The Dynamics of Interfirm Networks and Firm Growth

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Motivation

- Importance of analyzing the life cycle of a firm and growth patterns
  - Short-run: aggregate fluctuations and business cycles
  - Long-run: industry dynamics and economic growth
- Despite the recent surge of research on firm dynamics using micro data, no research has focused on the dynamics of interfirm production networks
- This research examines the dynamics of interfirm networks and how it relates to firm age and firm growth using panel data of Japanese supplier-customer network data.

Main empirical results

1. Older firms are larger in size, have more transaction partners, and their partners' average age is higher (assortativity)
2. Interfirm networks exhibit a higher rate of metabolism (link birth and death) compared to that of industry dynamics with firm entry/exit
3. Younger firms tend to add and drop links more frequently, and the stability of a transaction link increases with the duration of active relationship
4. Firm's sales growth is positively related with the expansion of transaction partners in various measures
5. The positive growth effect of adding a new partner declines and that of maintaining an existing partner increases in firm age

Related literature

- Life cycle of firms and industry dynamics
  - Dunne, Roberts and Samuelson (1988), Arkolakis (2016), Luttmer (2007)
- Firm age and growth
  - Haltiwanger et al. (2013), Evans (1987), Coad et al. (2014)
- Production network formation
  - Lim (2016), Kikkawa et al. (2017), Oberfield (2016), Baqaee (2016)
- Matching between firms and employees
  - Jovanovic (1979 a,b), Farber (1999)

