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Structural Change in Firm Dynamics: From Inter-Firm Network and Geospatial Perspectives.[1]

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Abstract

This paper examines how unprecedented population aging affects firm dynamics in Japan, using the panel data from 2007 to 2016. Our analysis confirms that during this time, average firm age increased due to low rates of firm entry and exit. Average age of CEOs also increased with population aging and low turnover of CEOs. Aging of firms and CEOs is more salient in rural areas than urban areas. Furthermore, as voluntary firm exits are positively correlated with the age of CEOs, more exits are likely to occur as population aging intensifies. In rural areas, low density of firms may imply higher search costs in finding new transaction partners. Firm exit induced by exit of transaction partners is more likely to happen for rural areas. Our results suggest that policies aimed at supporting business succession and addressing increases in voluntary exists should cater to the lifecycle of firms as well as the geographic location of firms.

Keyword: firm growth, metabolism, population aging, inter-firm network
JEL classification: D22, O12, R11

[1] This paper is produced as a part of the RIETI' project "Dynamics of Inter-organizational Network and Geography" as well as the joint project with the Small and Medium Enterprise Agency of Japan. The project with the SME Agency of Japan provides us with the access to the data of Tokyo Shoko Research, LTD. (TSR).

1. Introduction

There has been numerous studies on the long-term stagnation of the Japanese economy's since late 1990s, following the collapse of the so-called "bubble economy". What has been paid particular attention as a factor of the long-term stagnation, so-called "The Lost Decade", is the malfunction of business metabolism (Caballero, Hoshi and Kashyap, 2008; Nishimura, Nakajima and Kiyota, 2005). That is, if the "metabolism" worked properly, less productive firms would exit and highly productive ones would remain in the market, leading to efficient allocation of resources and higher productivity in the economy as a whole. It has been pointed out, however, that the exit of less productive companies was limited, with the life-lines offered to 'zombie firms' with evergreening loans and overly generous government guarantees. To resolve this issue, many have advocated for promoting firm selections with improved screening and monitoring of banks, setting higher interest rates for firms with low productivities and high default risks, and facilitating firms' new entry as well.

Moreover, Kim, Fukao and Makino (2010) elucidated structural factors of the "Lost Decade", which lasted from 1990s to 2000s, suggesting that even in late 2000s, firm entry and exit mechanism did not make progress in Japan. The Small and Medium Enterprise Agency of Japan launched a project to investigate structural changes in the past decade and to project the issues that will surround SMEs over the long-term. In this project, the findings also confirmed that Japanese SMEs have been aging and made clear that there was little advancement on firm entry and exit. With such a long period of low entry and exit rate, it is highly like that there was a drag in productivity improvement and a loss in welfare and productivity.

On the other hand, in the literature of firm growth, there has been researches on the relationships between firm growth, its size, and its age. For instance, Haltiwanger, Jarmin and Miranda (2013) shows that younger firms exhibit higher growth rate, and that their contribution to macro economy is large, taking the effects of firm entry and exit into account. Besides, Fujii, Saito and Senga (2017) makes clear that amongst Japanese firms, the growth rate is higher for younger ones.[2] These results also imply that firm aging can

[2] Younger firms contribute to the macro economy largely with the firm entry effect, but at the same time they exhibit higher exit rate and this makes their contribution smaller. Since the data employed in Fujii, Saito and Senga (2017) is not appropriate to capture firm entry, it does not investigate the contribution to the macro economy.

do harm to macroeconomic growth. Haltiwanger, Jarmin and Miranda (2013) further observes that by controlling firm age, the relationship between firm size and its growth becomes statistically insignificant, indicating that the firms that should be the policy target are younger ones rather than smaller in size.

It has gradually been known that not only individual firm issues but also inter-firm network has a non-negligible effect on firm growth. For example, it is shown that new inter-firm transaction network, triggered by the opening of Kyushu Shinkansen (bullet train), led to firm growth (Bernard, Moxnes and Saito, 2016). Also, it is revealed that the relationship between transaction network and firm growth differs by firm age (Fujii, Saito and Senga, 2017). These results imply that the relationship with outside company matters for firm growth, and under the circumstance where firm aging advances, the policy to promote inter-firm network building according to firms' age stage is crucial.

Although Haltiwanger, Jarmin and Miranda (2013) does not provide any discussion on a mechanism behind the relationship between firm age and its growth, the results in Fujii, Saito and Senga (2017) allow us consider that it is caused dependence of the outside-firm relationship on firm age. They found that amongst younger firms those that change transaction partners more grows with higher rates, and this means that younger firm has a little information, resulting in poor inter-firm transaction matching, and hence reforming transaction relationships becomes important for building appropriate transaction relationships. This therefore implies the importance of supporting the matching for young firms.

Lastly, as a part of the literature on inter-firm network, the studies focusing on its function to amplify macroeconomic fluctuations have made progress. As seen in the global financial crisis and large-scale natural disasters, it has been confirmed both theoretically and empirically that micro shocks spill over through inter-firm network and eventually result in macroeconomic fluctuations (Acemoglu et.al., 2012; Carvalho, 2014; Ogura, Okui and Saito, 2015; Carvalho, Nirei, Saito and Tahbaz-Salehi, 2016). While these researches pay attention mainly to effects of repercussions of temporal negative shock, these imply that there is a possibility of positive shocks, which can promote individual firm growth, spreading through inter-firm network and causing macroeconomic growth. It is therefore worth considering the policies that initiate macroeconomic growth by making use of inter-firm network, when firms' new entry does not advance and firm aging is undergoing.

This research examines the impact of super aging on industry metabolism and firm dynamics. Particularly, focusing on firm growth, exit, and inter-firm network, we present statistical facts mainly on these regional differences. Our result shows that in the past decade, aging of both firm and its CEO advanced, and these trends are more salient in the rural area. The probability of firm CEO turnover is lower in the rural areas, which suggests us the further aging of the CEO henceforth. The regression analyses also confirm that firm growth rate is lower as firm and its CEO ages are higher, and there is a positive correlation between the CEO age and the probability of firm voluntary exit. Furthermore, it is revealed that aging of firm and its CEO tend to stiffen inter-firm transaction network, making new relationship building less likely to occur. Finally, we show that the probability of firm exit depends on inter-firm network, firm exit tends to be linked to exit by customers as well as suppliers, and this effect is larger in the rural area. We infer that this larger effect in the rural area arises from the circumstances that the search for alternative transaction partners involves more difficulties in those areas.[3]

Putting these results together, it is anticipated that firm voluntary exit would continue to increase in the rural area where the CEOs are aging faster, and a propagation through inter-firm network would accelerate the firm exit in the area. In order to infer the effect of this firm exit acceleration on macroeconomic productivity via firm entry and exit, we need to investigate carefully whether exiting firms are more productive or not, which remains to be done. We need the policies that support business succession via M&A or something alike, so that technology, human capital and productive network, which are indispensable for industries, would not be lost in a chain of firm exit.

