CORPORATE INNOVATIONS, MERGERS AND ACQUISITIONS

BY

YAOHONG LIANG

ADVISOR: KUN HU

2019

Contents

List of Figures

List of Tables

1 Introduction

This is a short report of the research we've done. It mainly focus on firms characteristics in which variables such as firm size, R&D intensity and employment growth rate etc. are the main study subjects. We examined the relationship between firm size and other characteristics; firm characteristics along firm sectors; the relationship between firm size and firm growth rate. Compustat is the data set we worked on, and the following will explain what this data set is about and the empirical analysis we did on this data set.

2 Empirical Analysis

2.1 Data

In this research, we use the data set called compustat, which includes many useful information of companies. Every firm is uniquely defined by the variable "GVKEY", a unique six-digit number key. Some important variables applied in this research includes Firm-year (fyear), sic, R&D expenditure (xrd), employees (emp) and sale. We define a variable rnd_sale, as R&D to sale ratio, denoting the R&D intensity and sale_g as growth rate of sales and emp_g as growth rate of employment. Furthermore, we drop all firms in agriculture (SIC from 0 to 999), financial (SIC from 6000 to 6999) and public service (SIC from 9000 to 9999) as well as those do not have R& D expenditure for their entire appearance in the dataset. Only keep those in the timeframe from 1988 to 2018 and drop all firms with missing employment data. The summary statics is attached as table 1.

Table 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
fyear	98,867	2002.019	8.183	1998	2018
emp	98,867	8256.58	33509.74	0	905766
sale	98,702	2657.999	14153.56	-21.796	475793.5
xrd	84,300	112.151	595.908	-.648	22620
rnd_sale	80,726	4.787	133.710	-218.737	25684.4
sale_g	85,522	2.011	138.737	-20.237	30245
emp_g	88,683	.344	9.646	-1	1413.6

2.2 Presentations and Interpretation

2.2.1 Analysis on Firm Size and other Firm Characteristics

As we divide firms into four equally-sized groups, which is shown below, one important result we get is that as firm size increases, R&D intensity, sales and employment growth rate decrease. This result is an observation obtained from the table 2.

Table 2: Summary Statistics of 1998-2018 Sample

	Employment	Employment	R&D/Sales	Sales Growth	Emp Growth
Quartile	Mean	Max	Mean	Mean	Mean
1	30	79	7.83	0.78	0.09
2	197	390	0.95	0.39	0.16
3	1180	2777	0.11	0.20	0.14
4	30318	315889	0.05	0.10	0.06

2.2.2 Firm Characteristics along different Firm Sectors

We also examine firm characteristic along a different dimension: firm sector. Within each group, we winsorized the employment, R&D intensidy, sales growth rate and employment growth rate between 2.5% and 97.5%, since the variation between firms are quite large. The result is shown below.

Table 3: Summary Statistics of 1988-2018 along different Groups

	Employment	R&D/Sales	Sales Growth	Emp Growth	N
Group	Mean	Mean	Mean	Mean	
Mining	**10373**	0.11	0.18	0.06	2,100
Construction	2937	0.06	0.22	0.13	471
Manufacturing	6373	**0.82**	0.17	0.07	69,212
Infrastructure	**20033**	0.20	0.25	0.14	3,651
Trade	8404	0.06	0.19	0.11	2,936
Service	2328	**0.29**	0.27	0.14	20,497

It turns out that Mining and infrastructure sector have the largest average firm size and highest R&D intensity. However, for this result, we still need to examine if that is the case. To check if the R&D intensity and employment growth rate is significantly different from the other groups for manufacturing and service firms, we use the following regression:

$$R\&D\ \ Intensity_{it} = \beta_0 + \beta_1 Manu_{it} + \beta_2 Sev_{it} + u_{it}$$

and

$$Emp\ \ growth_{it} = \beta_0 + \beta_1 Manu_{it} + \beta_2 Sev_{it} + u_{it}$$

Where $Manu_{it}$ and Sev_{it} are indicator variables of whether a firm is in manufacturing or service sector. The hypothesis will be

$$H_0 : \beta_1 = \beta_2 = 0 \ \ vs. \ \ H_1 : \beta_1 \ \ or \ \ \beta_2 \neq 0$$