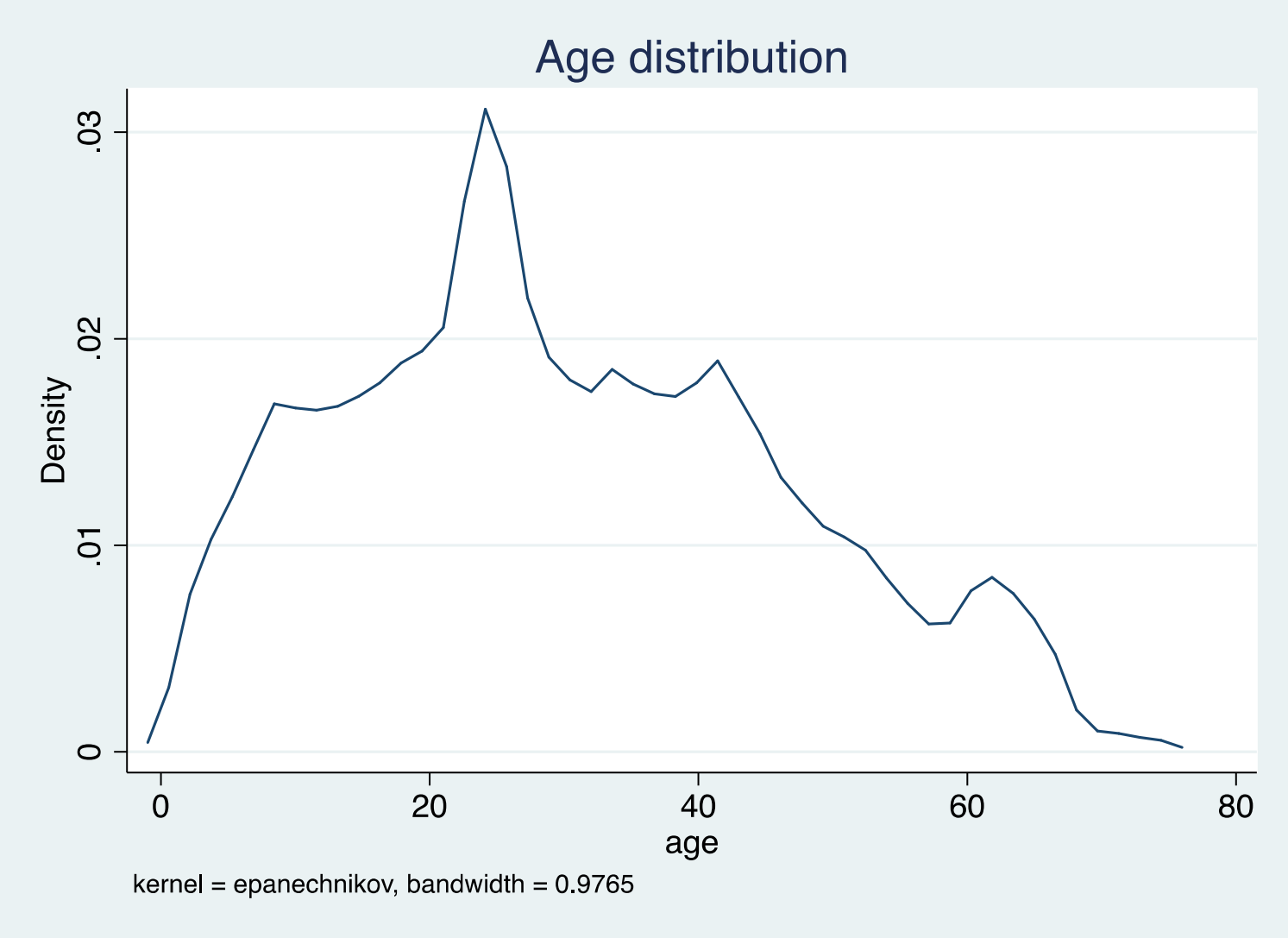
Data

- Tokyo Shoko Research (TSR)
- Sales, number of employees, headquarters address, industry classifications, year of establishment (age)
- Suppliers and customers up to 24 partenrs → merge self- and other-reported data
- Total of 1,899,437 firms are covered with median duration covered 7 years
- Panel (unbalanced) data of 2006-2016

Yearly summary

year	firms	entrants	average age	links	new links	terminated links	link/firm
2016	1224950	22687	28.3	4194850	759841	682439	3.42
2015	1198840	20831	28.0	4117448	834012	675083	3.43
2014	1211590	20379	27.6	3958519	667712	697099	3.27
2013	1213765	19820	27.3	3987906	685341	712436	3.29
2012	1201136	18871	27.0	4015001	673160	640799	3.34
2011	1160461	17726	26.8	3982640	698107	626270	3.43
2010	1127705	17058	26.6	3910803	718351	607268	3.47
2009	1075747	16809	26.6	3799720	775106	617728	3.53
2008	1031324	13910	26.8	3642342	723669	598697	3.53
2007	1006160	12273	26.5	3517370	1119291	583915	3.50
2006	1005489	11290	26.2	2981994			2.97

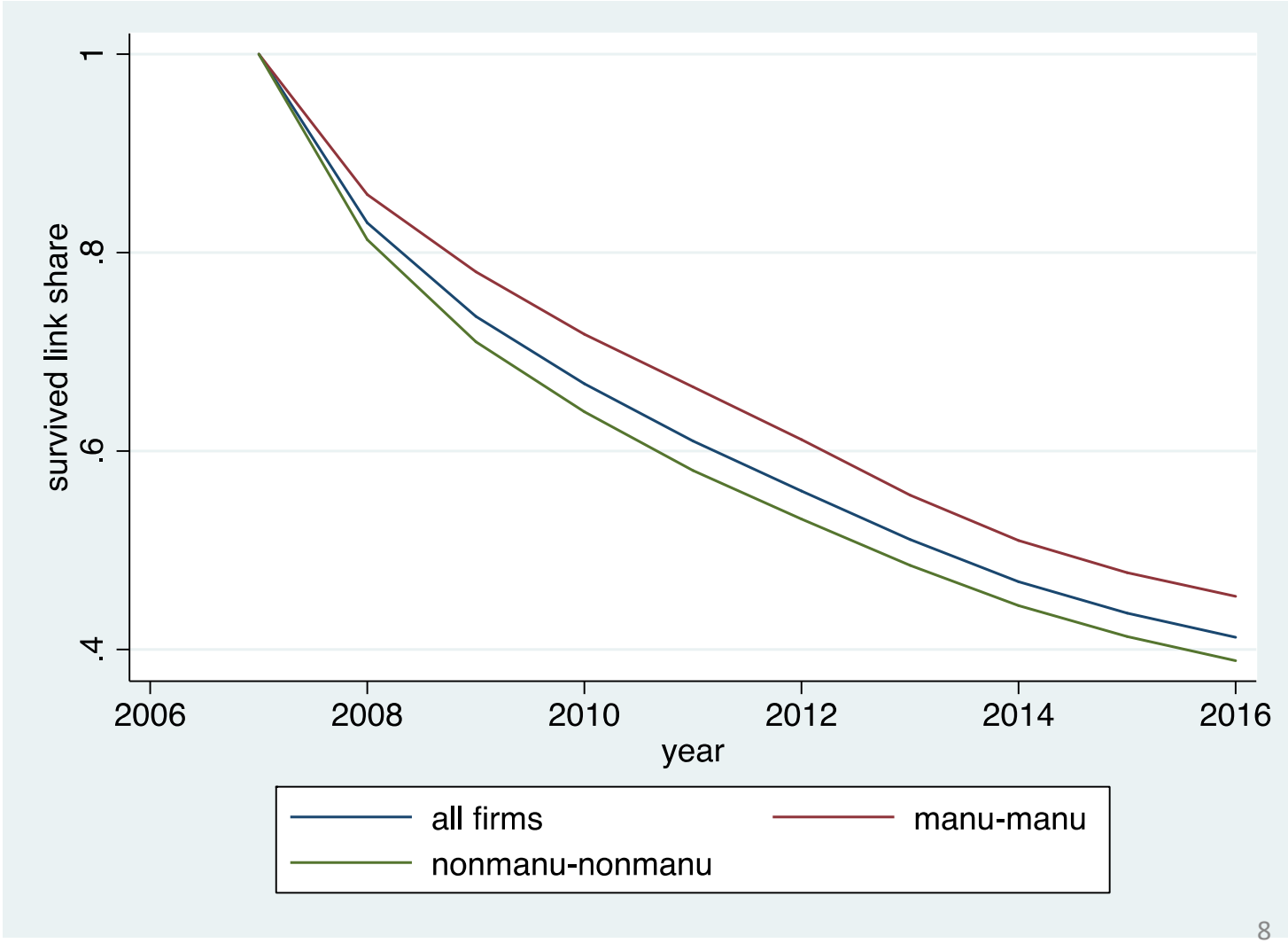
Firm age distribution (2014)