The remainder of this paper is organised as follows. Introducing, Section 2 introduces data to be used and describes the aging pattern and its regional differences in the past decade with figures. Section 3 shows the effect of aging on inter-firm network and firm growth through regression analyses. Section 4 clarifies the relationship between aging and firm exit, as well as spill over effect of firm exit via inter-firm network. Section 5 concludes.

[3] Miyauchi (2018) shows that the probability of gaining new clients differ by regions because the cost of building new business relationships is distinct depending on whether a firm is located in a cluster or not.

2. Aging of Firm and its CEO

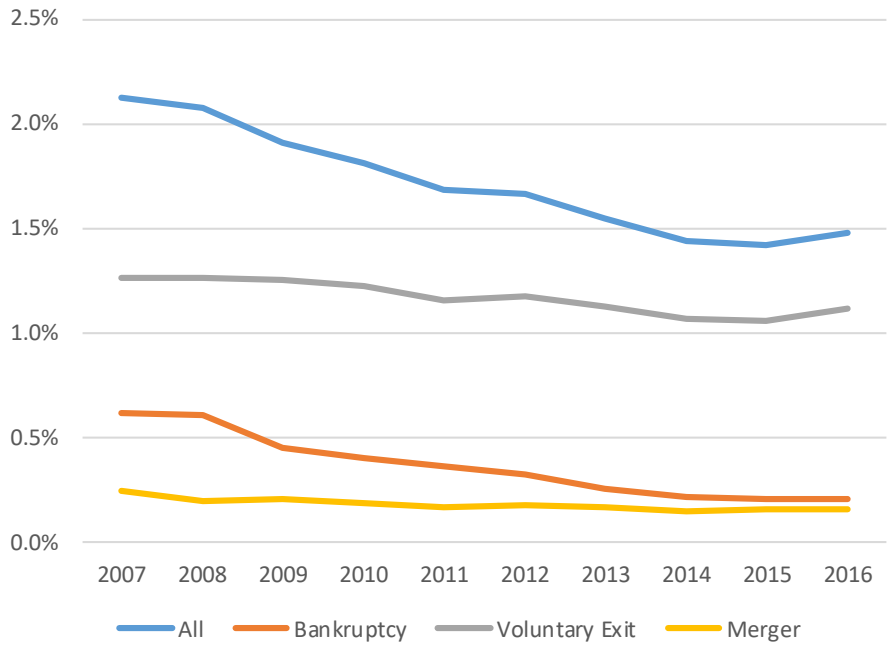
First, we overview changes in age distributions of firm and its CEO. Data assembled by Tokyo Shoko Research, LTD (TSR)[4] is employed for our analyses, which is also used in regression analyses in the subsequent sections. The TSR data consists of the firm information file and the transaction relationship information file, for around 1 million firms from 2007 to 2016. The firm information file contains industry classification, firm location address, the number of employees, the amount of sales, year of foundation, CEO's name and his/her birthday, while the transaction relationship information file comprises the most important suppliers and customers, each up to 24, which are identified with the TSR ID. Although the number of relationships that each firm can reports is at most 24, we can identify the firms with thousands of relationships by utilising information reported by the other firms. Also, this paper focuses on firm age, and CEO age and CEO turnover, each of which is identifiable by year of foundation, birthday of CEO, and changes in CEO's name, respectively.

In the past 10 years, how did firm age change? Figure 1 shows a change in firm age distribution. The firm age distributions have some peaks, which reflect the differences in the numbers of newly entered firms affected by an economic condition of each year. In the post-WW2 periods, the number of firms increased, and despite the temporal decrease in 1953 due to the recession after the end of special procurement demand during the Korean War, it carried on rising until the oil crises. Its growth slowed down afterwards, which turned to be an upper trend after Plaza Accord in 1985, and eventually it exhibits a significant decline after the collapse of bubble economy. These peaks in the distributions of the number of firms look similar to those in population distribution owing to baby booms, and the pyramid of the number of firm shifts similarly.

[4] The coverage of the TSR data have become larger year by year, and so this is not suitable for the analysis with a variable that depends on the coverage, such as a change in the number of firms. Whereas the number of firms decreased between 2007 and 2016 according to the Census, in the TSR data the number rose as 1,034,221, 1,055,557, 1,104,151, 1,158,362, 1,192,175, 1,240,063, 1,271,668, 1,264,156, 1,256,867, 1,281,440. With regards to a change in the number of clients, it is likely to have an upward bias due to this coverage expansion.

Figure 1. Firm Age Distribution Over Time

Figure 2. Exit Rates by Exit Type Over Time

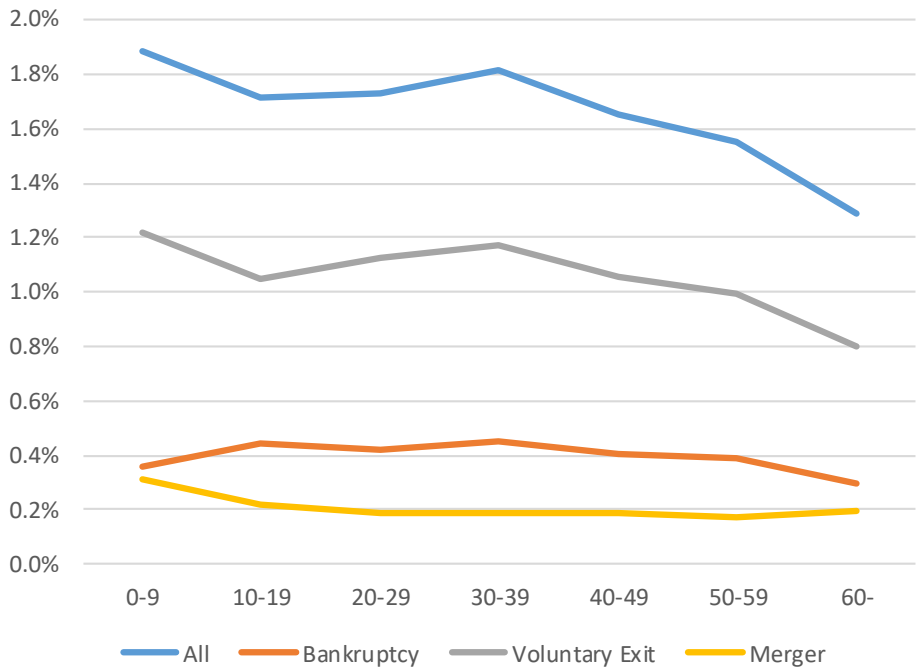


Note: X-axis represents years and Y-axis represents exit rates in percent.

