Intellectual Property Protection Lost and Competition: An Examination Using Large Language Models

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Motivation

Innovation:

- Innovation is a key driver of any country's growth.
- Is the current system of IP protection outdated?
- IP protection is about encouraging innovation but is feared to also mitigate (too much) competition.

How do changes in IP protection impact outcomes?

- Original classical theory from Nordhaus (1969). Trade-off between encouraging innovation by granting protection from a patent and the subsequent decreased competition and potential increased prices.
- Boldrin and Levine (2013, JEP) "The Case against Patents" reviews previous studies - concludes patents stifle productivity growth and innovation.

What happens if IP from patents is lost?

"What Should We Do With the Big Technology Companies?" (WSJ 2022)

How are Large vs. Small firms impacted? Valuations? R&D?

Do firms move toward secrecy and trade secrets?

Do IP lawsuits increase or decrease if protection is lost?

How does IP protection impact competition b/t large firms and their smaller competitors?

Literature (subset)

IP protection and innovation

- Lerner (2002) examines changes to the patent system that change IP protection in 60 countries over 150 years. Increases in IP protection are associated with decreased domestic patenting and increased foreign patenting.
- Boldrin and Levine (2008) meta-study examining 24 studies. Concludes weak or no evidence that strengthening patent protection increases innovation.
- Budish, Roin and Williams (2015) - long-term cancer research needs patent protection to begin later after drug approval to encourage innovation.
- Recent studies examine innovation after patent grants / rejections within focused areas using random assignment of patent examiners.
    - Galasso and Schankerman (2015): After patents of large firms are invalidated, small firm innovation in these areas increases. (1357 cases)
    - Sampat and Williams (2019): Patent grants in genetics had no impact on subsequent innovation.
    - Farre-Mensa, Hegde and Ljungqvist (2020) 1st patent grants are valuable to small firm financing, growth and increase prob. of additional patents.

Our Paper

We examine ex post outcomes after the Supreme Court 2014 decision of Alice Corp v. CLS Bank International.

- This decision was not broadly anticipated as impacted firms had negative stock market excess returns. It invalidated large areas of patent protection in business methods, media and systems claims.
- Over 33,700 patent applications made prior to Alice have been rejected in the 3 years post-Alice by examiners citing the Alice precedent.
- These rejected patents cover over 5,831 distinct CPC Subgroups, 919 Groups, and 283 Classes and 8 CPC Sections.

We train a NLP neural network large language model (LLM) model called Longformer using these 33,700 rejected patents.

We use this trained model to classify 642,678 *Pre-Alice existing* granted patents in the same CPC groups to assess their predited exposure to Alice & to calculate the effective decrease in IP protection of a firms' patent portfolio. (16.6% of granted patents over this period.)

Our Findings

We examine ex post competition, patenting, R&D, lawsuits and secrecy by large and small firms that are identified as "exposed / treated" by Alice (hidden exposure).

We document costs and benefits of patent protection. We find that large firms gain and small firms lose when IP protection is lost.

Large firms whose patent portfolios are impacted by Alice gain overall:

- Have increased market values and sales growth.
- *Decrease* their acquisition activity.
- Face less litigation, by NPEs or "patent trolls" and OCs (Operating Companies)
- Face *decreased* direct competition - in particular from small firms.

Our Findings - Smaller firms Lose

In contrast, smaller impacted firms, while they also decrease patenting, they:

- Face *increased* competition across multiple measures.
- Increase R&D - consistent with Aghion et al. (2015).
- Have decreased operating income and market valuations.
- Use alternative methods to increase secrecy and replace lost IP protection including nondisclosure clauses.

Implications of our paper's findings

- Our findings suggest that IP protection serves an important role to moderate the power of large firms.

- Loss of IP protection harms smaller firms who are less able to protect their market segment, but helps larger firms who benefit from market-wide weakening of IP protection through less direct threats by small (low share) firms.

$\Longrightarrow$ There are Costs and Benefits of IP Protection:

- Costs of decreased IP Protection: Increased competition for small firms but strengthening of big tech firms who have other methods of protecting their market shares.

- Benefits of decreased IP Protection: increases small firm competition and decreased patent troll activity.

Alice Corp v. CLS Bank International

Alice Corp. alleged that CLS Bank infringed upon 4 of their patents for methods, system and medium for mitigating settlement risk.

The patents in the suit claim coverage for an "invention (that) relates to methods and apparatus, including electrical computers and data processing systems applied to financial matters and risk management."

Patents cover methods, system and medium for mitigating settlement risk. Specifically they cover:

1. a method for exchanging financial obligations (the method claims),
2. a computer system configured to carry out the method for exchanging obligations (the system claims),
3. a computer-readable medium containing program code for performing the method of exchanging obligations (the media claims).

The History of Alice Case

Case judgments went back and forth.

- District court ruled the patents were invalid.
- 2-1 reversal by a three-judge panel of the Court of Appeals for the Federal Circuit (CAFC).
- However, given the case's complexity and its importance, the CAFC vacated the panel's opinion to hear the case in a full (en banc) session with all 10 judges.
- 5-5 ruling that Alice's system claims were not patent-eligible but 7-3 that the method claims were not patent-eligible.

$\Longrightarrow$ However, judges could not agree on a single standard to determine whether a computer-implemented idea is a patent-ineligible abstract idea.