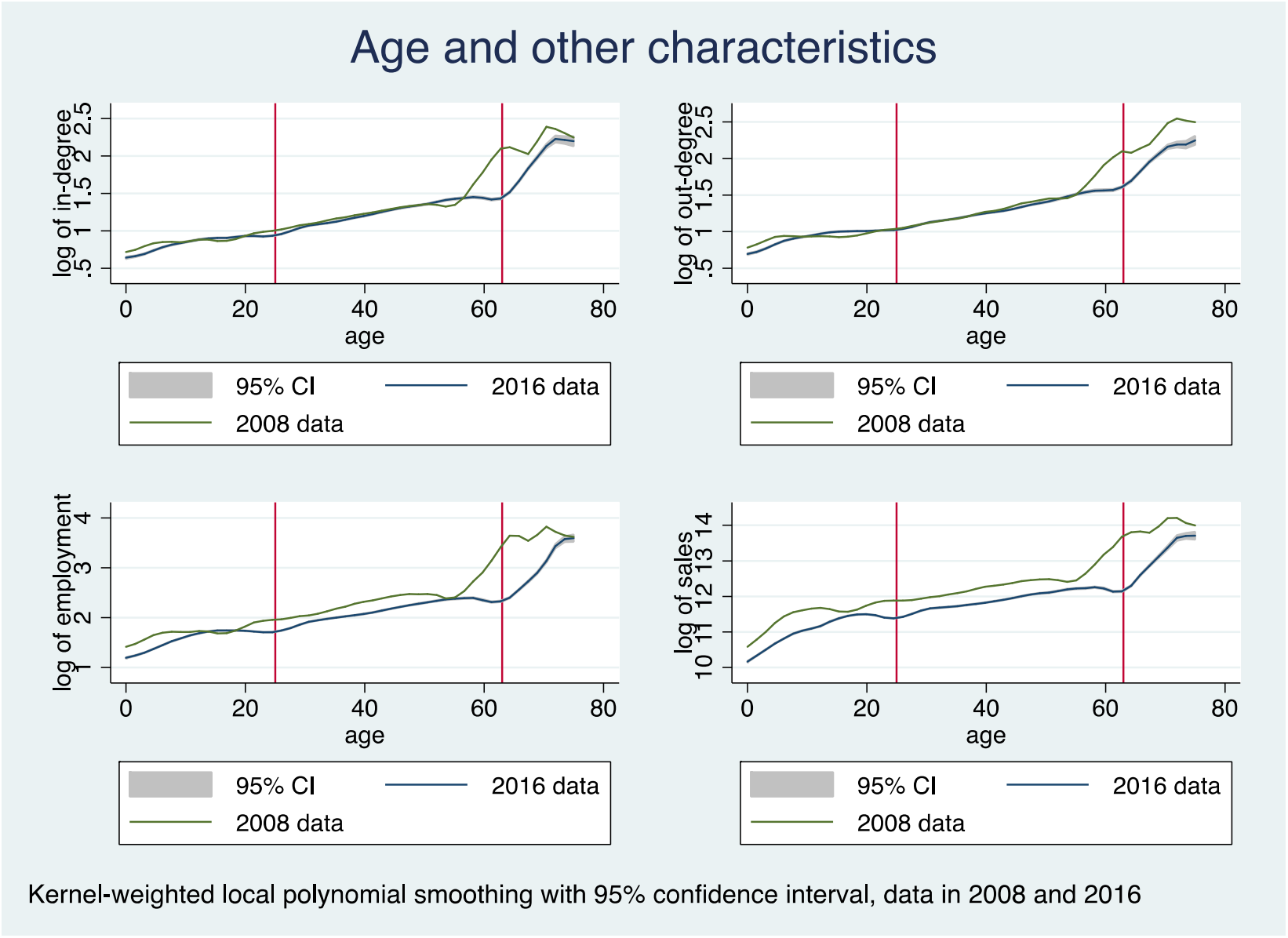
- Spike at:
  - 1989
  - 1973
  - 1953

Link survival rate (2007-2016)

