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The American Inventors Protection Act: A Natural Experiment on Innovation Disclosure and the Cost of Debt

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ABSTRACT

We examine the impact of innovation disclosure through patenting on firms' cost of debt, focusing on the American Inventors Protection Act (AIPA) as an exogenous shock in innovation disclosure regulation. Post-AIPA, firms have an incentive to apply for patents only if commercial success is likely. Accordingly, we expect post-AIPA patents to be a better proxy for successful innovation activity, and thus to have a stronger effect on reducing the cost of debt than pre-AIPA patents. Indeed, we find that pre-AIPA patents reduce the cost of debt only for the most innovative firms, while post-AIPA, this effect holds for all firms.

JEL Codes: G21; G32; O32; O38

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I. INTRODUCTION

We assess the effect of patenting activity on reducing innovative firms' cost of debt. Financing innovation by debt is inherently complex. First, innovative firms' assets have lower collateral value, as they are more dependent on intangibles, such as patents and human capital (Hall 2010). Second, it is difficult to value innovative firms due to cash-flow volatility. That is, it is difficult to evaluate whether patent applications will be successful and generate cash flows.

A growing body of academic literature suggests that bank financing is an important source of external capital for innovative firms (Kerr and Nanda 2015). In the context of bank financing, the risk of innovation failure and the uncertainty of R&D investment payoffs are potential sources of asymmetric information problems, which are typically associated with reduced access to credit (Hu et al. 2017) as well as higher loan spreads (Francis et al. 2012). Instead of forgoing value-creating R&D investments, however, innovative firms can use patents to signal the quality of their inventions and thus attempt to alleviate these asymmetric information problems and ease access to credit (Bhattacharya and Ritter 1983; Francis et al. 2012; Lin et al. 2017). Yet, there is a trade-off between innovation disclosure through patents and secrecy, as disclosure might enable competitors to obtain valuable technical knowledge (Hall et al. 2014).

We test the impact of innovation disclosure through patents on the cost of debt by exploiting an exogenous change in innovation disclosure: the implementation of the American Inventors Protection Act (AIPA) of 1999. AIPA requires US patent applications filed on and after November 29, 2000 to be published by the government 18 months after the application date. In the pre-AIPA period, patents became public only after they were granted, allowing firms to file as many patents as they wished as a way of trying to avert competition, realizing it would take a long time before the content of their patent applications would be revealed to the market and competitors could learn from it. In contrast, in the post-AIPA period, firms are required to disclose information, even if the patent is not granted eventually. For this reason, firms are expected to have an incentive to apply only for those patents of which they are relatively certain that they will result in a commercial marketplace success; otherwise, the details of their R&D investments would be revealed to the market, without the firm being able to capitalize on them. Hence, our testable hypothesis is that patents have become a better proxy for successful innovation and therefore have a stronger effect on reducing innovative firms' cost of debt as measured by their loan spreads in the post-AIPA period as compared with the pre-AIPA period.[1]

II. DATA AND METHODOLOGY

We examine the effect of innovation disclosure on the cost of debt for firms in five innovative industries, which are characterized by high patenting propensities relative to most other industries (Mansfield 1986), and which have been the focus of prior research (Plumlee et al. 2015). In particular, we examine chemicals and allied products (Standard Industrial Classification (SIC) 28), industrial and commercial machinery and computer equipment (SIC 35), electronics and communications (SIC 36), transportation equipment (SIC 37), and instruments and related products (SIC 38).

1 In order to protect small inventors, AIPA includes an opt-out clause under which inventors can preserve pre-grant secrecy beyond 18 months, but forgo foreign protection. If many of our borrowers use this opt-out clause, granted patents will remain a weak signal for successful innovation. Thus, the opt-out clause has the potential to mitigate against our predicted effect. However, Graham and Hegde (2015) report that <8% of US patent applications make use of the opt-out, with large US inventors (i.e. our borrowers) opting out less frequently than small US inventors. Therefore, we do not expect that the opt-out clause will substantially affect our results.

