O. (1983) Historical trends in American animal use and perception. International Journal for the Study of Animal Problems 4(3), 133–146.

24. Kennedy, M.K. (2011) Exploring the existence of an animal welfare Kuznets curve. Master thesis, California State University, Los Angeles, CA, available at: http://csus-dspace.calstate.edu/bitstream/handle/10211.9/1374/Madhavi%20 Kennedy_THESIS.pdf?sequence=8 (Accessed on February 8, 2018)

25. Kubinyi, E., Turcsán, B., & Miklosi, A. (2009) Dog and owner demographic characteristics and dog personality trait associations. Behavioural Processes 81, 392–401.

26. Kuznets, S. (1955) Economic growth and income inequality. American Economic Review 45, 1–28.

27. Lombardini, L., Kosenius, A.-K., Kulmala, S., & Lindroos, M. (2011) Is there a Finnish animal welfare Kuznets curve? Paper prepared for presentation at the EAAE 2011 Congress, available at: http://ageconsearch.umn.edu/bitstream/114379/2/Lombardini_Chiara_508.pdf (Accessed on February 8, 2018).

28. MacDonald, A.J. (1979) Review: Children and companion animals. Child: Care, Health and Development 5(5), 347–358.

29. MHLW (Ministry of Health, Labour and Welfare) (1965–2016), Report on public health administration and services (1965–1997, FY2005–2016), Health, Labour and Welfare Statistics Association.

30. MHLW (2016) Outline of report on public health administration and services, available at: http://www.mhlw.go.jp/english/database/db-hss/dl/rophas_2015_year.pdf (Accessed December 28, 2016).

31. MHLW (2018) Changes in annual number of dogs registered and number of dogs receiving rabies shots between 1960 and 2016, available at: http://www.mhlw.go.jp/bunya/kenkou/kekkaku-kansenshou10/02.html (Accessed February 22, 2018).

32. MIAC (Ministry of Internal Affairs and Communications) (2018a) 7-17 farm

households raising livestock or chickens and livestock or chickens raised (1877–2005), Chapter 7 Agriculture, forestry and fisheries. Historical Statistics of Japan, available at: http://www.stat.go.jp/english/data/chouki/07.html (Accessed March 20, 2018).

33. MIAC (2018b) Chapter 2 Population and households, 2-1 Total population B 1920 to 2016. Japan statistical yearbook 2018, available at: http://www.stat.go.jp/english/data/nenkan/67nenkan/1431-02.html (Accessed March 19, 2018).

34. Ministry of Finance (2018) Trade statistics of Japan, available at: http://www.customs.go.jp/toukei/info/index.htm (Accessed April 4, 2018).

35. Miranda-de la Lama, G.C., Estévez-Moreno, L.X., Sepúlveda, W.S., Estrada-Chavero, M.C., Rayas-Amor, A.A., Villarroel, M., & María, G.A. (2017) Mexican consumers' perceptions and attitudes towards farm animal welfare and willingness to pay for welfare friendly meat products. Meat Science 125, 106–113.

36. Morris, G.D., & Steffler, J. (2011) Was pet relinquishment linked to foreclosure? A spatial research note from California during the height of foreclosure. The Social Science Journal 48, 739–745.

37. Morris, M.C. (2013) Improved nonhuman animal welfare is related more to income equality than it is to income. Journal of Applied Animal Welfare Science 16(3), 272–293.

38. Morters, M.K., Bharadwaj, S., Whay, H.R., Cleaveland, S., Damriyasa, I.Md., & Wood, J.L.N. (2014) Participatory methods for the assessment of the ownership status of free-roaming dogs in Bali, Indonesia, for disease control and animal welfare. Preventive Veterinary Medicine 116(1–2), 203–208.

39. Naidoo, R. & Adamowicz, W.L. (2001) Effects of economic prosperity on numbers of threatened species. Conservation Biology 15(4), 1021–1029.

40. Passantino, A., Quartarone, V., Pediliggeri, M.C., Rizzo, M., & Piccione, G. (2014) Possible application of oxidative stress parameters for the evaluation of animal welfare in sheltered dogs subjected to different environmental and health conditions. Journal of Veterinary Behavior: Clinical Applications and Research 9(6), 290–294.