- Supreme Court decided to hear it and affirmed the decision of the CAFC that Alice method claim patents were not patent eligible.
- Also held that the media and systems claims were similar to the methods claims and also patent ineligible.
- Excess returns at judgement for impacted firms are significantly negative (1% level). Average was -.1%. Top 5% percent, excess returns $\leq$ -.8%. Amicus

Impact of the Alice Case

- Over 33,700 distinct patent applications made prior to Alice have been rejected in the 3 years post-Alice by examiners citing the Alice precedent (new "Office Action Research Database" at USPTO).
- These rejected patents cover over 5,831 distinct Cooperative Patent Classif. (CPC) Subgroups, 919 Groups, and 283 Classes and 8 CPC Sect.

- Patent rejections in top 12 mapped industries (shown in Table 3) include Data Processing Methods for Commerce (36% of 5,563 patent applications in 2013), Administration (31% of 2958 patents applied for in 2013), Finance (42% of 1,752 patents applied for in 2013), Payment Systems (36%), Video Games (27%). Smaller percentages for Computer Security (5.2%), Measuring and Testing (4.9%).

==> Ruling still leaves uncertainty.

Example of Uncertainty in patent eligibility after Alice

BlackBerry Limited v Facebook Inc. (C.D. Ca. Oct. 1, 2019), BlackBerry sued for patent encroachment based on 4 patents. In the end, BlackBerry lost as the U.S. District Court of CA found 3 BlackBerry patents to be ineligible based on Alice. The court acknowledged that "[i]t becomes increasingly difficult to wade through the vast number of appellate decisions regarding § 101 and discern a dividing line between cases that are found drawn to an abstract idea, and those that are not."

Invalid patents included: "Previewing a new event on a small screen device" (US pat. # 8,209,634);
"Handheld electronic device and associated method providing time data in a messaging environment" (8,301,713);
"System and method for switching between an instant messaging conversation and a game in progress" (8,677,250).
==> BlackBerry's stock fell sharply on the news of the 3 patents overturned.

Industries and CPC groups with highest Alice rejections

Panel B: Industries and Corresponding CPC Groups

Industry	CPC Group
Chemical & Physical Properties (Analyzing Materials)	G01N33
Coin-freed or Like Apparatus (Coin-freed Facilities or Services)	G07F17
Data Processing Methods (Administration)	G06Q10
Data Processing Methods (Commerce)	G06Q30
Data Processing Methods (Finance)	G06Q40
Data Processing Methods (Payment Systems)	G06Q20
Data Processing Methods (Specialized For Sectors)	G06Q50
Diagnosis, Surgery, Identification (Measuring for Diagnostic Purpose)	A61B5
Digital Data Processing (Arrangements for Program Control)	G06F9
Digital Data Processing (Computer Aided Design)	G06F30
Digital Data Processing (Computer Security)	G06F21
Digital Data Processing (I/O Arrangements for Data Transfer)	G06F3
Digital Data Processing (Information Retrieval)	G06F16
Digital Data Processing (Natural Language Processing)	G06F40
Games (Video Games)	A63F13
Graphical Data Reading (Recognizing Patterns)	G06K9
Microbiology & Enzymology (Measuring or Testing Processes)	C12Q1
Photogrammetry or Videogrammetry (Navigation)	G01C21
Pictorial Communication (Selective Content Distribution)	H04N21
Transmission of Digital Information (Network Security)	H04L63
Transmission of Digital Information (Network Specific Applications)	H04L67
Transmission of Digital Information (User-to-user Messaging)	H04L51

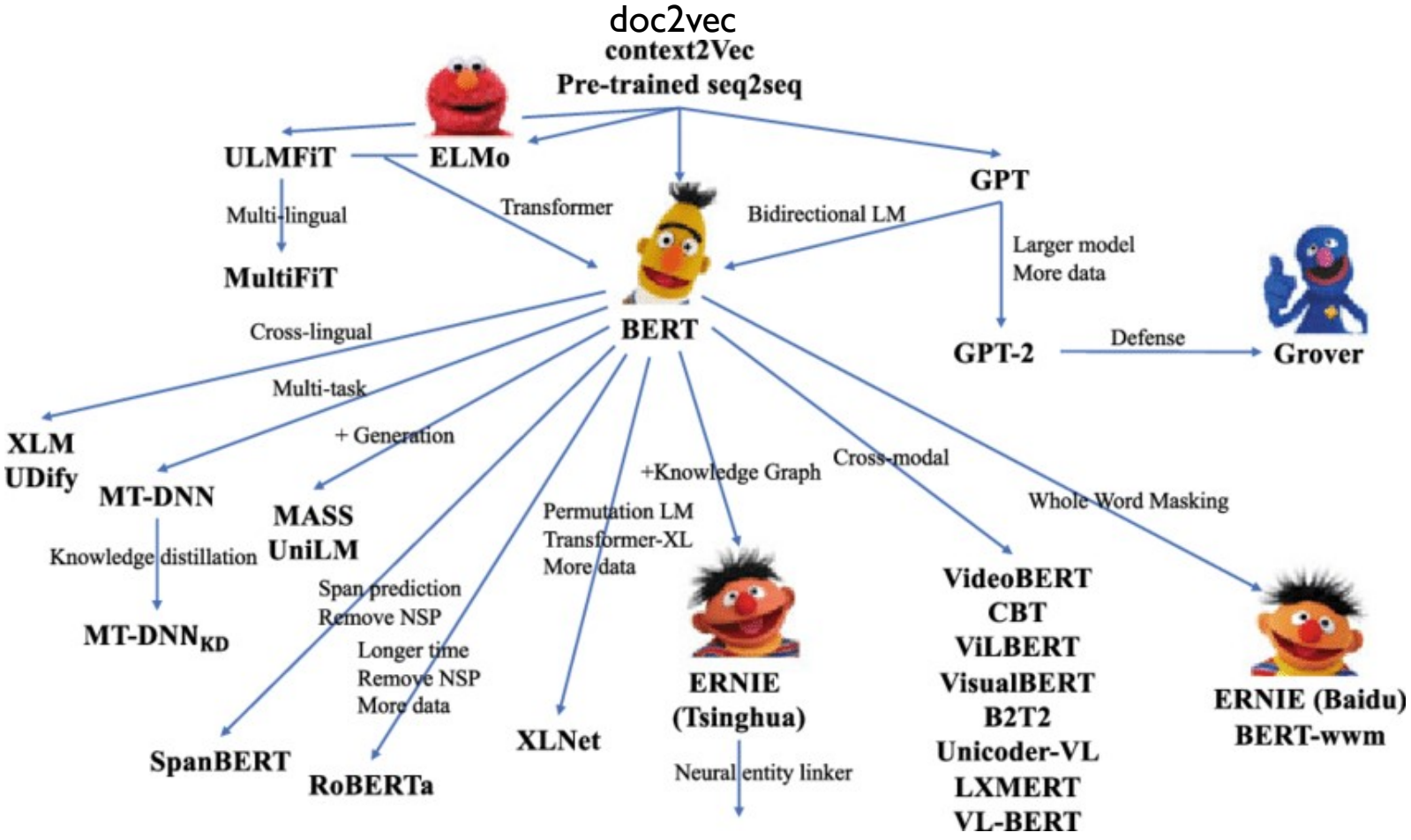
Source: https://patentsview.org/download/data-download-tables

