The Impact of Private Equity on Firms' Patenting Activity

Kevin Amess - CMBOR & Nottingham University Business School

Joel Stiebale - DICE, Heinrich Heine University Dusseldorf

Mike Wright - CMBOR & ERC, Imperial College, London

Research questions

- What is the impact of PE-backed LBOs on patent activity?

- Does post-LBO patent activity differ across firms with different pre-LBO ownership structures?

Features of a PE-backed LBO

- PE firms establish funds to raise capital for the purpose of acquiring a portfolio of mature firms

- 'Portfolio firms' acquired in an LBO – PE firms use debt (secured against target's assets and future cash flows) to facilitate the transaction

- The LBO governance structure
  - Senior management hold a significant equity stake
  - High leverage
  - Active PE investors – significant equity stake & Board representation

Controversy

- "Sometimes private equity … give the impression of being little more than amoral asset-strippers after a quick buck." (Brendan Barber (General Secretary of TUC, 2007)

- "We're in the business of creating strong, long-term competitive businesses." (Damon Buffini, Permira. BBC Radio 4 Today Programme)

Controversy

- The controversy is with the 'real' economic impact on firms subject to an LBO (Cumming et al., 2007)

- There are competing arguments concerning incentives of LBO governance structure

  ➢ Managers and PE firms equity stake motivates entrepreneurial behaviour – make investments with a long-term pay-off to create firms that are competitive in the long-term

  ➢ PE firms have a short-term investment horizon and high debt levels need servicing - reduce investments that have a long-term pay-off to boost short-term profit and service debt

- Do PE firms create strong businesses or do they undermine long-term competitiveness?

Entrepreneurial finance

- PE firms are able to ease access to finance in financially constrained firms (Boucly et al., 2011)

  ➢ Governance structure and PE firms financial expertise reassures creditors

  ➢ PE firms provide connections to sources of finance

- Relaxing target firms' financial constraints allows firms to invest in productive innovation

Entrepreneurial finance

- Following Boucly et al. (2011), we use pre-LBO ownership to identify potentially financially-constrained firms

- <u>Private firms</u> find it difficult to access finance due to asymmetric information problem
  - ❑ Private-to-private LBOs will increase investment in productive innovation – expect increase in patenting

- <u>PLCs</u> less likely to be financially constrained due to asymmetric information
  - ❑ LBOs will have no effect on patenting

- <u>PLCs</u> financially constrained if investors have short-term horizon
  - ❑ Post-LBO investors have a longer investment horizon resulting in a positive effect on patenting

Entrepreneurial finance

- Secondary Buyouts (SBOs) will not be able to increase their debt so do not gain access to additional finance
  - ❑ SBOs have no effect on patenting

- Subsidiaries/divisions have access to finance via internal capital markets (ICMs)
  - ❑ If ICM operates effectively, LBO will have no effect on patenting
  - ❑ If ICM is inefficient, LBO will have a positive effect on patenting

Previous studies: R&D expenditure

- Lichtenberg and Siegel (1990)

  - ➤ R&D intensity (R&D exp./sales) 49% lower pre-LBO
  - ➤ No impact on R&D intensity post-LBO

- Long and Ravenscraft (1993)

  - ➤ LBO targets have lower R&D intensity
  - ➤ R&D intensity declines by 40% post-LBO

- Analysis using R&D expenditure unable to distinguish between productive and unproductive expenditure

- Evidence to suggest that LBOs make more productive use of R&D expenditure (Wright et al., 1992; Zahra, 1995) and adopt strategies to better exploit their R&D investment (Bruining et al., 2013; Link et al., 2014)

Previous studies: Patenting

- Lerner et al. (2011)

  - Find evidence of post-LBO increase in citation-weighted patents
  - Unclear whether it is due to PE firms selecting innovative firms or a causal effect of the LBO

- Ughetto (2010)

  - PE firm characteristics impact on patent activity: stage specialisation (+ve), independent (-ve), non-EU (-ve)
  - Without a control sample (counterfactual), is unable to establish whether LBOs are associated with post-LBO changes in innovation activity