We compile our dataset as follows. We obtain loans raised by publicly listed US firms from the above-mentioned industries from the Loan Pricing Corporation's DealScan database. We define our dependent variable, the cost of debt, as the all-in-drawn spread above the London Interbank Offered Rate (LIBOR). We collect patent data for these borrowers from the Worldwide Patent Statistical Database (PATSTAT, version Autumn 2016). We consider patents that were eventually granted and end our sample period in 2013 because many later patent applications are still under revision (Hall et al. 2001). We consider the patent application year as it reflects the actual timing of innovation (Griliches 1990). We define two proxies: *Ln*(1 + *Patents*), reflecting the number of granted patents, and $Patent_D$, a dummy, which is equal to 1 if the borrower has at least one patent application that is eventually granted and zero otherwise. Following prior innovation literature (e.g. Atanassov 2013), we set the patent count to zero when no patent information is available. We also include loans to firms with no patents to alleviate any possible sample selection concerns. Finally, we include various loan-specific and borrower-specific control variables from DealScan and Compustat in our empirical model. Patent and borrower variables are observed in the year before loan signing (Francis et al. 2012). The final sample includes 6654 loans raised by 1095 US borrowers between 1985 and 2013. Table 1 summarizes our variable definitions and sources.

The shock to innovation disclosure related to AIPA provides us with a natural experiment in which we can compare the effect of patents on innovative firms' cost of debt before and after the implementation of the law. In particular, we hypothesize that the implementation of AIPA strengthens the negative relation between patents and firms' loan spreads because patents are considered to be a better proxy for successful innovation after the implementation of this law. To differentiate the effect of patents on loan spreads before and after the passage of the law, we divide our sample into a pre-AIPA period that ranges from 1985 to 2000 and a post-AIPA period that ranges from 2001 to 2013. For each subsample, we separately estimate an Ordinary Least Squares (OLS) regression model. We also estimate a difference-in-difference regression model for the full period.

Table 2 provides summary statistics and shows that the firms included in our sample are large with an average nominal asset size of $1.7 billion in the pre-AIPA period and $5.0 billion in the post-AIPA period. The average loan amounts to $192 million with a spread of 224 bps above LIBOR pre-AIPA which rises to $412 million with a spread of 238 bps above LIBOR post-AIPA. The average firm applies for 11.5 and 5.6 granted patents per year during the pre- and post-AIPA period, respectively. The cross-sectional variation is substantial. Pre-AIPA, 66% of loans are raised by borrowers that did not apply for any patents. Post-AIPA, this fraction rises to 81%. In contrast, the most innovative firm in our sample applies for 856 patents per year in the pre-AIPA period and 791 patents per year in the post-AIPA period. This reduction in granted patents is in line with our expectation that after the implementation of AIPA, firms will apply only for patents of which they are relatively certain that they will result in a commercial marketplace success.

Table 1 Variable definitions and sources

Variable	Definition
Innovation measures (PATSTAT)	
Patent$_D$	Dummy = 1 if the borrower has at least one patent application that is eventually granted, 0 otherwise. Granted patents are patent applications that are made in the year before loan signing and that are eventually granted
Ln(1 + *Patents)*	Natural logarithm of one plus the number of granted patents
Borrower characteristics (Compustat)	
Firm Size	Natural logarithm of total assets (AT) in US$ million
Leverage	Book value of total debt (DLTT + DLC) divided by book value of total assets (AT)
Liquidity	The difference between current assets (ACT) and inventories (INVT) divided by current liabilities (LCT)
Profitability	Operating income before depreciation (OIBDP) divided by total assets (AT)
R&D Expenditures	R&D expenditure (XRD) divided by sales (SALE)
High R&D Intensity$_D$	Dummy = 1 if loan is raised by a borrower with an R&D intensity above the 90th percentile in pre-AIPA or post-AIPA period, respectively, 0 otherwise
Altman's Z-score	The score is calculated as Z = 1.2 * working capital/total assets + 1.4 * retained earnings/total assets + 3.3 * earnings before interest and tax/total assets + 0.6 * market value of equity/book value of liabilities + 1.0 * sales/total assets = 1.2 * WCAP/AT + 1.4 * RE/AT + 3.3 * EBIT/AT + 0.6 * CSHO * PRCC_F/LT + 1.0 * SALE/AT
High Default Risk$_D$	Dummy = 1 if loan is raised by a borrower with an Altman's *Z*-score at or below the 25 percentile in pre-AIPA or post-AIPA period, respectively, 0 otherwise
Industry FE	Dummies identifying borrower's industry at two-digit SIC level
Loan characteristics (DealScan)	
Spread	All-in-spread drawn in bps over LIBOR
Ln(*Loan Amount*)	Natural logarithm of the loan amount in US$ million
Ln(1+ *Maturity*)	Natural logarithm of one plus loan maturity in months
Covenants$_D$	Dummy = 1 if the loan has financial covenants, 0 otherwise
Term Loan$_D$	Dummy = 1 if the loan is a term loan, 0 otherwise
Secured$_D$	Dummy = 1 if the loan is secured, 0 otherwise
Performance Pricing$_D$	Dummy = 1 if the loan uses performance pricing, 0 otherwise
High Information Uncertainty$_D$	Dummy = 1 if the loan is raised by an unrated borrower, 0 otherwise
Rating FE	Dummies identifying loan's rating class including a dummy for loans to unrated borrowers
Year FE	Dummies identifying loan's signing year