The Longformer Model

- We use the deep learning large language model, Longformer, to classify the likelihood of *granted* patents being invalid. Longformer is an improvement for long texts to BERT, which Google released in 2019.
  - The Longformer model can examine the full context of a word by looking at the words that come before and after it. For example, these two sentences have the same meaning:
    - Symptoms of influenza include fever and nasal congestion
    - A stuffy nose and elevated temperature are signs you may have the flu.
    - The Longformer model finds 0.98 similarity between these sentences. Using a TF-IDF model that filters stop words (such as "and"), the sentences have a similarity score of 0.
  - We show statistically that the Longformer outperforms BERT, Bag-of-Words (BOW), Term Frequency-Inverse Document Frequency (TF-IDF), and Word Embedding models.
  - Requires pre-training on existing text corpora. For comparison, we use Sci-BERT which is pre-trained for scientific classifications.

Large Language Models

Recent explosion of language models



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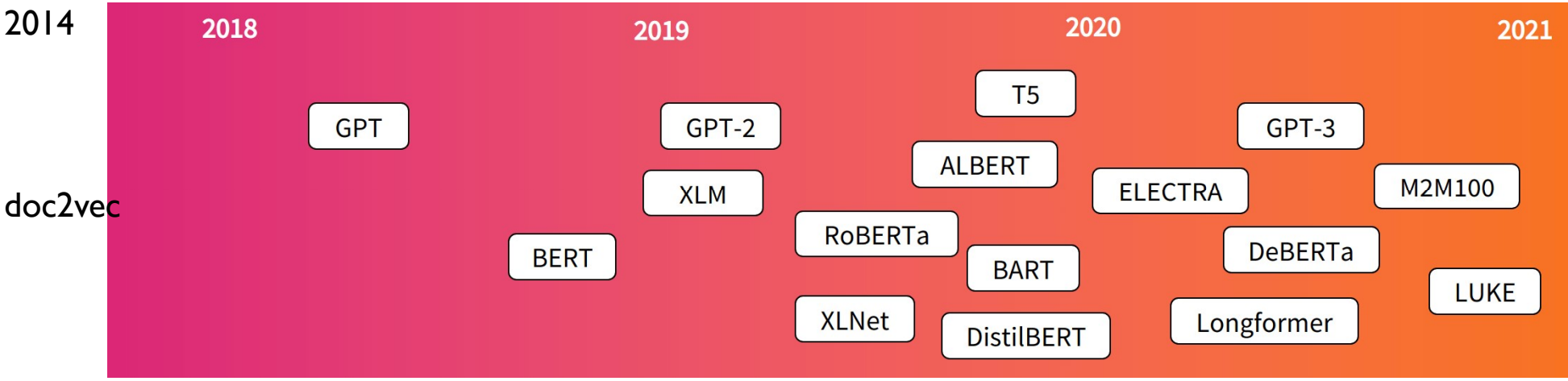


The Longformer Model and Patent Data

- We get USPTO patent data with patent applications, patents granted and rejected, and importantly the text from patent applications
  - Trained model with patents subset of rejected post-Alice "positives" combined with all other patents in similar CPC codes that were granted post-Alice.
  - Final positive list of 33,734 patents rejected post-Alice after removing re-filings and duplicates (patents with similarity score of $> .99$).
  - Train Longformer model using 23,734 of these patents (rest are hold-out sample).
  - Control set of "negatives" using different levels based on the granularity of patent's CPC: i) section; ii) class; iii) subclass; iv) group; and v) maingroup or subgroup
  - Can then assess the goodness of fit of our Longformer model with the hold-out sample of 10,000 rejected patents.