The F-test statistics for $R\&DIntensity_{it}$ is F(1,5) = 16.60 and Prob $>$ F = 0.0096. Therefore, we reject the null hypothesis, which states that R&D intensity is not significantly different from the other groups for manufacturing and service firms. Thus, the R&D intensity is significantly different from the other groups for manufacturing and service firms. Similar procedure applied for the other test and we got F(1,5) = 2.06 and Prob $>$ F = 0.2103. (See details in Appendix)
Then, we only focus on manufacturing and service firms, and see if there is a statistically significant different between this two. We run the following regression:

$$R\&D \ \ Intensity_{it} = \beta_0 + \beta_1 Manu_{it} + u_{it}$$

and

$$Emp \ \ growth_{it} = \beta_0 + \beta_1 Manu_{it} + u_{it}$$

The hypothesis is $H_0 : \beta_1 = 0 \ \ vs. \ \ H_1 : \beta_1 \neq 0$. By checking the p-value for β_1 for both regressions, we reject the null hypothesis, which states one is not significantly different from another.(details in Appendix). Now, we see that manufacture (and service) make up the majority of the sample. Manufacturing is also the most R&D intensive sector. R&D intensity and employment growth rate of Manufacturing is significantly different from other sectors.

Other than what shown above, we also need to consider one thing which is firm size distribution may change overtime, since many factors such as size of work force can influence the firm size. If that is the case, our analysis would be more complicated. After examining the firm size distribution over time, shown in figure 1, it turns out that the firm size distribution is relatively constant over time, even though the largest firms has become larger.

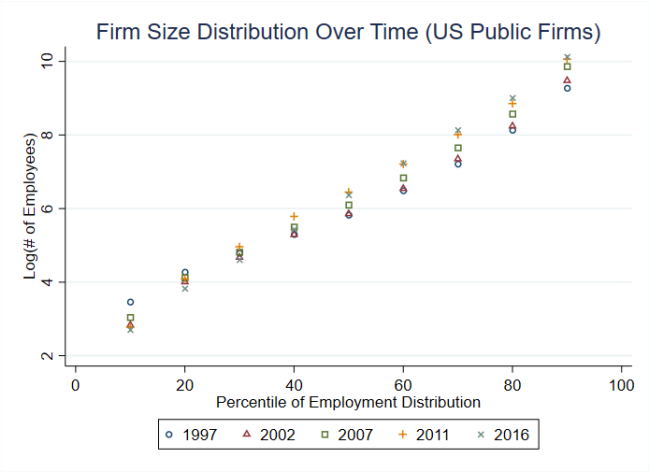

Fig. 1: Firm Size Distribution Over Time

2.2.3 Relationship between Firm Size and Firm Growth Rate

We examine the relationship between firm size and firm growth rate based on the models provided by the paper AK2019, at section 2.c, which shows that small firms grow faster. According to AK2019, we define forward employment growth $(Emp_{f,t+1} - Emp_{f,t})/Emp_{f,t}$ and model employment growth rate without conditioning on survival and thus retain employment growth rate = -1 for business that close between t and t+1. Also, since the metric is upwardly unbounded, a 1000% growth cap has been imposed and samples are divided into 20 groups. The final result we got is shown in figure 2. As we can see, employment growth rate tends to decline, though there are some small fluctuations, and this tendency becomes weaker as the firm size gets bigger, at about quantile of 10.