The changes in the firm age distribution are formed by aging of existing firms as well as firms' entry/exit pattern. Because the TSR data is not appropriate for analysing firm entry,[5] we concentrate on the exit pattern. Firstly, as can be seen in Figure 2, the exit rate has a decreasing trend in the decade, and this decline accelerates aging. Exit take the forms of closing/dissolution, bankruptcy, merger and so on, and every form has declined. Closing/dissolution, which is voluntary, account for the largest share, while exit by merger is very few. Exit by bankruptcy declines, which may reflect the malfunction of selection effect of bank.

Besides, for the relationship between firm age and exit rate, Figure 3 shows that exit rates of young firms are higher than old firms. In order to prevent firm aging, firm entry rate should be large enough to supplements high exit rate of young firms. Further, we need to clarify underlying causes of young firms' high exit rate support firm growth.

Figure 3. Exit Rates by Firm Age



Note: Each bin on the x-axis represents firm age. Y-axis represents exit rates in percent.

[5] Since firm data is added to the TSR database after a survey, in the case where a firm is not investigated soon after its entry, there can a gap between the entry year and the first recorded year of the firm on the database. This is why the TSR data is not desirable for an analysis of firm entry. Besides, because of the coverage improvement as discussed above, the share of newly entered firms that are investigated seemed to increase. Around 2007 not many young firms are surveyed and thus the coverage was limited which creates bias, the average firm age observed in the data is considered to be lower than the actual value. Therefore, we infer that the difference in the average firm age between 2007 and 2016 is larger in reality, and the speed of the firm aging is faster than observed.

Next, we will see how firm CEO age changed. Figure 4 shows the change in the distribution of the average CEO age over time. First of all, the shift in the peaks can be observed in the distribution of the CEO age. The peak of the distributions corresponds to baby boom generation, and it locates within working ages. The change in the distribution is formed by aging of the CEO, the pattern of CEO change, and the difference in age distributions of newly entered and exited firms.

Figure 5 describes a downward trend in the probability of CEO turnover, which, in turn, led to aging of CEOs. In addition, Figure 6 shows the exit rates by CEO age, indicating that older CEOs have higher exit rate. There is a positive correlation between firm exit rates and CEO age. Moreover, the exit in the form of closing/dissolution, so-called "voluntary exit," is the most frequent type of firm exits amongst the firms with old CEOs. These results suggest that as CEOs become older, firms decide to exit voluntarily with difficulties in finding successors and potential loss of assets due to stagnated development of exit by merger.

Figure 4. CEO Age Distribution Over Time

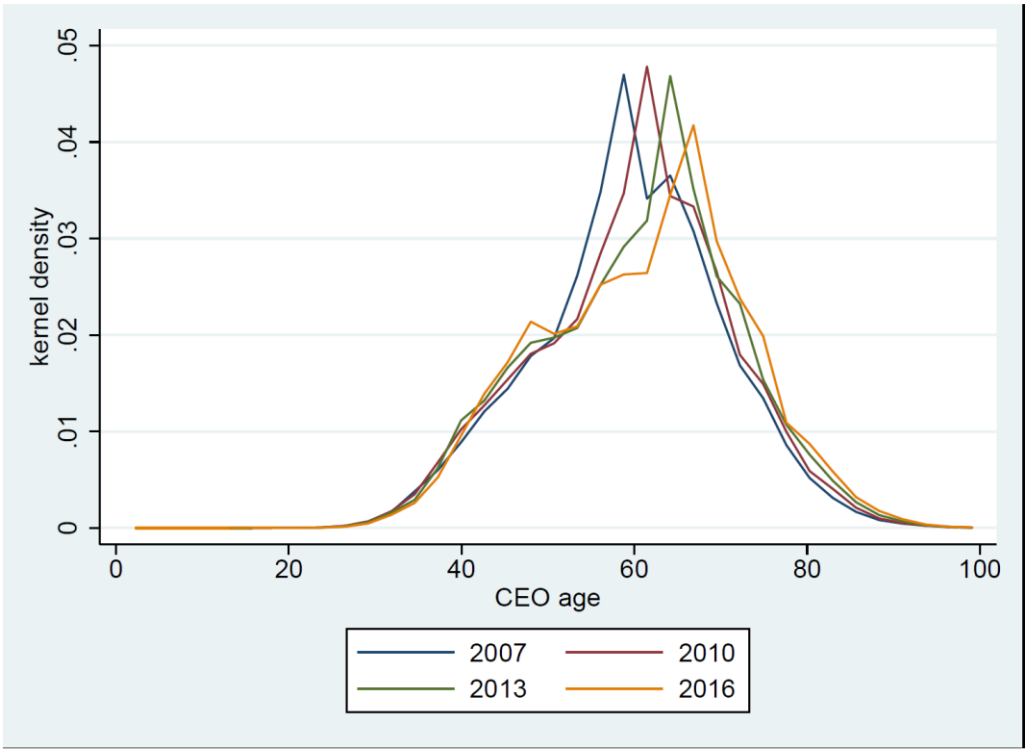
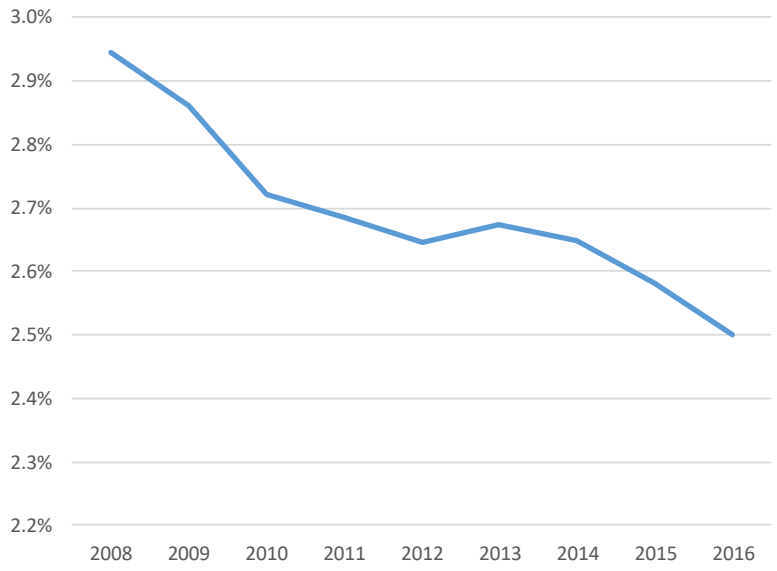
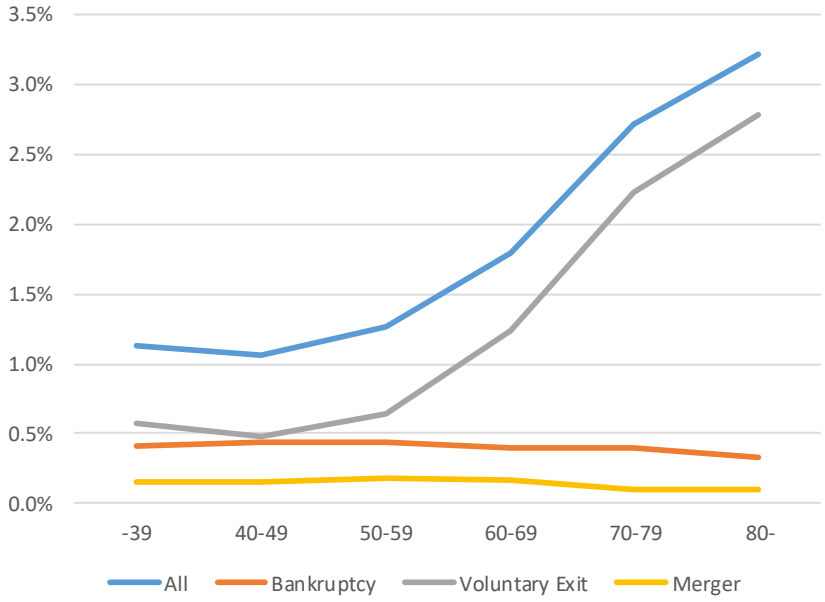