AIPA, American Inventors Protection Act.

III. RESULTS

Table 3 presents our results. In regressions (1)–(16), the coefficients of *Ln* (1 + *Patents*) and *Patent*$_D$ are of interest and indicate that only in the post-AIPA period, patents have a significantly negative effect on loan spreads. These

Table 2 Summary statistics

	Pre-AIPA period					Post-AIPA period				
	Mean	Median	Min	Max	*SD*	Mean	Median	Min	Max	*SD*
Innovation measures										
Granted Patents	11.51	0.00	0.00	856.00	55.03	5.61	0.00	0.00	791.00	39.19
Patent$_D$	0.34	0	0	1	0.48	0.19	0	0	1	0.39
Borrower characteristics										
Total Assets ($ million)	1716.19	281.94	1.59	42,942.00	4515.87	5014.24	1025.35	0.22	195,014.00	13,345.82
Leverage	0.28	0.26	0.00	2.08	0.23	0.29	0.24	0.00	10.47	0.34
Liquidity	1.57	1.16	0.04	40.73	1.71	1.66	1.27	0.00	31.52	1.57
Profitability	0.13	0.14	–2.41	1.14	0.18	0.10	0.12	–14.78	1.25	0.32
R&D Intensity	0.10	0.03	0.00	17.63	0.62	0.17	0.03	0.00	51.69	1.54
Altman's Z-score	4.16	3.02	–33.87	214.56	6.72	3.27	2.73	–179.55	61.02	5.32
Loan characteristics										
Spread (bps)	224.34	175.00	3.88	2500.00	213.21	238.21	200.00	4.50	1800.00	196.14
Loan Amount ($ million)	192.00	50.00	0.01	8000.00	460.00	412.00	150.00	0.11	24,000.00	1010.00
Maturity (months)	46.25	41.00	1.00	362.00	31.24	46.08	57.00	1.00	240.00	22.76
Covenants$_D$	0.46	0	0	1	0.50	0.63	1	0	1	0.48
Term Loan$_D$	0.29	0	0	1	0.45	0.31	0	0	1	0.46
Secured$_D$	0.51	1	0	1	0.50	0.55	1	0	1	0.50
Performance Pricing$_D$	0.34	0	0	1	0.47	0.44	0	0	1	0.50
High Information Uncertainty$_D$	0.68	1	0	1	0.47	0.42	0	0	1	0.49

Note: This table reports summary statistics for variables based on 2840 loans to publicly traded US firms for the pre-AIPA period from 1985 to 2000 and 3814 loans to publicly traded US firms during the post-AIPA period from 2001 to 2013. AIPA, American Inventors Protection Act; *SD*, standard deviation.