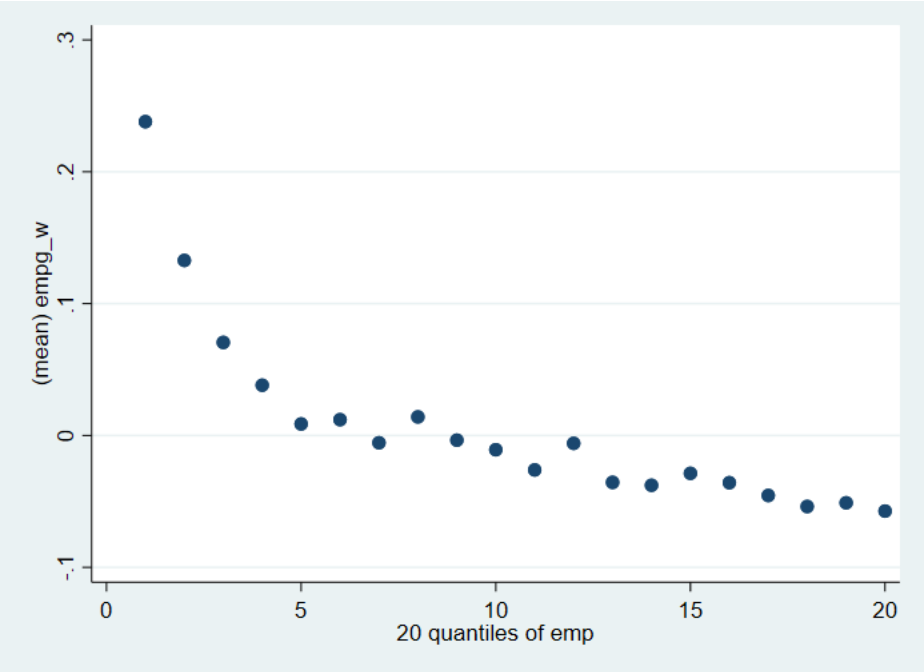

Fig. 2: Firm growth by firm size

The paper also provides a single regression to estimate and also control the fixed effects, defined as $\eta_{i,t}$, brought by industry-year. The regression are recognized as baseline regression here.

$$EmpGr_{f,t} = \eta_{i,t} - 0.0351 * ln(Emp_{f,t} + \epsilon_{f,t})$$

We run the regression along different periods and record them on table 4. To a certain extend, it tells us the employment growth rate and firm size have a negative relationship, though in this model the relationship merely been explained by around 10%. At this point, by replicating the procedure on AK2019, we confirm that small firms grow faster.

Moreover, we need to perform more robustness check to confirm the observation. We basically replicate the methods found on section 2.3 of JMP of Akcigit. First, we need to correct the survival bias for small firms using two-step Heckman Selection model. Recall that we set the growth rate of a firm as -1 when it exits the sample data. However, this cannot be counted in this case, since small firms have higher exit rate. Therefore, after we

Table 4: Baseline regressions along different period

VARIABLES	(1) 1988-2018	(2) 1988-2000	(3) 2000-2006	(4) 2007-2018
log employment	-0.0313***	-0.0465***	-0.0376***	-0.0111***
	(0.00171)	(0.00289)	(0.00355)	(0.00223)
Constant	0.209***	0.367***	0.247***	-0.00565
	(0.0122)	(0.0205)	(0.0256)	(0.0169)
Observations	98,027	40,872	25,946	31,209
R-squared	0.082	0.047	0.036	0.192
Sector-Year Controls	Y	Y	Y	Y

Robust standard errors in parentheses
*** p¡0.01, ** p¡0.05, * p¡0.1

applied two-step Heckman Slection model the coefficient of firm firm size shrinks to zero. That is the result brought by fixing the survival bias. Furthermore, we use IV regression to correct the measurement error. Since ”employment appears both in the regressors and denominator of the left-hand size variables, a measurement error can generate spurious negative association between size and growth rate.” as mentioned in section 2.3. After running the IV regression, we can see that the coefficient did become more negative. In that sense, it confirms the measurement error.