Figure 5. CEO Turnover Ratio



Note: X-axis represents years and y-axis the share of firms that changed CEOs.

Figure 6. Exit Rates by CEO Age: by Exit Type



Note: Each bin on the x-axis represents age group of CEOs. Y-axis represents exit rates in percent.

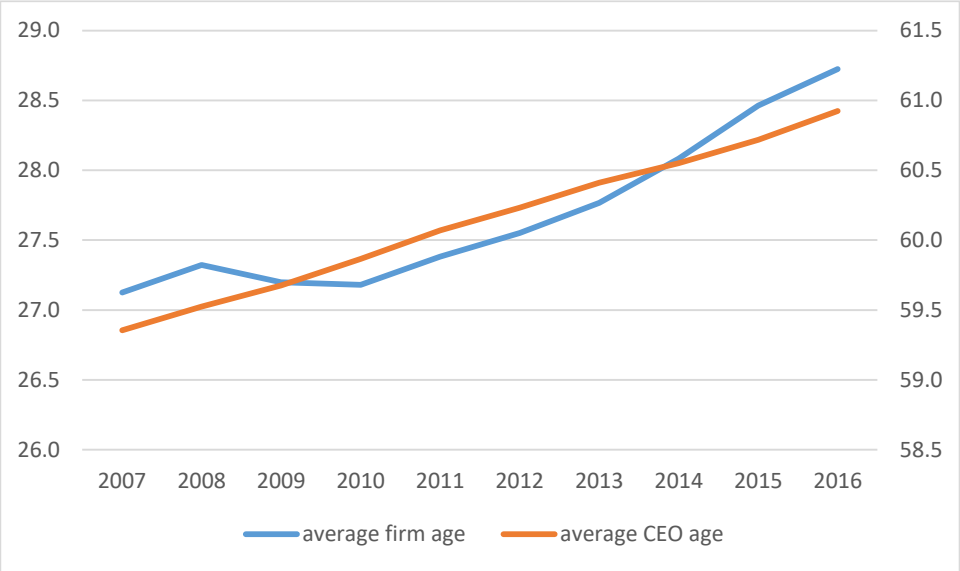
Figure 7 exhibits the distributions of the representative age before and after the representative change occurs between 2015 and 2016. The distribution before the change has its peak at around 70 years old, the same as the overall distribution in 2015, and while the changes between 40 and 60 years old are few, a lot of changes occur for those around 70 years old. Additionally, the peak of the distribution after the change is about early 40s, which is comprised by the second-generation baby boomer, observing the alternation of generations, but there is another peak at around 60 years old, implying that some companies did not experience large rejuvenation of the representative.

Figure 7. CEO Age Distribution Before and After Turnover

As argued above, we observe that age of CEOs and firms have both increased over time during the sample period. Average firm age increased from 27 in 2007 to 28.5 in 2016. Average CEO age increased from around 59 years in 2007 to 61 years in 2016 (Figure 8). Next, using the change in average age, we will see how the trends in aging differ between the urban and the rural areas.[6]

[6] We define the following prefectures as the urban area: Tokyo, Kanagawa, Saitama, Chiba, Aichi, Osaka, Kyoto. The rest of Japan is defined as the rural area.

Figure 8. Average Age of Firm and CEOs Over Time.

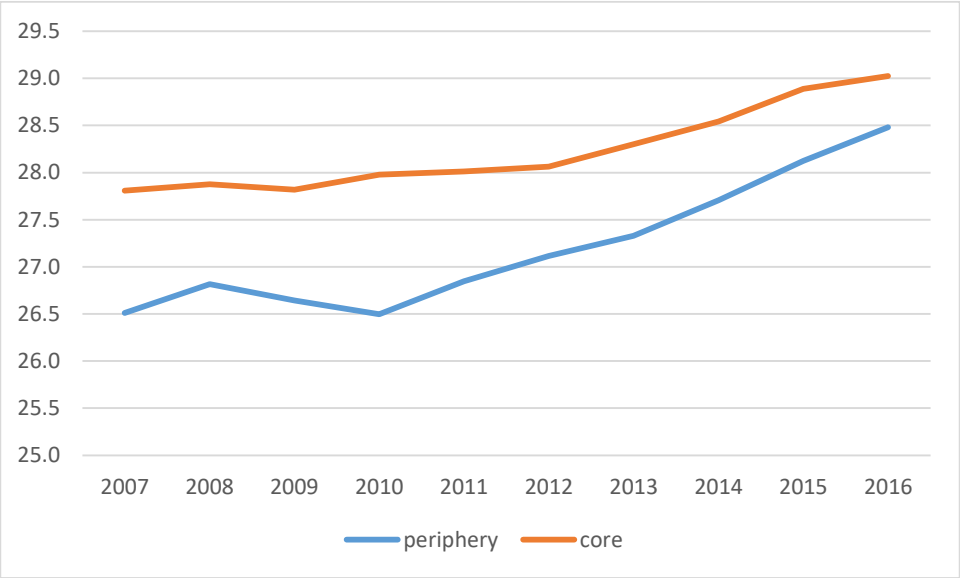


Note: X-axis represents years and Y-axis represents average firm age (left scale) and average CEO age (right scale).

