WORKING PAPER

Are Many Heads Better Than Two? Recent Changes In International Technological Collaboration

By

Daniel K.N. Johnson and
Katherine A. Sneed

Colorado College Working Paper 2006-01
August, 2006

Department of Economics and Business
Colorado College
Colorado Springs, Colorado 80903-3298
www.coloradocollege.edu/dept/EC

Are Many Heads Better Than Two?
Recent Changes In International
Technological Collaboration

Daniel K.N. Johnson
and
Katherine A. Sneed

Topic:
International scientific and technological collaborations have surprisingly become less common in the recent past, although with more partners per collaboration.

Abstract:
There are two counter-intuitive trends in technological collaboration currently at work, making collaborative patent applications less common but where they exist, the collaborations involve more partners. Patent data are used to examine these trends along with the impact of two recent policy changes, including the relevance for particular nations and technologies.

Daniel K.N. Johnson is an Assistant Professor of Economics at Colorado College, 14 East Cache La Poudre Street, Colorado Springs, CO 80903, tel: (719) 389-6654, fax: (719) 389-6927, email:djohnson@coloradocollege.edu.

Katherine A. Sneed is a senior Mathematical Economics major at Colorado College, 14 East Cache La Poudre Street, Colorado Springs, CO 80903, tel: (719) 389-6407, fax: (719) 389-6927, email:k_sneed@coloradocollege.edu.

Special thanks to participants at the 2002 International Conference on Emerging International Policy Issues in Science, Technology and Innovation at Harvard University. Financial support was provided by a National Science Foundation Award for the Integration of Research and Education, a Wellesley College Faculty Grant, a Colorado College Faculty Grant and a Mrachek Research Fellowship.

Are Many Heads Better Than Two?
Recent Changes In International
Technological Collaboration

International technological collaboration has become gradually more frequent over the past three decades, an unsurprising fact given advances in information, communication and travel technology. However, policy changes in science and technology (and perhaps immigration and national security) have had a great counteracting impact. This paper uses data from U.S. granted patents to identify which nations, technologies, and inventors have been most affected by changes in policy and political climate, changes which have a lasting impact on technological and scientific progress.

Figure 1 presents two important changes in recent patenting activity. After slow and steady growth between 1975 and 1995, the share of all successful U.S. patent applications which result from collaborative research dropped precipitously and has since continued to decline. Moreover, among patents which show collaborative activity, the average number of partnerships has risen remarkably since 1995. In other words, research collaborations are becoming more concentrated, with rarer collaborative patents each averaging more partnerships than before. Most frequently, patents represent one inventor or many, but rarely two inventors.

On June 8, 1995 the U.S. began a transition period designed to accord with the General Agreement of Tariffs and Trade (GATT), including a change in the rules governing the period of patent protection[1]. Since applications filed before June 8 were given the option of being grandfathered into the old system, there was a spike in applications preceding the change, followed by an inevitable drop in applications as the pipeline fell dormant. Interestingly, that marked a major turning point for collaborative activity, as the U.S. patent system has subsequently dealt increasingly with either single-inventor patents or many-inventor patents, and less often with two-inventor patents.

The period between September of 2001 and April of 2002 was also an unusual one for the science and technology community, as new immigration and Homeland Security regulations were composed and enforced in the U.S.[2,3] The post-2002 period has been anecdotally described as one of potentially more limited intellectual exchange and technological growth due to the increased costs of collaborative activities requiring academic conferences or student/work visas [4,5]. We test the impact of these policy shifts with the data below.