Empirical strategy

- Difference-in-differences (DID) combined with propensity score matching (PSM)

- Causal effect of a PE-backed LBO on innovation:

$$ATT = E[I^1_{t+s}|X_{t-1}, PE_t = 1] - E[I^0_{t+s}|X_{t-1}, PE_t = 1]$$

- The last term in the above equation (the counterfactual) is not observed. The counterfactual is estimated by use of a control sample:

$$E[I^0_{t+s}|X_{t-1}, PE_t = 0]$$

- If the selection of LBO targets is non-random, using a random set of control firms will result in sample selection bias

Empirical strategy

- To address the issue of sample selection bias we estimate the propensity score, $Pr(PE_t = 1 | X_{t-1})$, to construct a control sample that proxies the counterfactual

- We use nearest neighbour matching

- DID on treated and matched firms is:

$$\Delta I^1_{i,t+s} = \alpha + \theta PE_{it} + \eta_t + \varepsilon_{it}$$

$$\Delta I^1_{i,t+s} = \alpha + \theta_0 PE_{it} + \theta_1 PE_{it} Z_{i1t} \dots \theta_k PE_{it} Z_{iKt} + \eta_t + \varepsilon_{it}$$

Data Sources

- **Centre for Management Buyout Research**

  - Data on population of UK LBO deals: year of deal (and exit), PE financed, equity investors, debt investors

- **FAME**

  - Firm-level accounting data for UK firms
  - sales, productivity, profitability, capital, wages and industry affiliation

- **PATSTAT (European patent office and OECD)**

  - Extract patent applications for the years 1978-2008
  - Only consider patents that are ultimately granted but date them back to the application year
  - Quality-adjusted patents: patents weighted by forward citations

Sample

- Unbalanced panel of 35,081 firms

- 407 LBOs between 1998 and 2005

- 239 LBO firms and 1,689 control firms file at least one patent

Summary statistics:
PE firm / LBO level variables

Variable	Description	Mean	S. D.
Experience equity	# of previous deals involving equity	11.216	30.746
Experience debt	# of previous deals involving debt	29.283	27.930
Exp equity sector	# of prev. deals involving equity in industry	10.378	15.938
Exp debt sector	# of prev. deals involving debt in industry	15.865	23.617
PE × Pub2Priv	= 1 if public to private buyout	0.091	
PE × Priv2Priv	= 1 if private to private buyout	0.472	
PE × Divisional	=1 if divisional buyout	0.283	
PE × Secondary	=1 if secondary buyout	0.155	
Equity_syndicate	=1 for equity provider syndication	0.025	
Debt_syndicate	=1 for debt provider syndication	0.140	
Ratchet	=1 if PE firm uses an equity ratchet	0.118	

Summary statistics:
portfolio firm and industry level variables

Variable	Description	Mean	S. D.
PE	=1 if buyout in year t, 0 else	0.002	
Post_PE	= 1 for all years after a buyout, 0 else	0.010	
Patent count	Number of patent applications in current year	0.048	1.817
Quality-adjusted patent count	Number of patent applications in current year, weighted by the number of citations	0.983	128.1
Patent stock	Cumulated number of patents till current year	0.406	11.078
Quality-adjusted patent stock	Cumulated number of patents till year t, weighted by citations	20.614	1,405.1
Sales	Sales	27,511	204,00
Employees	Number of employees	206.5	1483.1
Capital	Tangible fixed assets	9,481	95,848
Fixed assets	Fixed assets	15,858	31,900
Labprod	Labour productivity, Sales per employee	360.25	4,042

Summary statistics:
portfolio firm and industry level variables

Variable	Description	Mean	S. D.
Cap_Emp	Capital per employee	313.95	8,299
Age	Firm age in years	22.014	21.215
Sales growth	Logarithmic yearly sales growth rate	0.09	0.509
d_export	=1 if overseas sales>0, 0 else	0.325	0.469
Av_wage	Average wage per employee	34.20	101.11
Profit_sales	Profits/Sales * 100	0.626	58.26
Leverage	Loans + overdrafts + liabilities / equity *100	304.16	870.06
Quiscore	Inverse indicator of likelihood of default	74.730	22.539
Findep	Industry-level financial dependence (US data)	0.066	0.298
Findep(UK)	Industry-level financial dependence (UK data)	0.217	0.377
Competition	Average of 1-Lerner Index (industry level)	0.943	0.027