Assessing the fit of the Longformer Model

- For the testing stage (after training), we have the 10,000 positives that were randomly selected as a hold-out sample from the rejected applications pool.
- We compare to 20,000 negatives that are randomly selected from the granted patents pool based on the CPC frequency distribution of the whole sample (from the overall CPC matching 642,678 patents).
- To assess the goodness of fit for the Longformer model, we produce goodness of fit statistics comparing to BERT, TF-IDF and Word2Vec. For TF-IDF and Word2Vec, we combine the machine learning algorithms using logistic regression, decision tree, and random forest.

Model Evaluation Statistics

To evaluate the results, we use the standard performance metrics: precision, recall, F1 score, and accuracy which are calculated form a *confusion* matrix.

The matrix has the following elements: True Positives (TP), False Positives (FP), True Negatives (TN), and False Negatives (FN). True (False) Positives are the predictions that are positive and correct (incorrect). True (False) Negatives are the predictions that are negative and true (false).

$$Precision = \frac{TP}{TP + FP} \ (penalizes\ false\ positives) \tag{1}$$

$$Recall = \frac{TP}{TP + FN} \ (penalizes\ false\ negatives) \tag{2}$$

$$F_1\ Score = 2 \cdot \frac{Precision \cdot Recall}{Precision + Recall} \tag{3}$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{4}$$

Model Evaluation Results

For all models, we conduct four experiments in which the only difference is the way we create the training samples. In experiment A, for each of the 23,734 positives, we find a matching negative patent that is in the same CPC Group. In sample B, C (not displayed in slide) and D, we keep adding 23,734 more matching patents to the negatives pool based on CPC Subclass, Class and Section respectively.

	A		D		$\frac{A+D}{2}$	
Model Name	F_1 Score	Accuracy	F_1 Score	Accuracy	F_1 Score	Accuracy
Longformer Finetune	0.647	0.745	0.639	0.800	**0.672**	**0.804**
SciBERT Finetune	0.651	0.735	0.638	0.777	0.669	0.778
BERT Finetune	0.623	0.733	0.624	0.774	0.642	0.775
RoBERTa Finetune	0.600	0.716	0.515	0.758	0.592	0.765
TF-IDF + Logistic Regression	0.547	0.643	0.550	0.719	0.559	0.679
TF-IDF + Decision Tree	0.503	0.602	0.491	0.690	0.409	0.697
TF-IDF + Random Forest	0.628	0.743	0.209	0.689	0.387	0.723
Word2Vec + Logistic Regression	0.606	0.731	0.358	0.730	0.497	0.755
Word2Vec + Decision Tree	0.492	0.607	0.461	0.702	0.365	0.707
Word2Vec + Random Forest	0.619	0.747	0.365	0.735	0.500	0.766

LR: Logistic Regression, DT: Decision Tree, RF: Random Forest

Granted Patents examined using the Longformer Model

- Our set of patents "to be examined for decreased value of intellectual property" consist of 642,678 patents that were granted between 06/19/1994 and 06/19/2014 and share the same primary CPC with at least one of the applications that were rejected by the USPTO based on the Alice decision.
- These examined patents represent 16.6% of the total granted patents over this period of time. These represent 5,831 CPC Subgroups (out of 126,540), 919 Groups, 283 SubClass, 88 Class, and 8 CPC Sections.
- Using the Longformer deep-learning model, we find 111,420 out of 642,678 patents (or 17.34% of the sample) have a Longformer score $>= 0.5$, with thus a high predicted likelihood of invalidation if these patents are challenged in a court.

Results from the Longformer Model

Top 10 CPC codes with highest numbers actual Alice rejections and predicted Longformer rejections.

Panel B: Summary of CPCs For Alice Rejections and Longformer Predictions by CPC group

Alice Rejections (For Patent Applications)			**Longformer Predictions (For Granted Patents)**		
Most Frequent CPCs	Count	Percentage(%)	Most Frequent CPCs	Count	Percentage(%)
G06Q30/02	1185	3.49	G06Q30/02	2898	2.52
G06Q40/04	675	1.99	G06Q10/10	2133	1.86
G06Q10/06	486	1.43	G06Q10/06	1992	1.73
G06Q40/08	397	1.17	G06Q30/06	1638	1.43
G06Q40/06	383	1.13	G06Q40/04	1563	1.36
G06Q10/10	370	1.09	G06Q40/02	1381	1.20
G06Q30/06	343	1.01	G06Q40/06	865	0.75
G06Q40/02	293	0.86	G07F17/32	841	0.73
G06Q30/0631	248	0.73	G06Q40/00	753	0.66
G06Q30/08	247	0.73	G06Q40/08	717	0.62