- Half of the initial set of links are gone in 6 years
- High rate of metabolism
- Manufacturing sectors exhibit higher survival rates



Age, size and degrees

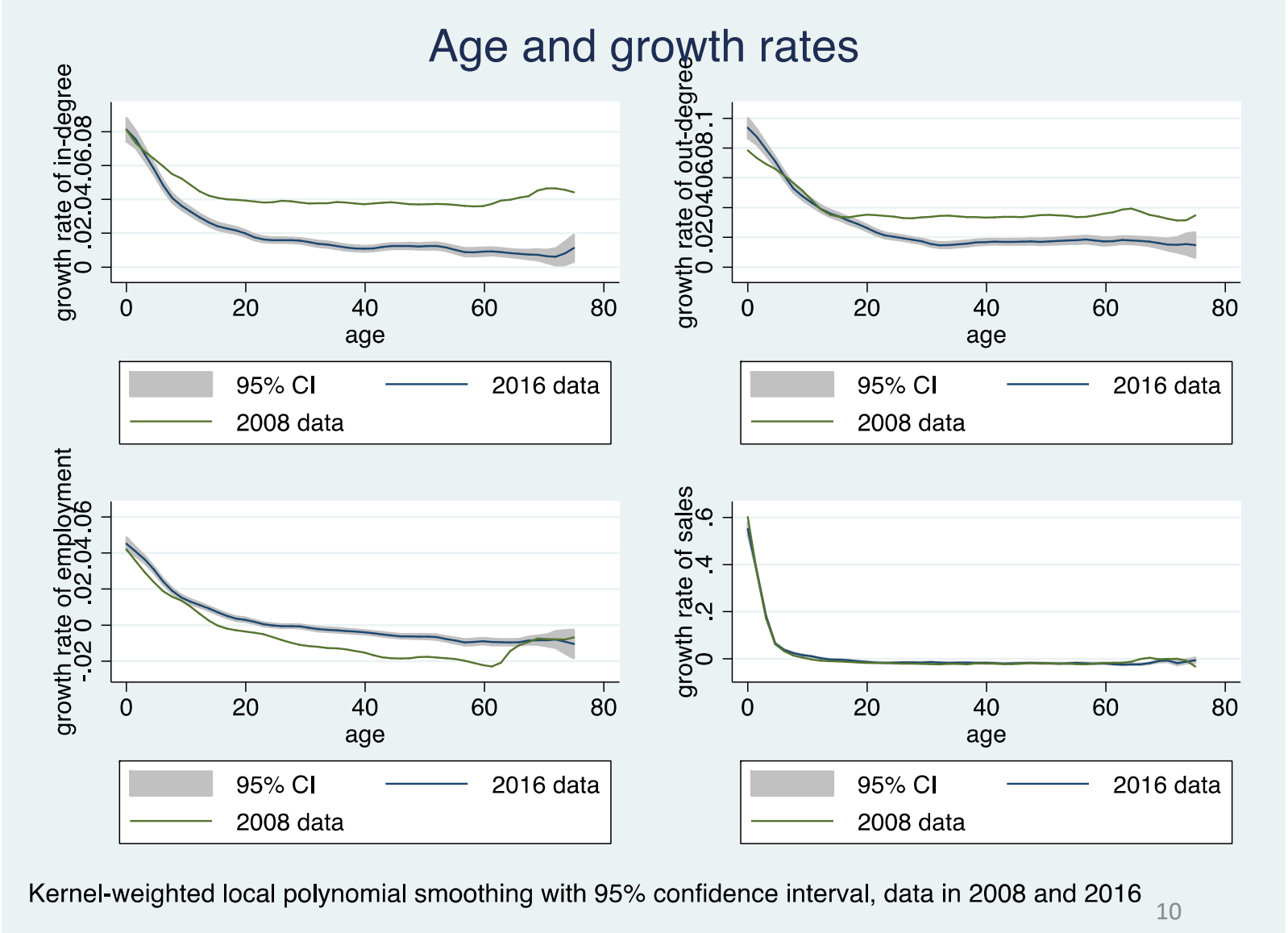


Kernel-weighted local polynomial smoothing with 95% confidence interval, data in 2008 and 2016