Table 3 AIPA and the cost of debt for innovative firms

	Spread (bps)																	
	Pre-AIPA period								Post-AIPA period								Full period	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Ln(1 + Patents)	2.33	4.36	1.36	2.43					–5.52**	–5.99***	–4.77**	–6.73***					2.97	
	(0.67)	(1.17)	(0.40)	(0.69)					(–2.44)	(–2.81)	(–2.16)	(–3.31)					(0.96)	
*Ln(1 + Patents) * High R&D Intensity$_D$*		–13.29**								2.74								
		(–2.02)								(0.33)								
*Ln(1 + Patents) * High Information Uncertainty$_D$*			2.27								–2.75							
			(0.30)								(–0.45)							
*Ln(1 + Patents) * High Default Risk$_D$*				1.45								5.59						
				(0.19)								(0.79)						
*Ln(1 + Patents) * Post-AIPA Period$_D$*																	–7.59 *	
																	(–1.93)	
Patent$_D$					6.85	10.19	13.58	5.64					–16.32**	–20.10***	–15.99**	–21.48***		10.43
					(0.74)	(1.05)	(0.97)	(0.58)					(–2.45)	(–3.41)	(–2.11)	(–3.42)		(1.15)
*Patent$_D$ * High R&D Intensity$_D$*						–29.19								25.41				
						(–1.08)								(0.87)				
*Patent$_D$ * High Information Uncertainty$_D$*							–10.08								–0.76			
							(–0.55)								(–0.06)			
*Patent$_D$ * High Default Risk$_D$*								12.43								22.84		
								(0.57)								(1.19)		
*Patent$_D$ * Post–AIPA Period$_D$*																		–24.57**
																		(–2.14)
Post-AIPA Period$_D$																	121.23***	121.40***
																	(5.66)	(5.66)
Leverage	78.56***	78.65***	78.57***	63.21***	78.49***	79.05***	78.97***	62.55***	33.66**	33.69**	33.62**	14.85	33.37**	33.67**	33.37**	14.78	46.02***	45.89***
	(3.98)	(4.01)	(3.99)	(3.06)	(3.96)	(4.01)	(3.99)	(3.01)	(2.04)	(2.04)	(2.04)	(0.97)	(2.01)	(2.03)	(2.01)	(0.97)	(2.90)	(2.88)
Profitability	–127.23***	–121.98***	–126.97***	–109.96***	–126.68***	–126.25***	–127.05***	–107.74***	–71.73**	–71.99**	–71.62**	–66.88***	–71.85**	–72.47**	–71.84**	–66.92***	–83.20**	–83.20**
	(–5.51)	(–5.34)	(–5.48)	(–4.71)	(–5.46)	(–5.57)	(–5.48)	(–4.58)	(–2.28)	(–2.28)	(–2.28)	(–2.84)	(–2.29)	(–2.29)	(–2.28)	(–2.84)	(–2.53)	(–2.53)
Liquidity	–5.31***	–5.48***	–5.31***	–4.84***	–5.35***	–5.34***	–5.31***	–4.88***	–2.84	–2.83	–2.82	–0.69	–2.81	–2.76	–2.80	–0.64	–4.33***	–4.35***
	(–3.04)	(–3.15)	(–3.04)	(–2.83)	(–3.06)	(–3.05)	(–3.04)	(–2.85)	(–1.18)	(–1.17)	(–1.17)	(–0.29)	(–1.16)	(–1.14)	(–1.16)	(–0.27)	(–2.71)	(–2.73)
High R&D Intensity$_D$	–6.28	11.16	–6.36	–6.83	–6.44	9.78	–6.33	–7.22	43.10***	41.17***	43.65***	30.12**	43.15***	35.46**	43.21***	29.86**	–3.14	–4.16
	(–0.40)	(0.64)	(–0.41)	(–0.44)	(–0.42)	(0.53)	(–0.41)	(–0.47)	(3.11)	(2.75)	(3.18)	(2.45)	(3.12)	(2.24)	(3.14)	(2.44)	(–0.18)	(–0.25)
*High R&D Intensity$_D$ * Post-AIPA Period$_D$*																	42.81**	44.20 **
																	(2.22)	(2.30)
High Default Risk$_D$				23.35**				21.19*				66.69***				64.64***		
				(1.98)				(1.67)				(6.35)				(6.02)		
Ln(Loan Amount)	–35.07***	–35.17***	–35.22***	–35.39***	–34.96***	–35.01***	–34.87***	–35.25***	–21.82***	–21.80***	–21.78***	–20.52***	–22.06***	–22.01***	–22.06***	–20.75***	–26.54***	–26.60***
	(–11.40)	(–11.46)	(–11.29)	(–11.54)	(–11.52)	(–11.57)	(–11.53)	(–11.64)	(–8.05)	(–8.05)	(–7.99)	(–7.87)	(–8.16)	(–8.15)	(–8.14)	(–8.06)	(–12.72)	(–12.85)
Ln(1 + Maturity)	66.16***	66.40***	66.14***	66.47***	66.10***	66.26***	66.11***	66.29***	–13.23**	–13.27**	–13.18**	–10.60*	–13.35**	–13.42**	–13.35**	–10.77*	24.80***	24.72***
	(7.52)	(7.55)	(7.52)	(7.58)	(7.51)	(7.52)	(7.51)	(7.57)	(–2.33)	(–2.34)	(–2.33)	(–1.90)	(–2.35)	(–2.36)	(–2.35)	(–1.93)	(4.36)	(4.34)
Covenants$_D$	–31.53**	–32.13***	–31.70**	–31.86**	–31.86***	–32.25***	–31.56**	–32.21***	–2.23	–2.26	–2.26	0.54	–2.42	–2.37	–2.43	0.41	–10.40	–10.60
	(–2.55)	(–2.60)	(–2.56)	(–2.57)	(–2.59)	(–2.63)	(–2.57)	(–2.62)	(–0.24)	(–0.25)	(–0.25)	(0.06)	(–0.26)	(–0.26)	(–0.26)	(0.05)	(–1.37)	(–1.40)
Term Loan$_D$	–36.05***	–35.77***	–36.14***	–36.19***	–35.93***	–35.55***	–35.88***	–36.01***	87.34***	87.32***	87.33***	82.94***	87.27***	87.23***	87.27***	82.88***	37.23***	37.25***
	(–3.18)	(–3.16)	(–3.19)	(–3.22)	(–3.17)	(–3.15)	(–3.17)	(–3.20)	(11.86)	(11.87)	(11.86)	(11.34)	(11.86)	(11.89)	(11.86)	(11.33)	(5.51)	(5.50)
Secured$_D$	24.60**	24.19**	24.74**	23.87**	24.60**	24.22**	24.52**	23.68**	54.74***	54.70***	54.72***	46.44***	54.72***	54.37***	54.73***	46.57***	37.79***	37.84***
	(2.56)	(2.51)	(2.57)	(2.49)	(2.56)	(2.51)	(2.54)	(2.46)	(7.11)	(7.11)	(7.10)	(6.23)	(7.10)	(7.09)	(7.10)	(6.23)	(5.64)	(5.64)