Figure 9 and Figure 10 compare these two areas in terms of average ages of firm and their CEOs, respectively. Whereas average firm age is higher in the urban region, both areas experienced an increase in firm age. However, as shown in Figure 10, although average age of CEOs was originally greater in urban areas, aging in rural areas accelerated, resulting in the reversal of the average age of CEOs in these two areas by the end of the sample. The exit rates decline in both areas in a similar way as shown in Figure 11.[7] However, as Figure 12 shows, the turnover of CEOs was always lower in the rural region, contributing to more rapidly aging CEOs in rural areas

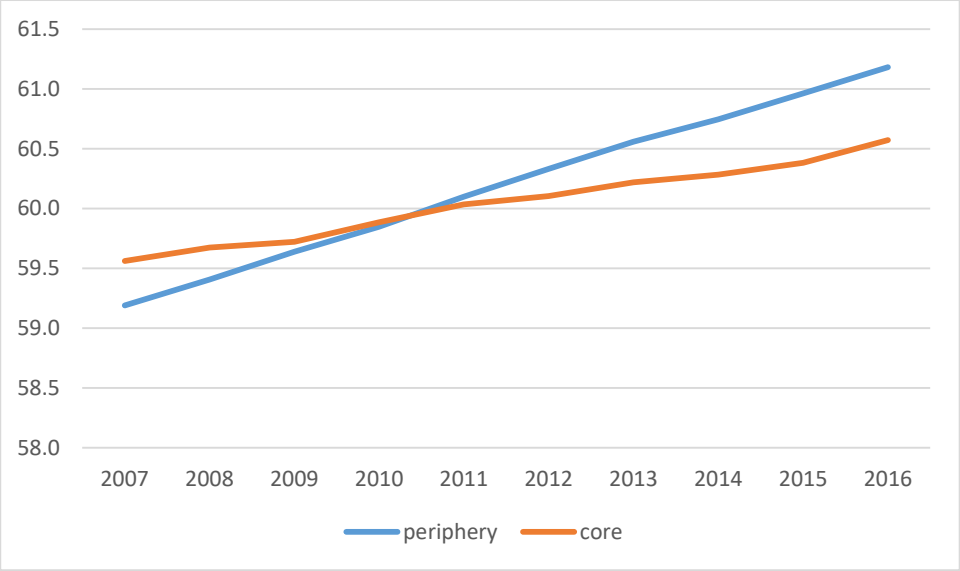
[7] We can see the difference in the firm exit rate between the urban and rural areas through the observations by the forms of the exit. While exit by closing/dissolution comprises a large share in the rural area, the most frequent exit is in the forms of bankruptcy and merger in the urban part. Appendix A shows the descriptive statistics.

Figure 9. Average Firm Age in Urban and Rural Areas Over Time



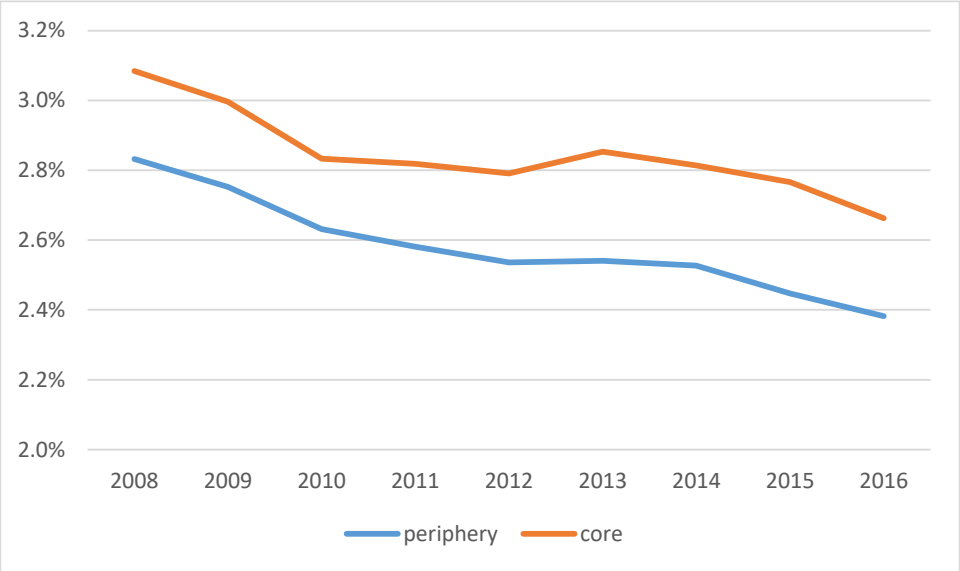
Note: X-axis represents years and Y-axis represents average firm age.

Figure 10. Average CEO Age in Urban and Rural Areas Over Time



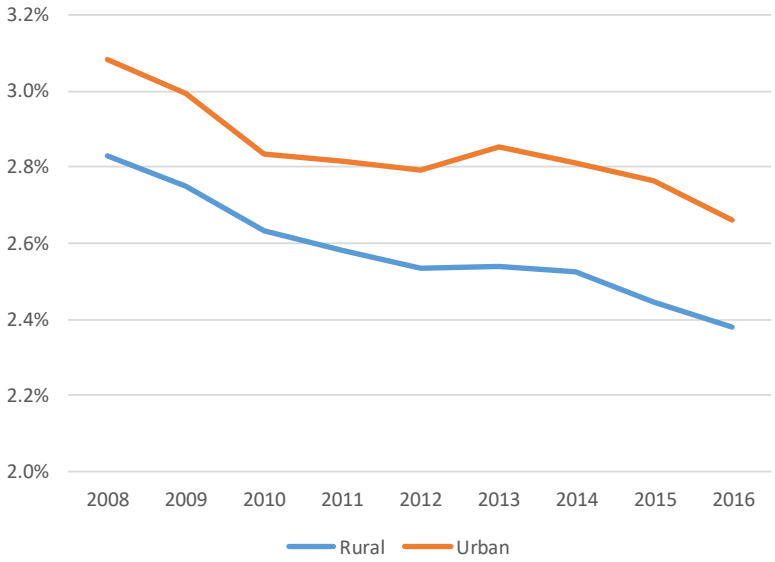
Note: X-axis represents years and Y-axis represents average CEO age.

Figure 11. Firm Exit Rates in Urban and Rural Areas Over Time



Note: X-axis represents years and Y-axis represents exit rate.

Figure 12. Turnover Rate of CEOs in Urban and Rural Areas Over Time



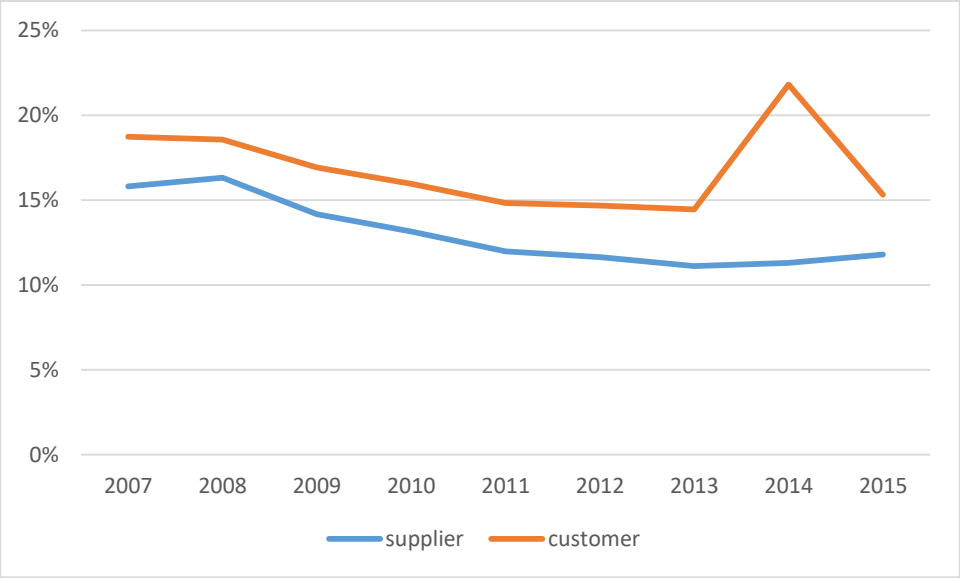
Note: X-axis represents years and Y-axis represents turnover rate of CEO.