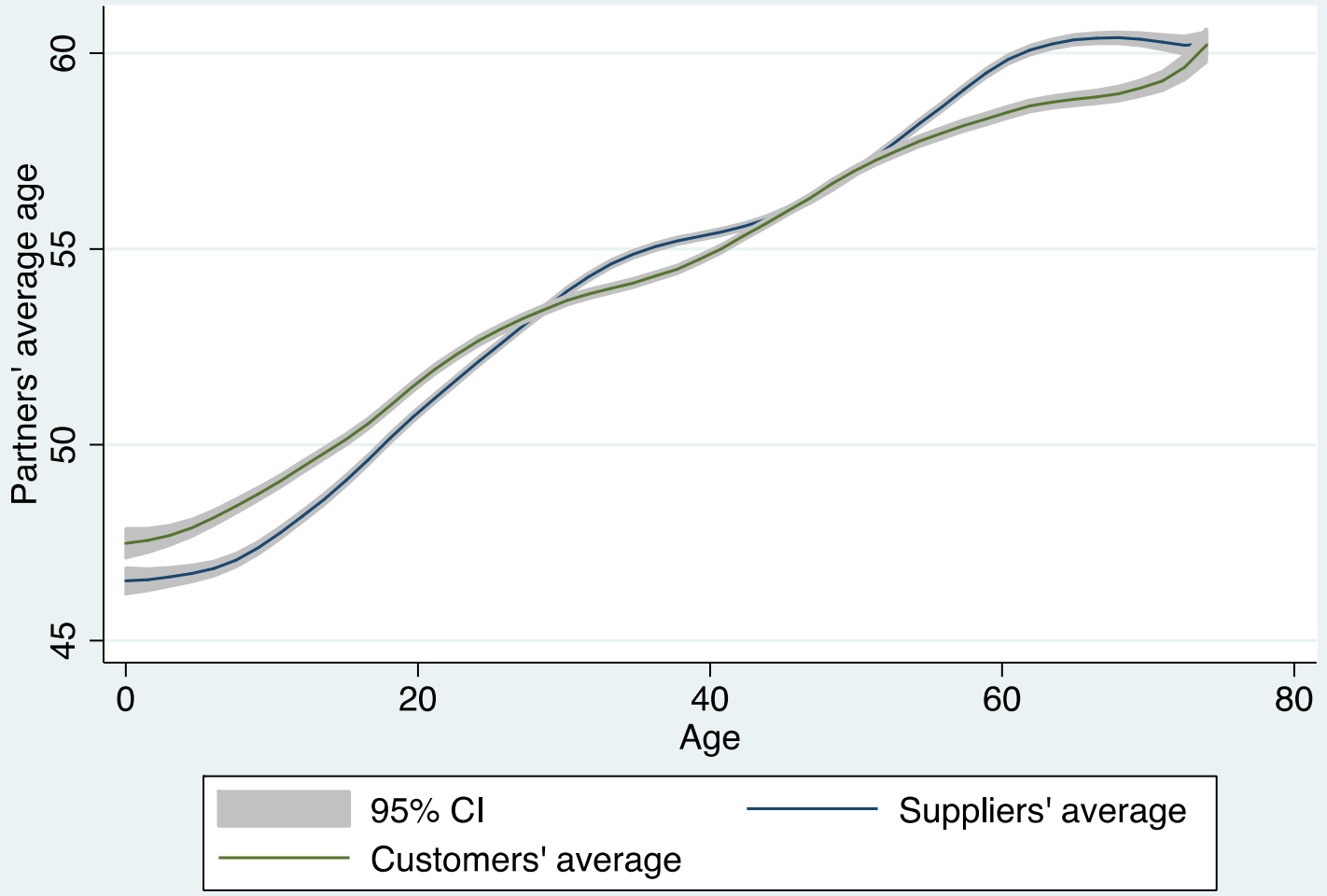
- Older firms are larger and have more partners
- Two kinks at 25 and 64 years old
- Cohort effect