Table 3 (*continued*)

	Spread (bps)																	
	Pre-AIPA period								Post-AIPA period								Full period	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Performance Pricing$_D$	–62.73***	–62.05***	–62.80***	–62.00***	–62.87***	–62.36***	–62.80***	–62.21***	–50.25***	–50.23***	–50.25***	–46.60***	–49.74***	–49.71***	–49.74***	–46.16***	–60.17***	–59.89***
	(–6.87)	(–6.80)	(–6.88)	(–6.82)	(–6.88)	(–6.84)	(–6.88)	(–6.79)	(–7.69)	(–7.68)	(–7.68)	(–7.07)	(–7.62)	(–7.62)	(–7.62)	(–7.02)	(–10.46)	(–10.42)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.282	0.283	0.282	0.284	0.282	0.282	0.282	0.284	0.506	0.506	0.506	0.524	0.507	0.507	0.507	0.524	0.371	0.372
Observations	2840	2840	2840	2840	2840	2840	2840	2840	3812	3812	3812	3812	3812	3812	3812	3812	6652	6652

Notes: For each independent variable, the top row reports the estimated coefficient and the bottom row reports the *t*-statistic. Standard errors are corrected for heteroscedasticity and borrower-level clustering. Firm size is not included in the regressions because it is highly correlated with loan amount and would cause multicollinearity problems. *, **, and *** denote significance at 10%, 5%, and 1%, respectively. AIPA, American Inventors Protection Act.

Table 4 Testing for differences in coefficients between pre- and post-AIPA periods

Regressions in Table 1	Variable	Estimated coefficients		Wald test	
		Pre-AIPA	Post-AIPA	χ^2	Significance level
(1) and (9)	*Ln*(1 + *Patents*)	2.33	–5.52**	3.63*	0.057
(2) and (10)	*Ln*(1 + *Patents*)	4.36	–5.99***	5.86**	0.016
(3) and (11)	*Ln*(1 + *Patents*)	1.36	–4.77**	5.22**	0.022
(4) and (12)	*Ln*(1 + *Patents*)	2.43	–6.73***	5.18**	0.023
(5) and (13)	$Patent_D$	6.85	–16.32**	4.22**	0.040
(6) and (14)	$Patent_D$	10.19	–20.10***	7.41***	0.007
(7) and (15)	$Patent_D$	13.58	–15.99**	3.57*	0.059
(8) and (16)	$Patent_D$	5.64	–21.48***	5.69**	0.017