How are firms affected by structural changes, exhibited by aging of firm and CEOs as discussed above? In the subsequent sections, we study the relationships between firm and its representative age, and firm dynamics, using regression analyses. Furthermore, as firm dynamics is considered to be closely associated with inter-firm network, firm growth and firm exit will essentially be related to inter-firm network. Because the construction of the

inter-firm network has geographical friction, building a relationship with firms located at a distance poses major difficulties. Therefore, when it comes to the differences in the firm dynamics by inter-firm network, taking into account the difference between urban and rural areas as a spatial point of view will deepen our understandings.

Before we introduce the regression results of firm dynamics from the next section, since here we investigate the evolution of changes in inter-firm network. Figure 13 shows the change in the average share of new partners out of all partners. Except for an unusual movement observed in 2014 for consumers, there is an overall downward trend in new connections. It implies that inter-firm network became more inflexible over the sample period.

Figure 13. Share of New Partners to All Partners Over Time



Note: X-axis represents years and Y-axis represents share of new partners

3. Inter-firm Network and its Impact on Firm Growth

In this section, we explore the relationships with firm age, CEO age, and the CEO change, paying particular attention to the changes in inter-firm network and firm growth. We use, for the change in the inter-firm network, new construction of suppliers (lnindeg_new), new construction of customers (lnoutdeg_new), change in the number of suppliers (lngrowth_indeg), and change in the number of customers (lngrowth_outdeg), and change in sales (lngrowth_sales) as firm growth, as dependent variables,[8] while as independent variables, firm age (lnage), CEO age (lnage_exe), and the CEO change dummy (d_change_exe).

Table 1. Relationship between Inter-Firm Connections and Sales Growth

VARIABLES	lnindeg_new	lnoutdeg_new	lngrowth_indeg	lngrowth_outdeg	lngrowth_sales
lnage	-0.0247***	-0.0223***	-0.00582***	-0.00559***	-0.0222***
	(0.000443)	(0.000470)	(0.000313)	(0.000350)	(0.000387)
lnage_exe	-0.00704***	-0.0339***	-0.0165***	-0.0227***	-0.0480***
	(0.00126)	(0.00137)	(0.000897)	(0.00104)	(0.00102)
d_change_exe	0.0372***	0.0166***	0.00442***	-3.85e-05	-0.00961***
	(0.00155)	(0.00159)	(0.000825)	(0.000941)	(0.00110)
lnindeg	0.208***	0.0363***	-0.0723***	0.0186***	-0.00302***
	(0.000443)	(0.000388)	(0.000256)	(0.000281)	(0.000280)
lnoutdeg	0.0174***	0.197***	0.0163***	-0.0760***	0.00261***
	(0.000355)	(0.000419)	(0.000196)	(0.000256)	(0.000230)
lnemp	0.106***	0.0634***	0.0351***	0.0267***	0.0150***
	(0.000282)	(0.000283)	(0.000185)	(0.000204)	(0.000219)
Constant	-0.0517***	0.227***	0.0759***	0.165***	0.274***
	(0.00662)	(0.00713)	(0.00492)	(0.00575)	(0.00519)
prefecture fixed effect	yes	yes	yes	yes	yes
industry fixed effect	yes	yes	yes	yes	yes
year fixed effect	yes	yes	yes	yes	yes
Observations	3,730,867	3,730,867	2,602,413	2,599,733	2,633,121
R-squared	0.338	0.260	0.042	0.045	0.026

The regression results show that the coefficients of firm ages are all negative. This indicates that as older firms are less likely to create new suppliers or consumers. Also, the growth rate of consumers and suppliers, as well as sales growth are negatively correlated with firm age. In addition, CEO ages are correlated with all the dependent variables, suggesting that as CEOs age, the network gets inflexible as seen in Figure 12, and sales growth and network growth stagnate. On the other hand, those firms that experience

[8] We add 1 to every observation as there are a number of them with zero new client.

turnovers in CEOs tend to build relationships with new clients, which may alleviate the inflexibility of the network.

4. Effect on Firm Exit

Next, we analyse the relationship with firm exit. Setting the exit dummy regardless of the form of exit (d_exit), the bankruptcy dummy (d_tosan), the closing/dissolution dummy (d_kaihaikyu), and the merger dummy (d_gappei) as dependent variables, and firm and its CEO age as independent variables, we run regressions.

Table 2. Probability of Firm Exit (Probit Regressions)

VARIABLES	d_exit	d_exit_tosan	d_exit_kaihaikyu	d_exit_gappei
lnage	-0.0477***	-0.0485***	0.0529***	-0.201***
	(0.00305)	(0.00446)	(0.00443)	(0.00563)
lnage_exe	0.581***	0.119***	0.969***	0.115***
	(0.0101)	(0.0143)	(0.0147)	(0.0213)
d_change_exe	0.158***	-0.0953***	0.130***	0.320***
	(0.00934)	(0.0158)	(0.0154)	(0.0134)
lnindeg	0.0242***	0.0752***	-0.0584***	0.0152***
	(0.00256)	(0.00375)	(0.00364)	(0.00519)
lnoutdeg	-0.0470***	0.00970***	-0.0916***	-0.0392***
	(0.00229)	(0.00336)	(0.00332)	(0.00435)
lnemp	-0.109***	-0.0830***	-0.259***	0.141***
	(0.00193)	(0.00293)	(0.00287)	(0.00363)
Constant	-4.521***	-3.347***	-6.154***	-3.369***
	(0.0512)	(0.0770)	(0.0717)	(0.112)
prefecture fixed effect	yes	yes	yes	yes
industry fixed effect	yes	yes	yes	yes
year fixed effect	yes	yes	yes	yes
Observations	3,730,842	3,730,842	3,730,842	3,730,842

While we observe the relationships between firm/CEO age and the exit rate in Section 2, we still see, controlling other firm characteristics, that the firm age work negatively on firm's exit probability and thus it is less likely to exit as its firm age gets higher, and that the CEO age has positive coefficients and so a firm is more likely to exit as the CEO age becomes higher. However, only for closing/dissolution, controlling other firm characteristics makes the coefficient on the firm age positive, in contrast to Figure 3,

indicating that as the firm becomes older it is more likely to exit. Additionally, the size of the coefficient on the CEO age is higher for the closing/dissolution dummy compared to other types of exit, which shows a firm is more likely to exit in the form of closing/dissolution as the CEO age gets higher. From these results, we can see that firms take different forms of exit by firm and its CEO ages.