Age and growth rates

- Growth rates declines with age
- Vertical shift but not horizontal shift

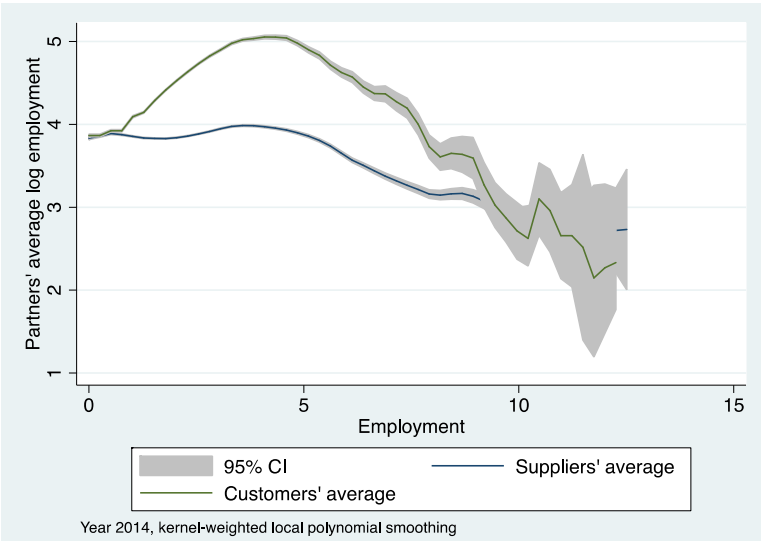


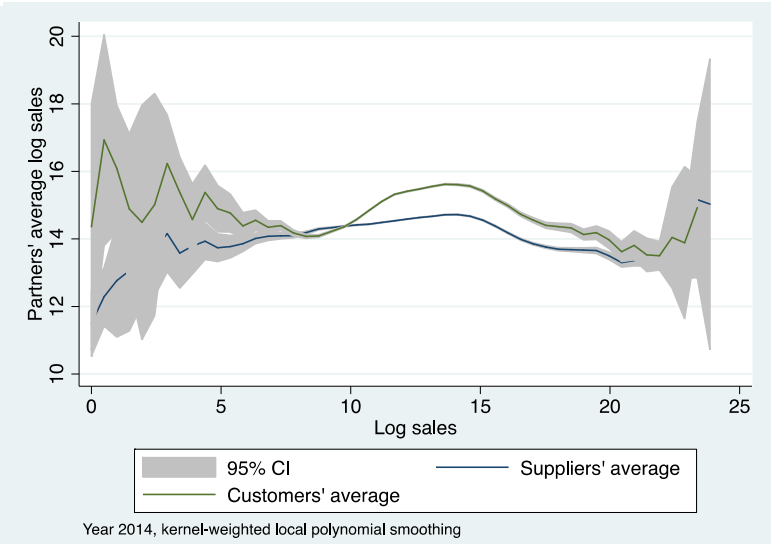
Assortativity (age)

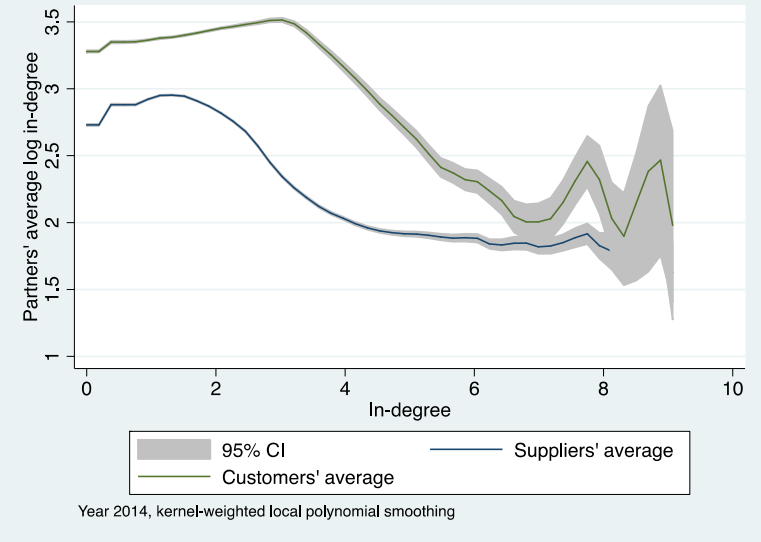


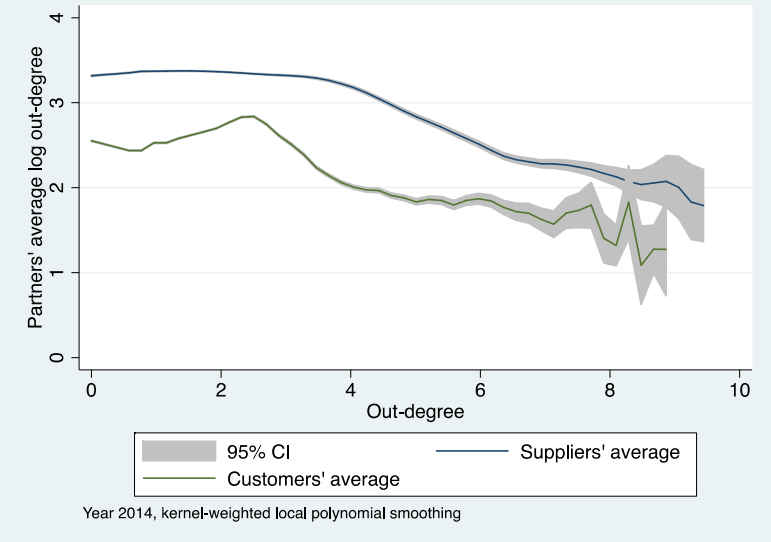
- Older firms are connected to other older firms
- Other variables don’t exhibit this clean relationship