Table 5: Results of Heckman and IV regression

VARIABLES	(1) Baseline	(2) Heckman	(3) Heckman	(4) Heckman	(5) IV
log employment	-0.0313***	-0.0212***	0.107***		-0.0427***
	(0.00171)	(0.00187)	(0.00520)		(0.00183)
logdltt			-0.0138***		
			(0.00391)		
logdd1			-0.0492***		
			(0.00418)		
Constant	0.209***	-0.0996	0.666***		0.243***
	(0.0122)	(0.220)	(0.0292)		(0.0705)
Observations	98,027	60,700	60,700	60,700	98,027
R-squared	0.082				0.081
Sector-Year Controls	Y	Y	Y	Y	Y
Instruments					Y

Robust standard errors in parentheses
*** p¡0.01, ** p¡0.05, * p¡0.1

3 Conclusion

In this study how firm size and other characteristics interplay has been examined; firm characteristics along firm sectors has been analyzed; what effects firm size can bring to firm growth rate has been studied. It shows that as firm size increases, R&D intensity, sales and employment growth rate decrease; Manufacturing is the most R&D intensive sector and its R&D intensity and employment growth rate is significantly different from other sectors that we examine here; Small firms tend to grow faster. Since the absolute value of coefficients we got are around 0.02 to 0.04, we may say that growth rate would decrease approximately by 0.03 as firm size increase by one unit. One limitation of this research may be the power of explanation of our model. Since R-square are not very large, in a sense, it undermines the validity of our result, which states small firms grow faster. On the other hand, we see that the coefficient of firm size shrinks to zero after two-step Heckman model applied and one of them is a positive number. It weakens the correlation between firm size and firm growth rate. Though many literature show that small firms grow faster, future study should also keep examining this result and not take it as granted. Larger samples and more precise models should also be considered for future researches.

Appendix

Linear regression

Number of obs	= 80,726
F(0, 5)	= .
Prob > F	= .
R-squared	= 0.0116
Root MSE	= 2.374

(Std. Err. adjusted for 6 clusters in sicGroup)

rnd_sale_w	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.manu_i	.6994736	.0417766	16.74	0.000	.5920835	.8068637
1.sev_i	.1702226	.0417766	4.07	0.010	.0628325	.2776127
_cons	.1246463	.0417766	2.98	0.031	.0172562	.2320364

Fig. 3: Overall test of significance for R&D Intensity

Linear regression

Number of obs	= 88,683
F(0, 5)	= .
Prob > F	= .
R-squared	= 0.0061
Root MSE	= .35672

(Std. Err. adjusted for 6 clusters in sicGroup)

emp_g_w	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.manu_i	-.0404414	.0189612	-2.13	0.086	-.0891827	.0082998
1.sev_i	.0272403	.0189612	1.44	0.210	-.0215009	.0759816
_cons	.1112827	.0189612	5.87	0.002	.0625415	.160024

Fig. 4: Overall test of significance for Emp Growth

Linear regression

Number of obs	75,332
F(0, 1)	.
Prob > F	.
R-squared	0.0079
Root MSE	2.4545

(Std. Err. adjusted for 2 clusters in sicGroup)

rnd_sale_w	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.manu_i	.529251	4.95e-13	1.1e+12	0.000	.529251	.529251
_cons	.2948689	4.67e-13	6.3e+11	0.000	.2948689	.2948689

Fig. 5: Test of significance for R&D Intensity

Linear regression

Number of obs	80,488
F(0, 1)	.
Prob > F	.
R-squared	0.0070
Root MSE	.33475

(Std. Err. adjusted for 2 clusters in sicGroup)

emp_g_w	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
1.manu_i	-.0676818	2.31e-14	-2.9e+12	0.000	-.0676818	-.0676818
_cons	.1385231	2.29e-14	6.1e+12	0.000	.1385231	.1385231

Fig. 6: Test of significance for Emp Growth