Notes: This table reports the results of Wald χ^2 tests regarding the coefficient estimates reported in Table 3. The test is based on a seemingly unrelated estimation model for the pre-AIPA and post-AIPA periods and tests the null hypothesis of equal coefficients in both periods. *, **, and *** denote significance at 10%, 5%, and 1%, respectively. AIPA, American Inventors Protection Act.

findings are consistent with the view that, under AIPA, firms have an incentive to only apply for patents if the likelihood of commercial success is large. Otherwise, they would risk revealing confidential information to the marketplace without being able to reap the associated economic benefits. In the post-AIPA period, lenders will thus have more certainty that pending patents will become granted patents, making them (more) predictive for marketplace success and future cash flows. As a result, lenders reward firms with more patenting activity with lower spreads. These results hold for both patent proxies, indicating that the effect is generally present, and not only driven by firms with a large number of patents. Wald χ^2 tests in Table 4 confirm that the coefficients of our patent proxies are significantly different between the pre-AIPA and post-AIPA period. All control variables have the expected signs. The post-AIPA effects are not only statistically significant but also economically significant. Regression (13) shows that the existence of granted patents reduces spreads by 16.32 bps. For the average borrower, this translates into interest payment savings of $672,212 per loan per year. Regression (9) indicates that a one-standard deviation increase in the number of patents reduces the spread for the average borrower by 38.6 bps leading to interest savings of $1.6 million per loan per year.

We also identify highly innovative firms as firms whose R&D expenditures as a percentage of sales are in the highest decile ($High\ R\&D\ Intensity_D$) and expand our regressions by including interaction effects between $High\ R\&D\ Intensity_D$ and our patent proxies. These interaction effects are significantly negative only pre-AIPA and then only for the *Ln*(1 + *Patents*) proxy. Hence, we conclude that pre-AIPA, when patents are only a weak proxy for successful innovation activity, patents can reduce the cost of debt for those firms whose revenues are most sensitive to innovation. However, post-AIPA, as the signaling quality of the patent information improves, this benefit can be captured by all firms. Overall, these results suggest that signaling innovation quality is the underlying mechanism through which patents affect innovative firms' cost of debt.

Inspired by Plumlee et al. (2015), we also examine whether the relationship between innovative firms' cost of debt and patenting activity is stronger for borrowers with a greater initial information uncertainty regarding future cash flows or a greater initial default risk. We identify borrowers with a greater initial information uncertainty as those who are unrated (*High Information Uncertainty*$_D$) and extend our regressions by including interaction effects between *High Information Uncertainty*$_D$ and our patent proxies.[2] We do not find that the effect of patenting activity is different for borrowers with greater initial information uncertainty. This result is consistent with Plumlee et al.'s (2015) finding that for borrowers with greater initial information uncertainty, only the quality of patenting activity as measured by patent citation count is associated with a lower cost of debt, while the mere presence of patenting activity is not. Next, we identify borrowers with a greater initial default risk (*High Default Risk*$_D$) as those with an Altman's (1968) *Z*-score at or below the 25th percentile. In our sample, these are borrowers having a *Z*-score at or below 1.59 pre-AIPA and 2.09 post-AIPA (1.84 in the full period). These values correspond closely to the recommended cutoff level indicating financial distress of 1.81 as identified by Altman (1968, 2000). We extend our regressions by including interaction effects between *High Default Risk*$_D$ and our patent proxies.[3] Although the relationship between *High Default Risk*$_D$ and innovative firms' cost of debt has the expected sign, we do not find that the effect of patenting activity on innovative firms' cost of debt depends on their initial default risk.

In regressions (17) and (18), we focus on the full period from 1985 to 2013. Regression (18) can be considered a difference-in-difference model where loans to borrowers with patents constitute the treatment group (*Patent*$_D$ = 1); loans to borrowers without patents constitute the control group (*Patent*$_D$ = 0); and *Post-AIPA Period*$_D$ is the treatment dummy. Considering our hypothesis, the interaction effect *Patent*$_D$ * *Post-AIPA Period*$_D$ is of main interest here. The significance of this interaction effect confirms that the signaling quality of the patent information improves after the implementation of AIPA. The negative sign and magnitude of this interaction effect indicate that the existence of granted patents during the post-AIPA period reduces spreads by almost 25 bps. The results of regression (17) lead to the same conclusion.[4]

We note that in some regressions, the explanatory power of our models is relatively modest, with adjusted R^2 values ranging from 28.2% in the pre-AIPA

2 Due to the rating fixed effects, there is no need to include *High Information Uncertainty*$_D$ itself in the regressions.