Assortativity (other variables)









Firm-level network dynamics (2014)

Table 1 : THE FIRM-LEVEL LINKAGE DYNAMICS

	In-degree			Out-degree		
	(1)	(2)	(3)	(4)	(5)	(6)
	Add	Drop	Continue	Add	Drop	Continue
Age	-0.0240***	-0.0111***	0.00376***	-0.0248***	-0.00931***	0.00708***
	(0.000491)	(0.000324)	(0.000173)	(0.000483)	(0.000340)	(0.000220)
In-degree	0.283***	0.272***	0.951***			
	(0.000885)	(0.000792)	(0.000173)			
Out-degree				0.270***	0.256***	0.935***
				(0.000847)	(0.000734)	(0.000280)
N	1,097,972	1,097,972	1,097,972	1,097,972	1,097,972	1,097,972
R^2	0.293	0.386	0.972	0.284	0.331	0.950
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Robust standard errors are reported

- As a firm's age increases, less new links are formed and more links survive → higher stability
- For both in- and out-degrees, older firms tend not to add more links (compared to drop)

Table 2 : STABILITY OF INTER-FIRM LINKAGES

	Probit: $I_{Survival>0}$			
	(1)	(2)	(3)	(4)
Log buyer's age	0.0283***	0.0372***	0.0367***	-0.000448
	(0.00147)	(0.00160)	(0.00160)	(0.00163)
Log seller's age	0.0878***	0.0689***	0.0676***	0.0254***
	(0.00143)	(0.00154)	(0.00154)	(0.00157)
Log buyer's sales		-0.00361***	-0.000732***	-0.00209***
		(0.000402)	(0.000413)	(0.000415)
Log seller's sales		0.0190***	0.0226***	0.0188***
		(0.000454)	(0.000468)	(0.000471)
Log link distance			-0.0174***	-0.0147***
			(0.00057)	(0.000573)
Age dummy 2				0.175***
				(0.00290)
Age dummy 4				0.232***
				(0.00316)
Age dummy 6				0.356***
				(0.00264)
N	3,282,948	3,211,750	3,211,750	3,211,750
Industry F.E.	Yes	Yes	Yes	Yes

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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Link-level probit regression

- A link tends to survive if the seller's age is higher
- A link tends to continue if the seller's sales is large and the buyer's sales is small (asymmetry)
- Link stability rises with its tenure → learning about the match specific quality?

Sales growth, age and degrees

Table 3 : FIRM GROWTH RATES BY AGE GROUP

	(1) All ages	(2) Age 0-4	(3) Age 5-9	(4) Age 10-19	(5) Age 20-39	(6) Age 40+
Log age	-0.0679***	-0.327***	-0.104***	-0.0599***	-0.0319***	-0.0334***
	(0.000970)	(0.0135)	(0.0113)	(0.00586)	(0.00352)	(0.00419)
Log employment	0.0178***	-0.00642	0.0116***	0.0199***	0.0208***	0.0153***
	(0.000532)	(0.00559)	(0.00231)	(0.00124)	(0.000771)	(0.000919)
Log degree	0.0137***	0.0151**	0.0123***	0.0133***	0.0138***	0.00845***
	(0.000635)	(0.00652)	(0.00295)	(0.00158)	(0.000923)	(0.00109)
Continuation rate	0.0605***	-0.0260	0.0202*	0.0362***	0.0616***	0.111***
	(0.00332)	(0.0225)	(0.0114)	(0.00675)	(0.00458)	(0.00754)
Creation rate	0.0525***	0.0843***	0.0639***	0.0440***	0.0431***	0.0479***
	(0.00142)	(0.00694)	(0.00424)	(0.00247)	(0.00178)	(0.00351)
Observations	682,391	19,358	46,468	115,032	288,006	213,527
R^2	0.029	0.081	0.019	0.015	0.017	0.022
Industry F.E.	Yes	Yes	Yes	Yes	Yes	Yes