41. Payne, E., Bennett, P.C., & McGreevy, P.D. (2015) Current perspectives on attachment and bonding in the dog–human dyad. Psychology Research and Behavior Management 8, 71–79.

42. Stavisky, J., Brennan, M.L., Downes, M., & Dean, R. (2012) Demographics and

economic burden of un-owned cats and dogs in the UK: Results of a 2010 census. BMC Veterinary Research 8, 163.

43. Sulkowski, A. & White, D.S. (2016). A happiness Kuznets curve? Using model-based cluster analysis to group countries based on happiness, development, income, and carbon emissions. Environment, Development and Sustainability 18(4), 1095–1111.

44. Takahashi-Omoe, H., Omoe, K., & Okabe, N. (2008) Regulatory systems for prevention and control of rabies, Japan. Emerging Infectious Diseases 14(9), 1368–1374.

Appendix

In this appendix, I provide three sets of results from when I used time (year or fiscal year) as the horizontal axis instead of per capita income. In addition to economic conditions, time trends are also an important determinant of animals' welfare levels, and this was true in the canine case. If one analyzes farm animals such as pigs, annual economic development data can be used because such farm animals are slaughtered when they are less than a year old. Economic conditions would significantly influence the number of pigs bred in the next year, which is known as the pig cycle in economics. In such cases, it is more appropriate to use an annual economic development measure as the horizontal axis. However, I analyzed animals kept in homes. It is true that economic conditions may affect the number of newly bred animals, but those that have already been bred in homes usually continue to be bred even if the economic conditions of their house get worse. There is a time lag for adjusting the numbers of pets or companion animals bred in homes. When considering these facts, it seemed useful to provide the results from when I used time as the horizontal axis.

Case A1: The Percentage of Stray Dogs Captured

In Figure A1, I showed the relationship between "stray dogs that were captured" and "time." The worst year was 1968, with 25.1% being captured (Table A1). The average real income for 1968 was 906 thousand yen (Cabinet Office, 2018b).

Case A2: The Percentage of Not-Rehomed Stray Dogs (Time Series)

In Figure A2, I showed the relationship between "not-rehomed stray dogs" and "time." The worst year was 1979, with 97.0% of dogs not being rehomed (Table A1). The

average real income for 1979 was 1,835 thousand yen (Cabinet Office, 2018b).

       I also applied OLS using the same data. The result was as follows:

$$Y = -0.000344X^2 + 0.0130X + 0.859$$
$$[-37.88] \qquad [26.11] \quad [150.54]$$
$$\text{adj } R^2 = 0.985 \qquad n = 52$$

Here, Y was not-rehomed dogs (in %) and X was time with the value of 1965 as 1 and was increased in increments of one per year. The t-values are provided in brackets. All parameters were statistically significant at the 1% level. The sign conditions were satisfied since the coefficient of the quadratic and linear terms were negative and positive, respectively. The estimation result indicated an inverted U-shaped relationship. By using estimated parameter values, I calculated that the turning points were the years from 1982–1983 (Table A1). The average real income for 1982–1983 was 1,942–1,981 thousand yen (Cabinet Office, 2018b).

Case A3: The Percentage of Rabies Shots

       In Figure A3, I show the relationship between "dogs that received rabies shots" and "time." The worst periods could be between the 1980s and the first half of the 1990s.
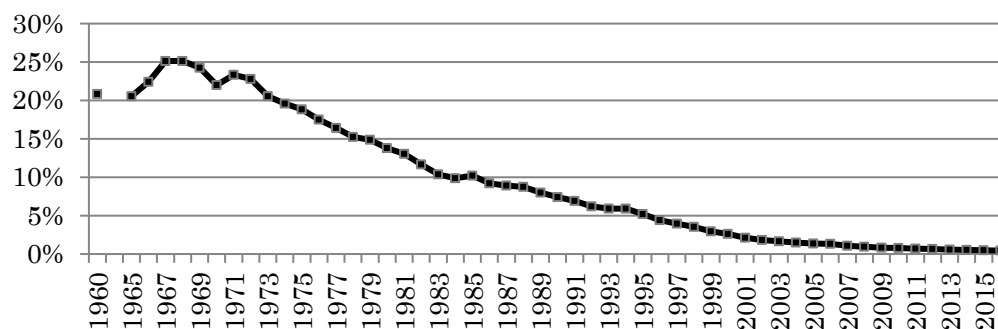