The number of collaborations could potentially be explained as a function of characteristics of the technology, the time period and inventors themselves. We propose that a linearization of the form

$$\begin{aligned}\text{collabs/patent} = {} & \alpha_{\text{US-US}} + \alpha_{\text{US-other}} + \alpha_{\text{other1-other2}} + \beta_{\text{GDP}}(\text{GDP}) + \beta_{\text{pop}}(\text{pop}) + \beta_{\text{IPR}}(\text{IPR}) + \\ & \beta_{\text{short}}(\text{short}) + \beta_{\text{long}}(\text{long}) + \beta_{\text{tech}}(\text{technology}) + \beta_{\text{pol}}(\text{political}) + \\ & \gamma_{\text{date}}(\text{month}) + \text{constant} + e\end{aligned}$$

will approximate the impact of each characteristic on the propensity to collaborate, where

collabs/patent is the number of collaborative relationships per patent
$\alpha_{\text{US-US}}$ is an indicator of a purely domestic U.S. collaboration
$\alpha_{\text{US-other}}$ is an indicator of collaboration between a U.S. and a non-U.S. researcher
$\alpha_{\text{other1-other2}}$ is an indicator of collaboration between non-U.S. researchers of different nations
GDP is the difference between the gross domestic product of each collaborator's nation of residence
pop is the difference between the population of each collaborator's nation of residence
IPR is the difference between the intellectual property rights (IPR) of each collaborator's nation of residence
pol is an indicator of difference between the political regimes of each collaborator's nation of residence
short is an indicator of patents with 18 months or less between application and grant
long is an indicator of patents with 60 months or more between application and grant
tech is an indicator of whether the patent is in biotechnology, computers, or

another technology field

month is the date of application of the granted patent (as a time trend), and

e is the linearization error.

We model a censored normal distribution in the data, as the number of collaborations must be non-negative. *GDP* is measured in thousands of 2000 real dollars per capita [6], *population* in billions [6], *IPR* on a strength and enforcement scale from 1 to 5 [7], *short* and *long* lags as potential indicators of importance and market value [8], *tech* using standard U.S. Patent Classification definitions (based on U.S. Patent and Trademark Office definitions, available from authors), and *pol* as a binary measure of similar political structures [9]. We estimate the α, β, and γ coefficients, permitting the β and γ estimates to vary across three policy periods: a) 1/1975 to 4/1995, b) 8/1995 to 8/2001, and c) 4/2002 to 4/2004.

For computational reasons, we group the data into cohorts that share the same independent variable values [10]. For example, one observation includes the average collaborations per patent of all patents with U.S.-France collaborations of a 36-month lag in biotechnology with an application date of March 1995. Standard errors are corrected using appropriate group size weights [11].

Table 1 shows multiple regression results for two different dependent variables, the average number of collaborations per collaborative patent (counting a collaboration as a pair-wise combination of two inventors on the same patent) and the share of patents that are collaborative.

Domestic U.S. partnerships are more likely than are collaborations internal to a foreign nation ($\alpha_{US\text{-}US} > 0$, in comparison to the reference group). U.S.-foreign partnerships are less likely, and least likely are non-U.S. partnerships which span national boundaries.

Income differences between nations are associated with less collaboration ($\beta_{GDP} < 0$). The GATT 1995 changes served to reduce that effect, but the post-2002 period has made the income difference more important than ever. This bodes poorly for the future of scientific cross-pollination between the U.S. (or Europe or Japan) and partners in Africa, Latin America and Asia.

Population differences have historically been associated with less collaboration, a pattern that has been reversed since 2002. This in part reflects relatively new Sino-U.S. and Indo-U.S. partnerships.

As intuition would suggest, nations with different IPRs are less likely to collaborate ($\beta_{IPR} < 0$), a pattern lessened briefly in the wake of GATT reforms, perhaps due to optimism about global standardization.

Curiously, nations with differing political structures are more likely to collaborate on technology ($\beta_{pol} > 0$). This is perhaps due to the definitions of political structure, which distinguish between subtypes of democracy more readily than they distinguish between military or single-party regimes.

Patents with both short and long period lags tend to have fewer inventors than the comparison group (i.e. lags between 18 and 60 months).

The computer and biotechnology clusters are less apt to collaborate, controlling for other factors, than are their peers in other industries. In fact, biotechnology is less collaborative post-2002 than it has ever been before. This may reflect litigation or venture capital trends in those fields.