Sample Patents flagged by Longformer

Figure 1: Sample Patents with high Longformer Scores

Large Companies	Patent Num.		KPSS VALUE (Millions)	Total Patents	Patents at Risk (Bert>.5)	Treatment Value
ORACLE CORP	6157941-A	Client-server communication methods to support mobile devices with more automation for two-way communication	$2,378.64	20254	757	0.09
QUALCOMM INC	6122384-A	Algorithms to process sounds and voices in order to suppress noise	$984.39	37451	810	0.14
GOLDMAN SACHS	7321873-B2	A computerized method for providing streamlined communications for OTC trading over the internet	$1,015.16	897	73	0.01
MICROSOFT CORP	5850232-A	A method (using a software interface for a display device) for flipping images in a window using overlays	$2,144.33	95064	3966	0.22
WALT DISNEY	6128132-A	A method for combining multiple images to create autostereo images as used for example in 3-D movies	$935.07	2258	77	0.00
Small Companies						
BLUCORA INC	6016504-A	A computer method for tracking product sales transacted on the Internet.	$355.67	68	6	0.08
INTERNAP CORP	6009081-A	A method for managing information flow in a private network when many types of communication links need to be managed.	$253.88	60	4	0.11
AFFYMETRIX INC	6020135-A	A method to analyze genetic data to assess the likelihood of cancer expression based on a number of genetic factors observed information.	$166.85	1963	52	0.62
EXTREME NETWORKS INC	6034957-A	A data path architecture for managing data flow through a Local Area Network (LAN) that provides sufficient bandwidth to remove any possibility of network congestion.	$162.16	721	24	0.24
RAMBUS INC	6125422-A	A computer memory controlling method (tracks which cell used for what data) for settings with many dynamic memory devices (DRAM's)	$123.76	4401	32	0.60

Most Frequently Used Words in Model Predictions (Appearance Ratio= # of words with $\geq 0.5/<0.5$)

Industry	Top Fifteen Words
Commerce (Digital Data Processing)	rebate, bidder, bidding, seller, auction, discounted, sponsor, referral, incentive, purchaser, solicitation, purchasing, solicit
Administration (Digital Data Processing)	interview, consultant, procurement, forecasting, accountability, contractor, consultation, planner, deadline, strategic, forecast, audit, objectively, finalized, logistics
Finance (Digital Data Processing)	underwriting, liquidity, lender, financing, equity, investor, treasury, debt, hedge, earnings, earning, owed, investing, insurer, mortgage
Payment Systems (Digital Data Processing)	settlement, refund, debited, credited, clearinghouse, transacting, approving, dispute, crediting, enroll, deducted, debiting, ach, paying, approves
Coin-freed Facilities or Services (Coin-freed or Like Apparatus)	rewarded, earn, payouts, payoff, redeem, earned, redeemed, redemption, awarding, betting, dealer, profitability, payout, wagered, wager

Sample

Sample Selection

- Panel of public firms
  - All publicly traded firms from 2011-2017 with at least 1 impacted patent and also include all their text-based TNIC competitors from Hoberg and Phillips (2016, JPE).
  - Kogan, Papanikolaou, Seru, and Stoffman (KPSS) (2016) extended to 2020, matching of patents to individual firms and patent values.
  - Only 58 public firms with patents had no impacted patents. Results are robust to including these firms.
  - Final sample of 3,444 unique patenting firms.
  - 3 years pre and post-Alice: 2011 to 2017 yields 19,372 firm-year observations

Data sources

Data Sources

- Patent text data from Google Patents
- Patent rejection data from USPTO.
- Textual measures of firm-specific competition - 10K text using Hoberg and Phillips (2014, 2016) measures.
- metaHeuristica data from firm 10-K text for competition and infringement complaints, non-compete, and non disclosure agreements.
- Lawsuit data from PACER, and Non-Practicing Entity (NPE) data from Stanford NPE Litigation Database
- Firm data from Compustat and M&A data from SDC.

Firm Treatment Measure

$$Treatment_i = \frac{\sum_{j=1}^{N_i} PatentValue_{i,j} \times AliceScore_{i,j}}{Sales_i} \tag{5}$$

where:

*$PatentValue_{i,j}$ an individual patent j's dollar value from Kogan et al. (2016) (we also use citations for robustness)
*$AliceScore_j$ is the Longformer score for patent j
*$Sales_i$ is firm i's total sales in 2014.

Firm Decisions and Outcomes

We examine Post-Alice Outcomes:

$$Y_{it} = \beta_1 * Low_i XPostXTreatment_i + \beta_2 * High_i XPostXTreatment_i + \gamma Z_{it-1} \quad (6)$$

Does a firm's increased Alice exposure impact *Y*:

- Patents and R&D
- Performance and Market Valuation
- Competition and Litigation
- Acquisitions

Control variables *Z* include:

- Firm size and age
- We also include ***firm*** and year fixed effects

Patents and R&D

Large (Small) firm subsequent patenting ↓ by 9.4% (13.4%) with 1 sd ↑ in treatment.
Small firms R&D ↑ by 76.7% with 1 sd ↑ in treatment.