Then, how does the firm exit spill-over through the inter-firm network? Using probit regressions, we analyse how exits of connected firms are related to the probability of a firm exit. Here, we exclude exits by mergers, and we focus on the total exits, exits by bankruptcy, and voluntary exits from closure/dissolution. Table 3 shows that irrespective of the exit forms, the spill-over effects of clients' exit is statistically significant, implying that those firms whose customers and suppliers exit are more likely to exit.

Table 3. Propagation of Firm's Exits (Probit Regressions)

VARIABLES	d_exit	d_exit_tosan	d_exit_kaihaikyu
mean_d_exit_s	0.345***		
	(0.0190)		
mean_d_exit_c	0.496***		
	(0.0181)		
mean_d_exit_tosan_s		1.057***	
		(0.0356)	
mean_d_exit_tosan_c		1.239***	
		(0.0303)	
mean_d_exit_kaihaikyu_s			0.168***
			(0.0436)
mean_d_exit_kaihaikyu_c			0.282***
			(0.0413)
Constant	-4.533***	-3.387***	-6.153***
	(0.0513)	(0.0777)	(0.0717)
prefecture control	yes	yes	yes
industry control	yes	yes	yes
year control	yes	yes	yes
firm control	yes	yes	yes
Observations	3,730,842	3,730,842	3,730,842

Note: "mean_d_exit_s" refers to the average exit rate of suppliers of all exit types. "mean_d_exit_c" refers to the average exit rate of consumers of all exit types. "mean_d_exit_tosan_s" refers to the average bankruptcy rate of suppliers. "mean_d_exit_tosan_c" refers to the average bankruptcy rate of consumers. "mean_d_exit_kaihaikyu_s" refers to the average voluntary exit (closure/dissolution) rates of suppliers. "mean_d_exit_kaihaikyu_c" refers to the average voluntary exit(closure/dissolution) rates of suppliers. All variables are averaged at prefecture- and year-level.

With respect to the size of the spill-over effects of firm exits, we find that the coefficients on bankruptcy are larger than others, suggesting that the exit by bankruptcy is more likely to be led to partners' bankruptcy. For bankruptcy, customers' bankruptcy have higher positive correlation with connected firms' bankruptcy, compared to suppliers' bankruptcy.[9]

Next, we investigate the differences in propagation effects across regions. The intuition is that firms in rural areas will have higher propagation effects of exits of connected firms, since firms in rural areas have fewer number of connected firms to begin with. Also, lower density of firms for a given area makes it difficult for firms to find replacements if connected firms exit in rural areas. We add the interaction terms of clients' exit rate and the urban area dummy, referred to as 'core' (Table 4).[10] Interaction terms have negative coefficients, indicating that the spill-over effects are larger in rural areas than in urban areas. For total exits, the spill-over effects of consumers in urban areas are smaller than those in rural areas. For bankruptcy, the spill-over effects of both consumers and producers in urban areas are smaller than those in rural areas. We do not find significant differences in voluntary exits (closure/dissolution).

[9] However, Carvalho, Nirei, Saito and Tahbaz-Salei (2016) shows that the spill over effect is larger from the suppliers, and the effect reaches indirect clients such as a client's client.

[10] 'Urban' areas include the following prefectures: Tokyo, Kanagawa, Chiba, Saitama, Aichi, Osaka and Kyoto prefectures. All other prefectures are 'rural' in our paper.

Table 4. Propagation of Firms Exits: Core vs. Rural Area (Probit Regressions)

VARIABLES	d_exit	d_exit_tosan	d_exit_kaihaikyu
mean_d_exit_s	0.347***		
	(0.0260)		
mean_d_exit_c	0.525***		
	(0.0236)		
mean_d_exit_tosan_s		1.138***	
		(0.0502)	
mean_d_exit_tosan_c		1.290***	
		(0.0384)	
mean_d_exit_kaihaikyu_s			0.197***
			(0.0601)
mean_d_exit_kaihaikyu_c			0.296***
			(0.0526)
mean_d_exit_s_core	-0.00550		
	(0.0381)		
mean_d_exit_c_core	-0.0733**		
	(0.0369)		
mean_d_exit_tosan_s_core		-0.161**	
		(0.0714)	
mean_d_exit_tosan_c_core		-0.134**	
		(0.0628)	
mean_d_exit_kaihaikyu_s_core			-0.0566
			(0.0874)
mean_d_exit_kaihaikyu_c_core			-0.0384
			(0.0851)
Constant	-4.507***	-3.323***	-6.046***
	(0.0635)	(0.0947)	(0.0880)
prefecture fixed effect	yes	yes	yes
industry fixed effect	yes	yes	yes
year fixed effect	yes	yes	yes
firm control	yes	yes	yes
Observations	3,730,842	3,730,842	3,730,842

Note: Variables written as "X_core" are interaction terms that interact variable "X" with core dummy, where core dummy takes value 1 if prefectures are in core regions, and 0, otherwise. For descriptions of "X", please refer to the footnote of Table 3.

5. Conclusion

This study explores that firm age and CEO age have structurally changed firm dynamics such as firm entry and exit in Japan. The followings are revealed by our analyses. As firm and its CEOs age, firm's growth stagnates, building of new business relationship is less likely to occur, and the inter-firm network becomes inflexible. However, turnover of CEOs can mitigate the inflexibility of firms' network. Also, due to inflexible inter-firm network, the exit of transaction partners propagates through inter-firm network and increases the likelihood of the exit of own firms. Furthermore, the spill-over effects are larger in rural areas. This is because firms are less likely to find alternative connections when partner firms exit due to lower density of firms in rural areas,

Our findings suggest that voluntary exits are likely to increase going forward as aging trend exacerbates in Japan. Policies should be considered that help facilitate aging CEOs to find successors for potentially profitable and productive firms. Inflexible and persistent inter-firm networks seem to be a result of aging firms and aging CEOs. Also, the exit of firms propagates through these inflexible inter-firm networks. Therefore, it is crucial to incentive firms to continue searching for new business connections and potential partners beyond the business partners that they have worked together with. Also, as such propagation effects through inter-firm networks are larger for rural areas, the efforts to address these issues and make networks more flexible should be greater for rural areas.