Finally, there is ample statistical evidence that collaborative activity is slowing in each successive policy period ($\gamma_{1975\text{-}1995} > \gamma_{1995\text{-}2001} > \gamma_{2002\text{-}2004}$). This is true for domestic and for international collaborations, whether involving U.S. partners or not, even while controlling for the other characteristics above. In fact, post-2002 partnerships are not merely slowing, but are decreasing from their 2001 levels for all non-U.S. collaborations. The lone exception to this trend appears to be domestic U.S. collaborations which, where they exist (which is rarer than ever before), have more inventors than ever in the past.

In sum, baseline collaborative activity is waning with time. Other factors may ameliorate this trend (e.g. international convergence in per capita income or IPRs), but the pattern points to a disturbing, dramatic and heretofore undocumented technological development of the last decade. This pattern is not limited to U.S. researchers, but on average affects all applicants to the U.S. patent system. We believe that the trend is alarming enough to warrant serious investigation into its behavioral causes, and into potential policy means of redressing it if necessary.

References

1. United States Patent and Trademark Office (June 28, 1995). Patent and Trademark Office Handles Upsurge In GATT Related Applications *http://www.uspto.gov/web/offices/com/speeches/95-22.html*. Press Release.
2. *USA Patriot Act*, Pub L. no. 107–56, (2001).
3. *Homeland Security Act of 2002*, Pub L. no. 107–296. (2002).
4. Brooks, Anthony, "Looser Visa Process Urged for Foreign Students" (August 15, 2004). National Public Radio. http://www.npr.org/templates/story/story.php?storyId=3852263.
5. American Chemical Society discussion entitled "The Impact of Post 9-11 Visa Policy on Science and Technology Competitiveness", May 3, 2004. http://www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=government%5Cscproject%5Csc_may03_04.html
6. *WDI online*, Washington, DC: World Bank Group
7. Ginarte, Juan C., and Walter G. Park (1997), "Determinants of patent rights: A cross-national study." *Research Policy* 26: 283-301.
8. Johnson, Daniel K.N. and David Popp (2003), "Forced Out of the Closet: The Impact of the American Inventors Protection Act on the Timing of Patent Disclosure," *Rand Journal of Economics*, 34(1): 96-112.
9. *Statesman's Year-book* (1986-2000). Macmillan Press and St. Martin's Press, New York.
10. Caballero, R.J. and Jaffe, A.B. "How High are the Giants' Shoulders: An Empirical Assessment of Knowledge Spillovers and Creative Destruction in a Model of Economic Growth." In O.J. Blanchard and S. Fischer, eds., NBER Macroeconomics Annual. Cambridge, MA: MIT Press, 1993.
11. Greene, W.H. *Econometric Analysis*. New York: Macmillan Publishing Company, 1993.