Propensity score estimation

ln_sales	0.200***
	(0.018)
ln_Labprod	-0.158***
	(0.027)
d_export	-0.091*
	(0.047)
ln_av_wage	0.057
	(0.040)
ln_cap	0.013
	(0.012)
ln_age	-0.060***
	(0.019)
Profit_sales	0.003
	(0.010)
Leverage	-0.00004
	(0.00003)
Patent stock	0.001
	(0.001)
Patent citation stock	-0.00001
	(0.00003)
Observations	143,653
Pseudo R squared	0.110
Log likelihood	-2486.5
LR test (chi squared)	615.11

Balancing property

Variable	Sample	Treated	Control	t-test, p>|t|
Propensity score	Unmatched	0.0104	0.0024	0.000
	Matched	0.0104	0.0104	0.998
ln_sales	Unmatched	9.9017	8.8335	0.000
	Matched	9.9017	9.8813	0.851
ln_Labprod	Unmatched	4.6661	4.8842	0.000
	Matched	4.6661	4.657	0.887
d_export	Unmatched	0.3123	0.3249	0.616
	Matched	0.3123	0.3381	0.468
ln_av_wage	Unmatched	3.1276	3.2345	0.004
	Matched	3.1276	3.1846	0.196
ln_age	Unmatched	2.7396	2.7341	0.915
	Matched	2.7396	2.7044	0.628
ln_capital	Unmatched	7.8350	6.5577	0.000
	Matched	7.8350	7.7925	0.796
Patent stock	Unmatched	1.0098	0.3787	0.350
	Matched	1.0098	0.5798	0.349
Patent citation stock	Unmatched	25.833	20.599	0.927
	Matched	25.833	17.165	0.712
Profit_sales	Unmatched	-.00893	-.64032	0.829
	Matched	-.00893	-.03416	0.726
Leverage	Unmatched	256.65	303.20	0.280
	Matched	256.65	245.59	0.820

ATT from propensity score matching

Panel A: Patents			
	t+1	*t*+2	*t*+3
PE	0.166*	0.278**	0.383**
	(0.075)	(0.121)	(0.156)
Number of observations	814	814	814

Panel B: Quality-adjusted patents			
	t+1	*t*+2	*t*+3
PE	0.747**	1.127**	1.292**
	(0.338)	(0.518)	(0.581)
Number of observations	814	814	814

Heterogeneous effect of deal types

Panel A: Patents			
	t+1	t+2	t+3
PE × Priv2Priv	0.401**	0.691**	0.940***
	(0.162)	(0.269)	(0.350)
PE × Pub2Priv	-0.064	-0.130*	-0.162
	(0.043)	(0.077)	(0.101)
PE × Secondary	-0.006	-0.043	-0.046
	(0.034)	(0.055)	(0.072)
PE × Divisional	-0.047	-0.090*	-0.113*
	(0.030)	(0.049)	(0.061)
Number of observations	814	814	814

Heterogeneous effect of deal types

Panel B: Quality-adjusted patents			
	t+1	*t*+2	*t*+3
PE × Priv2Priv	1.662**	2.520**	2.902**
	(0.736)	(1.138)	(1.311)
PE × Pub2Priv	-0.021	0.043	0.039
	(0.117)	(0.218)	(0.254)
PE × Secondary	-0.103	-0.205	-0.261
	(0.175)	(0.280)	(0.364)
PE × Divisional	-0.074	-0.131	-0.156
	(0.094)	(0.152)	(0.193)
Number of observations	814	814	814

PE firms and financial constraints

- Boucly et al. (2011) argue that pre-LBO ownership structure impacts on firms financial constraints, which are likely most severe for private firms

- So does the positive effect for private-to-private transactions reflect the role of PE firms in relaxing financial constraints?