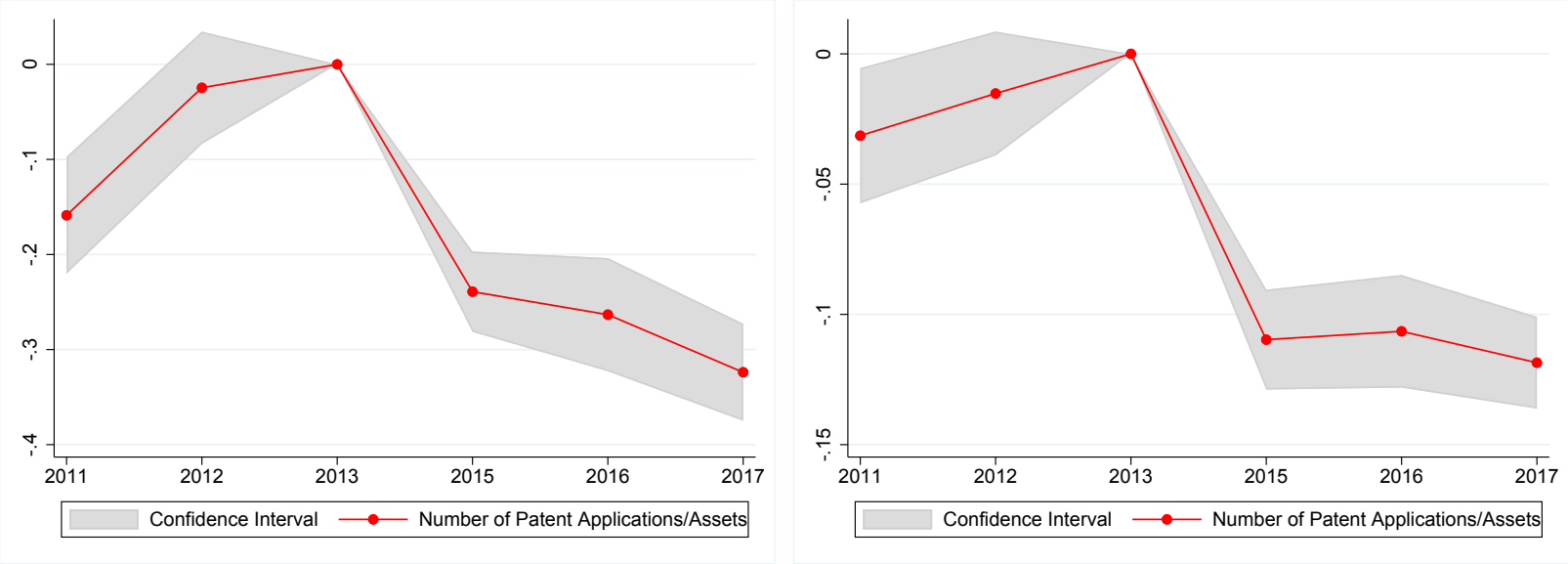
Dependent Variable:	$\frac{\#\ of\ Patents}{Assets}$		$\frac{\#\ of\ Patents}{Sales}$		$\frac{R\&D}{Sales}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Small × Post × Treatment	-0.174***	-0.056***	-0.534***	-0.160***	7.086***	1.463***
	(-8.22)	(-7.34)	(-8.90)	(-7.69)	(4.49)	(3.71)
Large × Post × Treatment	-0.057***	-0.041***	-0.145***	-0.101***	-0.206	-0.218
	(-4.66)	(-4.03)	(-4.29)	(-3.86)	(-0.92)	(-1.07)
Log(Sales)	-0.001***	-0.001***	-0.010***	-0.010***	-0.093***	-0.095***
	(-3.74)	(-3.80)	(-7.76)	(-7.66)	(-6.25)	(-6.33)
Log(Age)	-0.001	-0.001*	0.000	-0.001	0.139***	0.161***
	(-1.33)	(-1.78)	(-0.02)	(-0.48)	(3.65)	(4.10)
Observations	19372	19372	19372	19372	19372	19372
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Treatment Calculation	KPSS	Citation	KPSS	Citation	KPSS	Citation
Adj. R^2	0.083	0.085	0.101	0.098	0.078	0.051

Graphical Time Trend for Patents

Figure 2: Patent Applications For Small Firms

This figure reports the point estimates per year for *Small* × *Treatment* where we add year indicators for each year. 2013 is the reference year. The gray line indicates the 90% confidence interval.

Panel A: KPSS Panel B: Cites



Performance and Valuation

Large firm sales growth ↑ by 14.1% with a 1 sd ↑ in treatment. Small firms' operating margins ↓ by 27.5 ppt (91% of pre-Alice operating margin) and their Tobin's q ↓ by 0.21 ppt (12% of their pre-Alice Tobin's q).

Dependent Variable:	Sales Growth		$\frac{\textit{Operating Income}}{\textit{Sales}}$		Tobin's Q	
	(1)	(2)	(3)	(4)	(5)	(6)
Small × Post × Treatment	0.535	0.043	-11.649***	-2.507***	-10.355***	-2.641***
	(1.16)	(0.38)	(-3.57)	(-3.09)	(-3.12)	(-2.86)
Large × Post × Treatment	0.493***	0.323***	0.685	0.626	0.887	1.144
	(2.99)	(2.95)	(1.26)	(1.25)	(0.69)	(1.37)
Log(Sales)	-0.208***	-0.208***	0.362***	0.365***	-0.344***	-0.341***
	(-27.36)	(-27.36)	(7.81)	(7.92)	(-6.56)	(-6.51)
Log(Age)	-0.017	-0.015	-0.539***	-0.577***	-1.088***	-1.115***
	(-0.82)	(-0.72)	(-5.10)	(-5.43)	(-6.98)	(-7.13)
Observations	19251	19251	18518	18518	18874	18874
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Treatment Calculation	KPSS	Citation	KPSS	Citation	KPSS	Citation
Adj. R^2	0.172	0.171	0.065	0.055	0.075	0.073

Competition and Patent Protection

Small firms face increased VC entry, product similarity and complain more about competition.