Figure 1: Collaborative patent activity

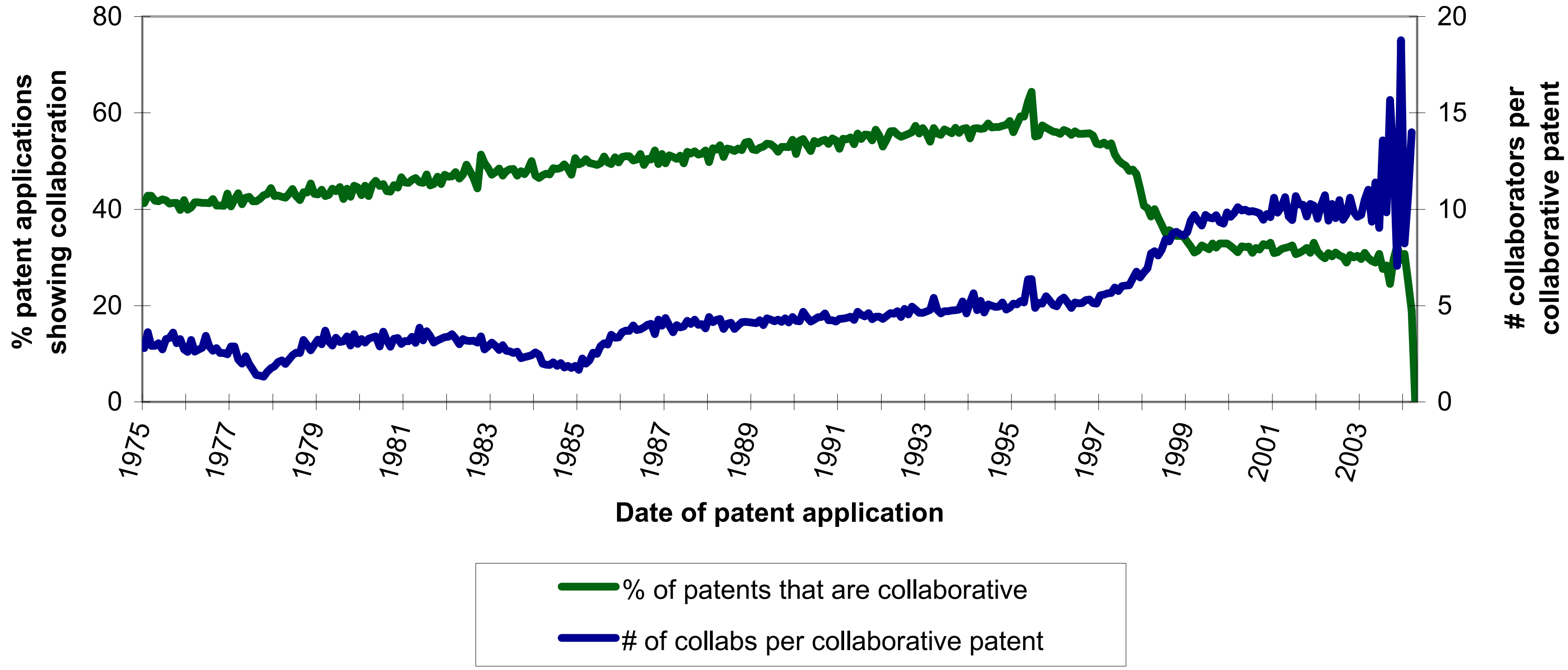

Table 1: Estimated coefficients

		Collaborations per collaborative patent			Share of patents that are collaborative		
Variable		**Estimate**	**t-statistic**		**Estimate**	**t-statistic**	
Constants		-9.57	35.87	***	-0.06	43.51	***
U.S. domestic	$\alpha_{US\text{-}US}$	16.17	25.42	***	0.20	58.56	***
U.S. international	$\alpha_{US\text{-}other}$	-8.61	25.14	***	-0.05	24.55	***
Non-U.S. international	$\alpha_{other1\text{-}other2}$	-50.56	118.62	***	-0.27	115.68	***
GDP difference	$\beta_{GDP,\ 1975\text{-}1995}$	-0.24	18.81	***	-1.32×10^{-3}	18.46	***
	$\beta_{GDP,\ 1995\text{-}2001}$	-0.10	10.55	***	-5.63×10^{-4}	10.78	***
	$\beta_{GDP,\ 2002\text{-}2004}$	-0.41	4.51	***	-1.85×10^{-3}	3.61	***
Population difference	$\beta_{pop,\ 1975\text{-}1995}$	-6.30	10.57	***	-0.04	10.65	***
	$\beta_{pop,\ 1995\text{-}2001}$	-2.10	7.14	***	-0.02	10.19	***
	$\beta_{pop,\ 2002\text{-}2004}$	13.10	4.92	***	0.07	4.45	***
IPR difference	$\beta_{IPR,\ 1975\text{-}1995}$	-12.10	80.32	***	-0.07	79.93	***
	$\beta_{IPR,\ 1995\text{-}2001}$	-6.00	53.38	***	-0.03	52.76	***
	$\beta_{IPR,\ 2002\text{-}2004}$	-11.96	11.20	***	-0.07	11.22	***
Political similarity	$\beta_{pol,\ 1975\text{-}1995}$	1.82	9.93	***	0.01	12.13	***
	$\beta_{pol,\ 1995\text{-}2001}$	-1.06	5.56	***	-1.74×10^{-3}	1.61	
	$\beta_{pol,\ 2002\text{-}2004}$	6.82	3.69	***	0.05	4.88	***
Short lag	$\beta_{short,\ 1975\text{-}1995}$	-9.77	63.62	***	-0.06	65.35	***
	$\beta_{short,\ 1995\text{-}2001}$	-16.62	87.37	***	-0.09	82.03	***
Long lag	$\beta_{long,\ 1975\text{-}1995}$	-87.81	169.91	***	-0.46	168.53	***
	$\beta_{long,\ 1995\text{-}2001}$	-66.23	114.59	***	-0.35	113.33	***
Computer technology	$\beta_{tech=comp,\ 1975\text{-}1995}$	-43.38	141.93	***	-0.22	136.44	***
	$\beta_{tech=comp,\ 1995\text{-}2001}$	-19.70	84.90	***	-0.10	79.11	***
	$\beta_{tech\ =comp,\ 2002\text{-}2004}$	-30.61	22.68	***	-0.15	19.12	***
Biotechnology	$\beta_{tech=bio,\ 1975\text{-}1995}$	-17.74	97.77	***	-0.09	87.63	***
	$\beta_{tech=bio,\ 1995\text{-}2001}$	-14.52	74.91	***	-0.07	68.42	***
	$\beta_{tech=bio,\ 2002\text{-}2004}$	-40.18	26.38	***	-0.22	24.62	***