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Appendix A. Regional Comparison of CEO Age Distribution

In the body of this paper, comparing the average CEO age between the urban and rural areas, we see that, although in 2007 the average age is higher in the urban area, because the rate of the CEO change is lower and as a result the aging of the CEO advanced faster in the rural area, the average age in the rural region becomes greater than that in the urban counterpart. This section closely looks at the age distributions.

Figure A-1 compares the changes in the distributions of the CEO age between the urban and rural areas. The large peak in the 2007 age distribution corresponds to the baby boom generation, and because, similar to the demographic pyramid, there are the generations born during and soon after the WW2 with smaller population sizes before the baby boomers, it looks like there are two peaks in the distributions. We can see that a proportion of the baby boomers in the CEO is large in the rural part while the urban area has more CEOs born before the end of the WW2. Besides, though a proportion of young CEOs aged around 40 is slightly larger in the urban region, since the differences in the peaks between the regions are much bigger, the average CEO age is as a result higher in the urban areas. On the other hand, in 2016, whereas the peak of those born in the pre- or during the war disappears in both regions, the peak by the baby boomers remains to consist of a large share, the average age is higher in the rural area owing to the increase in the proportions of relatively young generations in the urban area, from the second generation baby boomer aged early 40s to early 50s. In addition, Figure A-2 and A-3 indicate the gradual changes in the CEO age distribution in urban and rural areas, respectively.

Lastly, we compare the age distributions before and after the CEO change between the urban and rural areas. The age distribution before the change exhibits an advanced aging in the rural area, and this is considered to be because the rural area is more aged in all the distribution of the CEO, as observed in Figure B-1. On the other hand, we can see that the probability of being younger is higher in the rural area in the after-the-change distribution. This implies that while the probability of the CEO change is lower in the rural region, the age gets lower substantially when the change happens. We can see that the increase in young CEO in the urban more than the rural area in Figure B-1 is caused not by the difference in the age distributions after the change, but rather by the difference in the probability of the CEO change.

Figure A-1 Comparison of CEO age distributions in Urban and Rural Areas

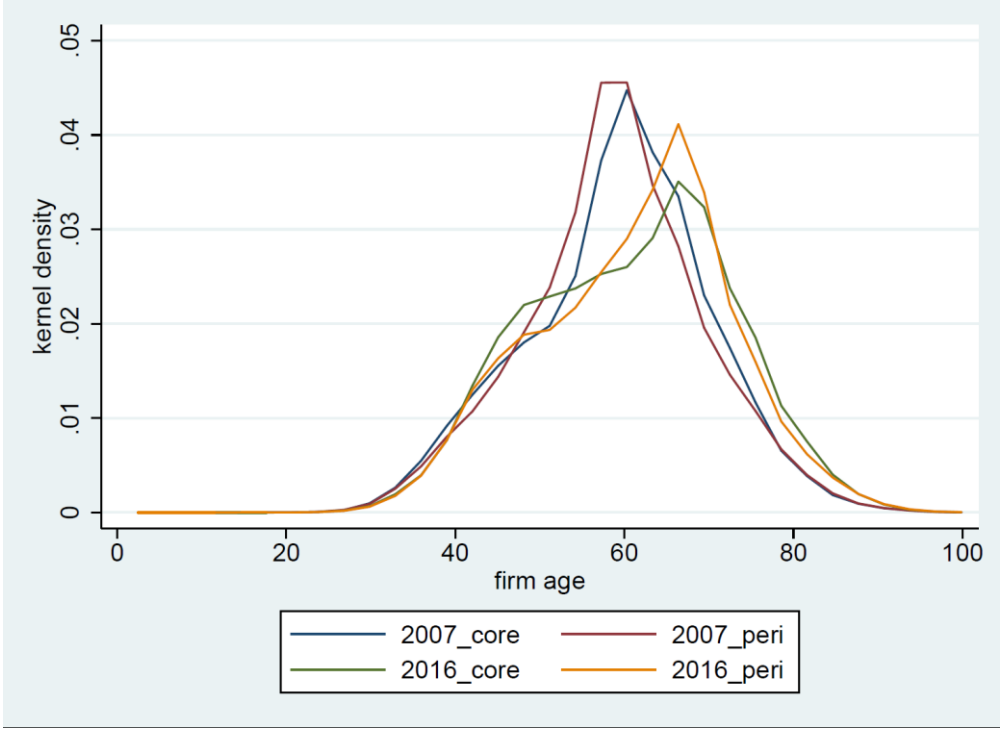

Figure A-2 Changes in CEO age distributions in Urban Areas

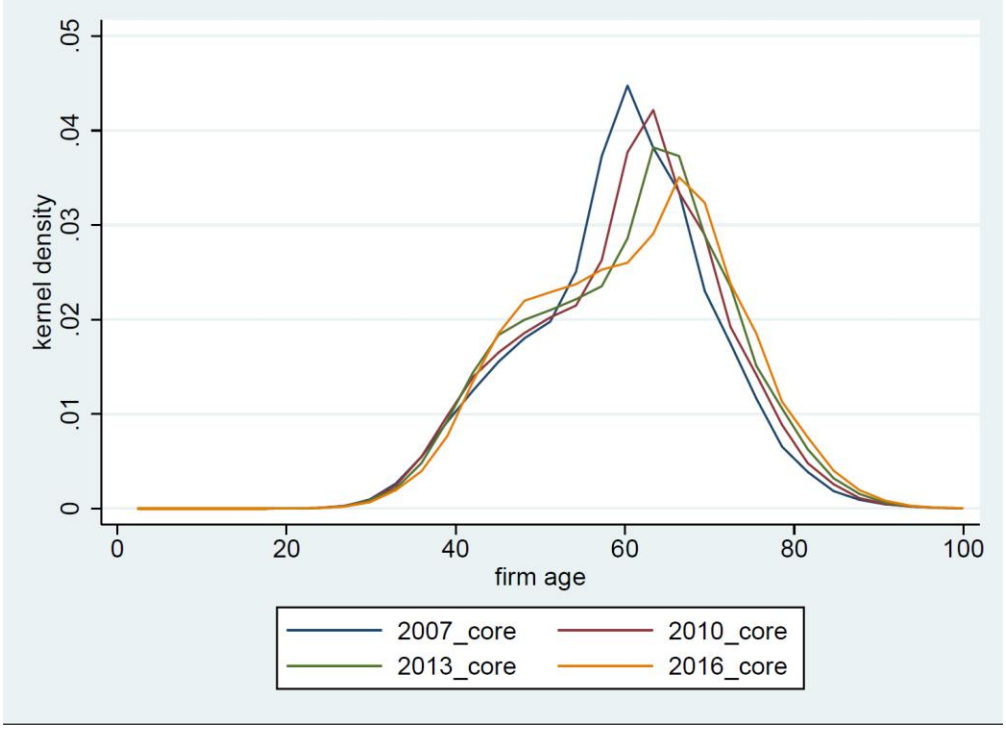

Figure A-3 Changes in CEO age distributions in Rural Areas