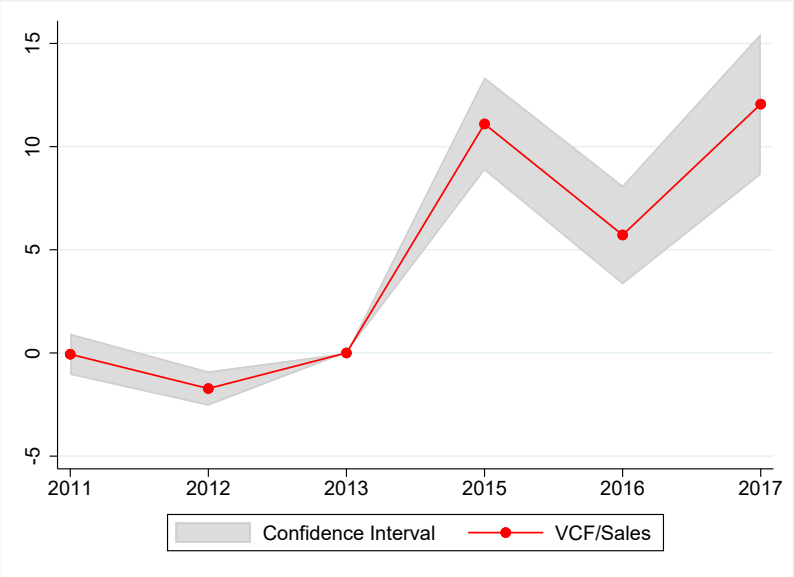
Dependent Variable:	$\frac{VCF}{Sales}$		TSIMM		Complaints	
	(1)	(2)	(3)	(4)	(5)	(6)
Small × Post × Treatment	10.905***	2.273***	106.834***	22.697***	14.760***	3.710**
	(7.52)	(5.35)	(9.09)	(6.56)	(3.06)	(2.44)
Large × Post × Treatment	0.341*	0.140	9.124**	1.449	-7.492*	-2.437
	(1.87)	(1.33)	(2.15)	(0.70)	(-1.79)	(-0.97)
Log(Sales)	-0.452***	-0.456***	0.883***	0.850***	0.122	0.116
	(-15.15)	(-15.26)	(5.23)	(4.80)	(1.34)	(1.27)
Log(Age)	0.388***	0.420***	-0.151	0.155	-0.260	-0.215
	(6.43)	(6.89)	(-0.33)	(0.32)	(-0.82)	(-0.68)
Observations	19286	19286	19268	19268	19289	19289
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Treatment Calculation	KPSS	Citation	KPSS	Citation	KPSS	Citation
Adj. R^2	0.261	0.232	0.094	0.056	0.008	0.006

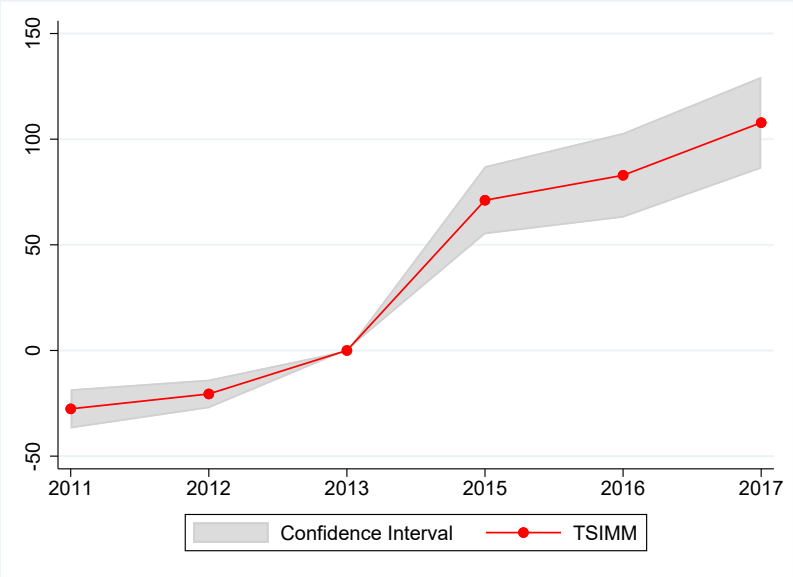
Graphical Time Trend for Competition for Small Firms

Figure 3: Impact of Alice on Competition for Small Firms

This figure reports the point estimates per year for *Small* × *Treatment* using columns (2) and (4) of our competition measure where the dependent variable is VCF/Sales (Panel A) and Total Similarity (TSIMM) (Panel B). The regression specifications are the same as those reported in columns (2) and (4) of our competition table, except that *Small* × *Treatment* is allowed to vary by year, and 2013 is chosen as the reference year. The gray line indicates the 90% confidence interval.

Panel A: Venture Capital Entry (VCF Score) Panel B: Total Similarity





Firm Product Encroachment

Large (Small) firms face increased (decreased) product encroachment.

Dependent Variable:	Delta TNIC Score
Big1 × Big2 × Treat1 × Post	-0.382***
	(-6.07)
Big1 × Small2 × Treat1 × Post	-0.534***
	(-8.31)
Small1 × Big2 × Treat1 × Post	1.776***
	(27.81)
Small1 × Small2 × Treat1 × Post	1.592***
	(21.66)
Observations	13,448,224
Pair Fixed Effects	YES
Year Fixed Effects	YES
R^2	0.092

Firm IP Risk and Protection

Small firms face increased IP risk and increase their use of noncompete and nondisclosure clauses.