Application month (trend)							
U.S. domestic	$\gamma_{U.S.\text{-}U.S.,\ 1975\text{-}1995}$	4.20×10^{-2}	10.36	***	9.62×10^{-4}	45.51	***
	$\gamma_{U.S.\text{-}U.S.,\ 1995\text{-}2001}$	2.60×10^{-2}	9.15	***	6.23×10^{-4}	41.82	***
	$\gamma_{U.S.\text{-}U.S.,\ 2002\text{-}2004}$	7.70×10^{-2}	9.78	***	-3.99×10^{-4}	8.80	***
U.S. international	$\gamma_{U.S.\text{-}other,\ 1975\text{-}1995}$	12.42×10^{-2}	74.29	***	6.98×10^{-4}	74.76	***
	$\gamma_{U.S.\text{-}other,\ 1995\text{-}2001}$	8.22×10^{-2}	64.29	***	4.40×10^{-4}	61.23	***
	$\gamma_{U.S.\text{-}other,\ 2002\text{-}2004}$	7.99×10^{-6}	0.01		-2.71×10^{-5}	0.81	
Non-U.S. domestic	$\gamma_{other1\text{-}other1,\ 1975\text{-}1995}$	4.76×10^{-2}	30.96	***	3.17×10^{-4}	37.77	***
	$\gamma_{other1\text{-}other1,\ 1995\text{-}2001}$	5.27×10^{-2}	40.26	***	2.85×10^{-4}	39.22	***
	$\gamma_{other1\text{-}other1,\ 2002\text{-}2004}$	2.08×10^{-2}	3.47	***	-2.59×10^{-4}	7.38	***
Non-U.S. international	$\gamma_{other1\text{-}other2,\ 1975\text{-}1995}$	16.19×10^{-2}	85.50	***	9.01×10^{-4}	84.59	***
	$\gamma_{other1\text{-}other2,\ 1995\text{-}2001}$	13.73×10^{-2}	96.84	***	7.64×10^{-4}	95.15	***
	$\gamma_{other1\text{-}other2,\ 2002\text{-}2004}$	-4.39×10^{-2}	5.90	***	-2.48×10^{-4}	5.81	***
Observations		3829899			3829899		
Pseudo R^2		0.58			0.88		

Notes: *** indicates significance at the one percent level.