PE firms and financial constraints

- We conduct two further sets of analysis to further explore the issue of financial constraints

- Analyse effects according to industry-level financial dependence

  ➢ Difference between investment and internal cash flow (median firm within industries)

- Pre-LBO credit ratings used to indicate financially constrained firms

  ➢ *Quiscore* is an indicator of creditworthiness
  ➢ Firms with a score above 80 are identified as being "secure" so we deem all other firms as being financially constrained to some degree

The effect of LBOs on financially dependent firms

Panel A: Patents			
	t+1	*t*+2	*t*+3
PE	-0.040	-0.082*	-0.100*
	(0.025)	(0.041)	(0.051)
PE × findep	-0.064	-0.130	-0.178
	(0.065)	(0.127)	(0.166)
PE × Priv2Priv	0.297**	0.598**	0.808**
	(0.138)	(0.260)	-0.341
PE × Priv2Priv × findep	1.588***	1.981***	2.624***
	(0.477)	(0.682)	(0.924)
Findep	0.047	0.112*	0.154*
	(0.031)	(0.066)	-0.085
Number of observations	814	814	814

The effect of LBOs on financially dependent firms

Panel B: Quality-adjusted patents			
	$t+1$	$t+2$	$t+3$
PE	-0.062	-0.110	-0.137
	(0.071)	(0.129)	(0.166)
PE × findep	-0.153	-0.212	-0.261
	(0.246)	(0.459)	(0.602)
PE × Priv2Priv	1.354*	1.717	2.086
	(0.799)	(1.084)	(1.302)
PE × Priv2Priv × findep	4.044**	9.807**	10.282**
	(1.767)	(4.147)	(4.352)
Findep	0.087	0.195	0.231
	(0.078)	(0.144)	(0.179)
Number of observations	814	814	814

The effect of LBOs on firms with a low Quiscore

Panel A: Patents			
	t+1	*t*+2	*t*+3
PE	0.024	0.015	0.025
	(0.179)	(0.259)	(0.335)
PE × D(quiscore≤80)	-0.028	-0.051	-0.020
	(0.313)	(0.454)	(0.586)
PE × Priv2Priv	0.488**	0.901***	1.250***
	(0.215)	(0.312)	(0.404)
PE × Priv2Priv × D(quiscore≤80)	0.688	0.683	0.642
	(0.438)	(0.636)	(0.822)
D(quiscore≤80)	0.002	0.019	-0.022
	(0.180)	(0.261)	(0.337)
Number of observations	377	377	377

The effect of LBOs on firms with a low Quiscore

Panel B: Quality-adjusted patents			
	t+1	*t*+2	*t*+3
PE	0.073	0.228	0.236
	(0.407)	(1.018)	(1.029)
PE × D(quiscore≤80)	-0.031	-0.300	-0.260
	(0.712)	(1.783)	(1.802)
PE × Priv2Priv	0.707	0.851	0.978
	(0.490)	(1.227)	(1.240)
PE × Priv2Priv × D(quiscore≤80)	1.713*	7.517***	7.365***
	(0.998)	(2.499)	(2.525)
D(quiscore≤80)	-0.041	0.069	0.032
	(0.410)	(1.026)	(1.037)
Number of observations	377	377	377

Robustness checks

- Results robust to different controls for: PE and LBO characteristics (ratchet clause, equity & debt syndication, leverage, MBO vs. MBI), industry features (degree of competition, manufacturing vs. services and portfolio firm heterogeneity (volatility of sales and profit)

- Longer post-LBO period (5years on an unbalanced panel

- Different measure of quality-adjusted patents (excluding "blocking" citations, applicants citations)

- Different matching estimators (propensity score reweighting, matching with/without replacement, matching within different industry classifications)

- Different measures of financial dependence and thresholds of Quiscore

Conclusions

- PE-backed LBOs have a positive and significant impact on patenting

- Effects are concentrated in private-to-private transactions

- Effects are most pronounced in portfolio firms that are more likely to be financially constrained pre-LBO

- Evidence is consistent with PE firms helping to create strong businesses in private-to-private transactions