Dependent Variable:	IP Risk		Noncompete		Nondisclosure	
	(1)	(2)	(3)	(4)	(5)	(6)
Small × Post × Treatment	11.531***	3.596***	1.145	0.417	14.622***	2.449***
	(3.78)	(4.07)	(1.52)	(1.29)	(4.51)	(3.34)
Large × Post × Treatment	2.630	1.354	-0.893	-0.330	-0.351	-0.419
	(1.00)	(0.77)	(-1.31)	(-0.98)	(-0.52)	(-1.02)
Log(Sales)	0.027	0.026	0.044**	0.044**	0.002	-0.005
	(0.52)	(0.51)	(2.20)	(2.19)	(0.04)	(-0.12)
Log(Age)	-0.279*	-0.256	-0.091	-0.088	0.192**	0.241**
	(-1.78)	(-1.64)	(-1.11)	(-1.08)	(2.04)	(2.46)
Observations	19289	19289	19289	19289	19289	19289
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Treatment Calculation	KPSS	Citation	KPSS	Citation	KPSS	Citation
Adj. R^2	0.068	0.067	0.002	0.002	0.049	0.025

Lawsuits and Legal Protection

Large firms face decreased lawsuits.

Dependent Variable:	# Alleged		# NPE Alleged		# OC Alleged	
	(1)	(2)	(3)	(4)	(5)	(6)
Small × Post × Treatment	0.610**	0.045	0.415**	0.036	0.126	-0.018
	(2.17)	(0.36)	(2.40)	(0.42)	(0.73)	(-0.27)
Large × Post × Treatment	-4.588***	-1.987***	-2.052***	-1.060**	-2.535***	-0.893***
	(-4.56)	(-3.18)	(-2.96)	(-2.51)	(-5.09)	(-2.82)
Log(Sales)	0.038***	0.037***	0.023***	0.022***	0.011***	0.010**
	(4.66)	(4.49)	(3.99)	(3.86)	(2.72)	(2.52)
Log(Age)	0.148***	0.154***	0.067***	0.070***	0.068***	0.071***
	(3.85)	(3.98)	(2.59)	(2.70)	(3.41)	(3.54)
Observations	19372	19372	19372	19372	19372	19372
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Treatment Calculation	KPSS	Citation	KPSS	Citation	KPSS	Citation
Adj. R^2	0.021	0.017	0.015	0.014	0.028	0.022

Acquisitions

High Mkt. Share firms face decrease their acquisition activity by ↓ by 16.5% (14.3%) with 1 sd ↑ in treatment.

Dependent Variable:	$\frac{Acquisitions}{Sales}$		$\frac{Targets\ With\ Patents}{Sales}$		Log(Acquisitions)	
	(1)	(2)	(3)	(4)	(5)	(6)
Small × Post × Treatment	0.214	0.024	0.003	-0.001	0.899	0.044
	(1.64)	(0.64)	(0.69)	(-0.62)	(1.11)	(0.17)
Large × Post × Treatment	0.012	-0.031	-0.021**	-0.016**	-4.477***	-2.949***
	(0.09)	(-0.35)	(-2.04)	(-2.12)	(-2.64)	(-3.00)
Log(Sales)	-0.035***	-0.036***	-0.001***	-0.001***	-0.126***	-0.128***
	(-6.60)	(-6.63)	(-3.32)	(-3.40)	(-3.71)	(-3.77)
Log(Age)	0.007	0.008	0.001**	0.001**	0.208*	0.213*
	(0.49)	(0.54)	(2.18)	(2.23)	(1.66)	(1.70)
Observations	19372	19372	19372	19372	19372	19372
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES
Treatment Calculation	KPSS	Citation	KPSS	Citation	KPSS	Citation
Adj. R^2	0.008	0.008	0.007	0.007	0.004	0.004

Conclusions

- We examine the impact of decreased IP protection resulting from the Alice Supreme Court Decision on U.S. firms' decisions and outcomes.
- We estimate a neural network large language model (LLM) (called Longformer) with individual patent text to identify *existing* granted patents exposure to Alice.
- 111,420 out of 642,678 patents (17.34% of the sample) pre-Alice granted patents in Alice CPC impacted codes have a Longformer score $>= 0.5$.
- We find small firms lose and large firms gain:
  - Small firms face sharply increased competition post-Alice and have $\downarrow$ operating income and $\downarrow$ market valuations.
  - Small firms $\uparrow$ R&D and $\uparrow$ nondisclosures.
  - Large firms $\uparrow$ sales growth and $\uparrow$ market values. Their products face $\downarrow$ direct competition. They undertake fewer acquisitions and face fewer patent lawsuits.

$\Longrightarrow$ Overall, we show that patent protection in large areas benefits small firms by shielding them from competition from larger rivals, but has costs in terms of decreased competition and increased lawsuits by patent trolls.

Alice Amicus Briefs at Supreme Court (found after writing this paper)

Key Amicus briefs in support of Alice Corp.

- Advanced Biological Laboratories
- International Business Machines (IBM)
- International Assoc. for the Protections of Intellectual Property
- Trading Technologies Intl., Inc., including Cantor Fitzgerald, L.P. Casino Gaming, LLC
- U.S. Startups and Inventors for Jobs
- Professors including Daniel Spulber, Professor Richard A. Epstein.

Key Amicus briefs in support of CLS Bank Intl.

- Computer & Communications Industry Assoc.
- Google
- Amazon
- Netflix
- Verizon
- Microsoft
- Adobe
- HP
- Red Hat
- Professors including Bronwyn Hall, Eric Maskin, F.M. Scherer

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