Figure A1. Relationship between Stray Dogs Captured (Vertical Axis) and Time (Horizontal Axis)
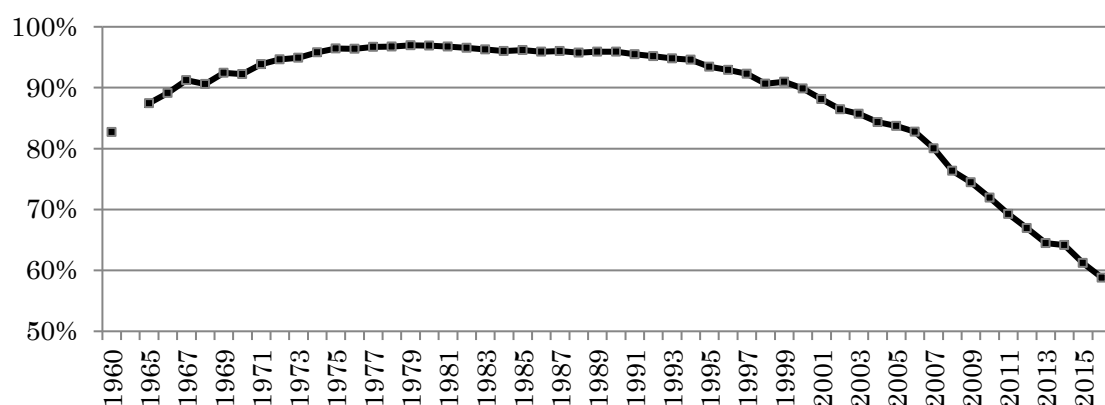
Source: MHLW (1965–2016)

Figure A2. Relationship between Not-rehomed Dogs (Vertical Axis) and Time (Horizontal Axis)
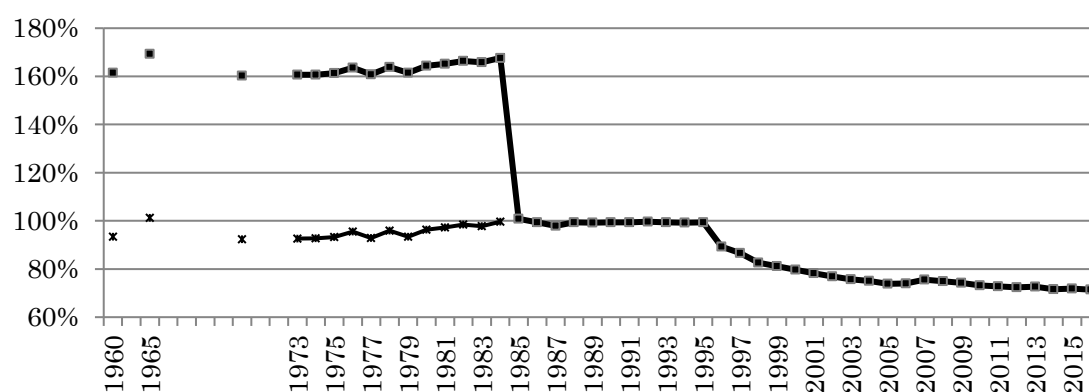
Source: MHLW (1965–2016)

Figure A3. Relationship between Rabies Shots (Vertical Axis) and Time (Horizontal Axis)

Note: Data were not available from 1961 to 1972, except for 1965 and 1970. The thick line with squares shows the original data, while the thin line with cross marks is adjusted so that the value in 1984 is 100%.

Source: MHLW (1965–2016)

Table A1. Year or Periods of Turning Points

	Case A1	**Case A2**	**Case A3**
Total data	1968	1979	1980s-first half of 1990s
	(906)	(1,835)	(1,853–2,750)
(OLS)	-	1982–1983	
		(1,942–1,981)	

Note: Per capita income in thousand yen is provided in parentheses.