3 In contrast to using credit ratings to estimate initial default risk, this approach does not suffer from missing data.

4 In regressions (1)–(16), we observe substantial differences in the coefficients for *High R&D Intensity*$_D$ for the pre-AIPA *versus* post-AIPA period. Hence, we also include an interaction term *High R&D Intensity*$_D$ * *Post-AIPA Period*$_D$. Also note that due to the inclusion of year fixed effects, including the *Post-AIPA Period*$_D$ treatment dummy is not strictly necessary, but simply leads to the omission of one additional year fixed effect while the coefficients of our patent proxies and interaction effects are unaffected.

period to 52.0% in the post-AIPA period. This observation suggests that besides the variables of interest regarding a firm's patenting activity and the set of controls, other factors also affect innovative firms' cost of debt. Although beyond the scope of the current paper, one such relevant factor could be the quality of a firm's patenting activity as measured by its patent citation count (see, e.g. Plumlee et al. 2015).

IV. CONCLUSION

We assess the effect of innovation disclosure through patents on reducing innovative firms' cost of debt using the AIPA as a natural experiment. The implementation of AIPA constitutes a significant change in innovation disclosure regulation, with patent applications becoming public 18 months after filing, whereas previously, patent applications were disclosed only after being granted. We show that innovation disclosure through patenting activity only has a significant effect on the cost of debt in the post-AIPA period. We propose signaling innovation quality via patents as the underlying mechanism that explains the negative relation between patenting activity and the cost of debt. In particular, whereas pre-AIPA, firms had an incentive to apply for a large number of patents as a way of trying to keep out competition, post-AIPA firms have an incentive to apply only for those patents about which they are relatively certain that they will result in a commercial marketplace success.

The publication of patents may thus not only benefit society, in that it facilitates knowledge diffusion (Graham and Hegde 2015), but also provides firms' private benefits in the corporate loan market in that it allows them to obtain more favorable conditions from banks on their loans.

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REFERENCES

Altman, E. I. (1968), 'Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy', *The Journal of Finance*, 23, 589–609.

Altman, E. I. (2000), 'Predicting Financial Distress of Companies: Revisiting the Z-Score and Zeta Models', Working Paper. New York, NY: Stern School of Business, New York University.

Atanassov, J. (2013), 'Do Hostile Takeovers Stifle Innovation? Evidence from Antitakeover Legislation and Corporate Patenting', *The Journal of Finance*, 68, 1097–131.

Bhattacharya, S., and J. Ritter (1983), 'Innovation and Communication: Signalling with Partial Disclosure', *The Review of Economic Studies*, 50, 331–46.

Francis, B. et al. (2012), 'Do Banks Value Innovation? Evidence from US Firms', *Financial Management*, 41, 159–85.

Graham, S., and D. Hegde (2015), 'Disclosing Patents' Secrets', *Science*, 347, 236–7.

Griliches, Z. (1990), 'Patents Statistics as Economic Indicators: A Survey', *Journal of Economic Literature*, 28, 1661–707.

Hall, B. H. (2010), 'The Financing of Innovative Firms', *Review of Economics and Institutions*, 1, 1–30.

Hall, B. H., A. Jaffe, and M. Trajtenberg (2001), 'The NBER Patent and Citation Data File: Lessons, Insights, and Methodological Tools', NBER Working Paper No. 8498.

Hall, B. H. et al. (2014), 'The Choice Between Formal and Informal Intellectual Property: A Review', *Journal of Economic Literature*, 52, 375–423.

Hu, J., G. Li, and F. Zhu (2017), 'Regional Financial Developments and Research and Development Investment-Cash Flow Sensitivity: Evidence on Chinese Public High-tech Companies', *International Review of Finance*, 17, 627–43.

Kerr, W. R., and R. Nanda (2015), 'Financing Innovation', *Annual Review of Financial Economics*, 7, 445–62.

Lin, Z. J., S. Liu, and F. Sun (2017), 'The Impact of Financing Constraints and Agency Costs on Corporate R&D Investment: Evidence from China', *International Review of Finance*, 17, 3–42.

Mansfield, E. (1986), 'Patents and Innovation: An Empirical Study', *Management Science*, 32, 173–81.

Plumlee, M. et al. (2015), 'Bank Loan Spread and Private Information: Pending Approval Patents', *Review of Accounting Studies*, 20, 593–638.