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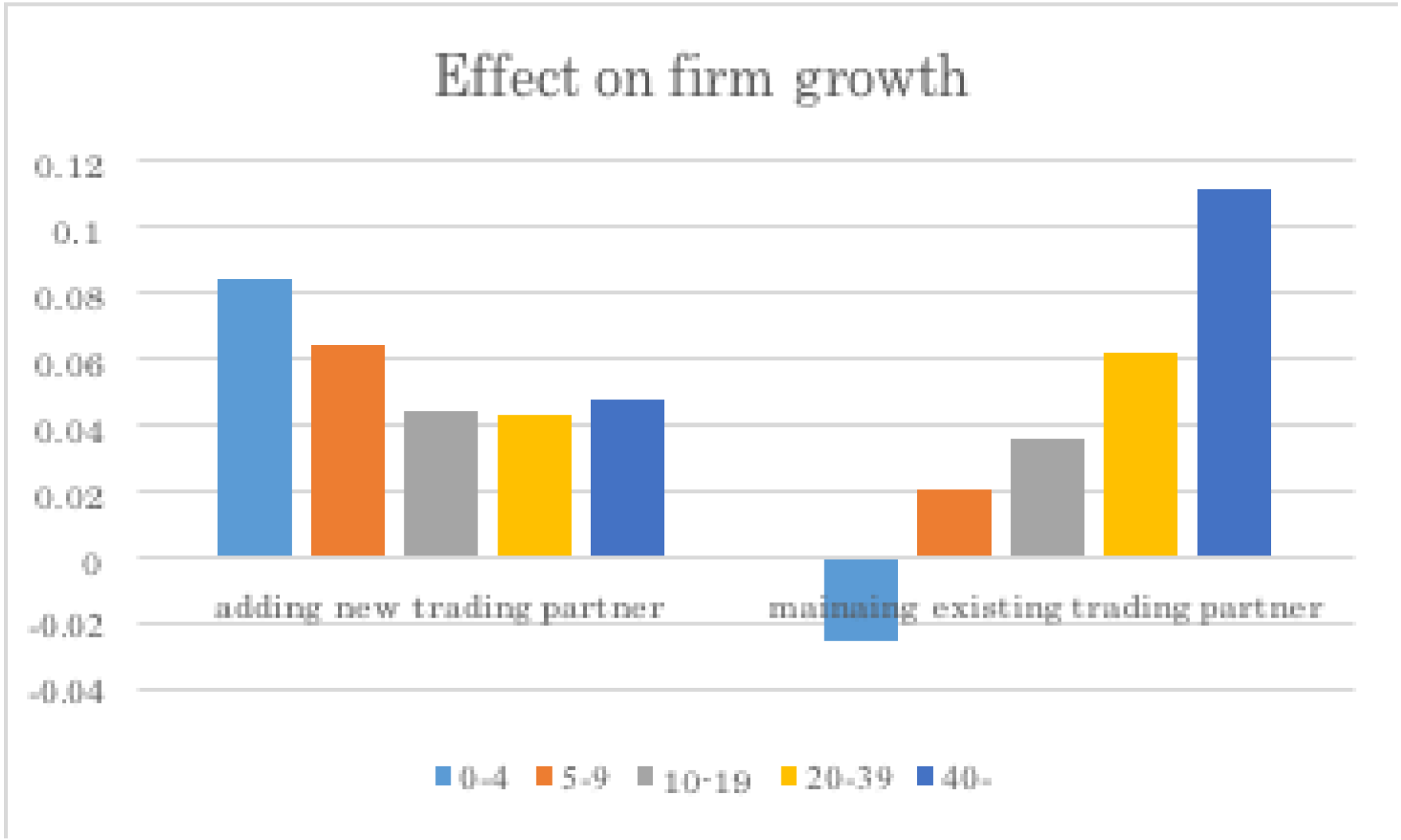
Adding or maintaining a partner



Sales growth, age and degrees

- As age rises, growth rates decrease, but its effect diminishes
- The positive effect of degrees on sales growth rates also diminishes as age rises
- The positive effect of link continuation rate on growth rates increases with age
- Firms that start new transactions have higher growth rates and the effect diminishes with age

Future work

- More rigorous panel data analysis (firm fixed and random effects)
- Build a theoretical framework
  - Explicit production function with intermediate inputs + search model + Bayesian learning of match-specific quality
  - Meeting strangers vs. friends' friends
  - Monte Carlo simulations

Conclusion

1. Older firms are larger in size, have more transaction partners, and their partners' average age is higher (assortativity)
2. Interfirm networks exhibit a higher rate of metabolism (link birth and death) compared to that of industry dynamics with firm entry/exit
3. Younger firms tend to add and drop links more frequently, and the stability of a transaction link increases with the duration of active relationship
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