Visionary Leader and Followers:

An Empirical Study of India's Public R&D Laboratories

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We empirically study the effect of a visionary leader appointing followers to implement her vision. Our evidence is from 42 Indian public R&D labs with 12,500 employees. From a base of negligible foreign patents, the labs collectively emerged as a leading patentee from emerging markets, licensing patents to multinationals. This followed organizational change at two levels. A new leader assumed stewardship of the parent organization that sets the vision for the labs. This was followed by a change in the directors of the organization's constituent labs. The lab directors were all appointed by the visionary leader. We exploit exogeneity in the timing of lab director change, driven by rigid bureaucratic rules, as the basis of identification.

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1. Introduction

In this paper, we empirically study the effect of a visionary leader appointing followers to implement her vision. We study this in the context of Indian public R&D labs and exploit exogeneity in the timing of lab director change, driven by rigid bureaucratic rules, as the basis of identification.

There is a growing theory literature on leadership change in economics, notably work by Rotemberg and Saloner (2000) and Van den Steen (2005). Rotemberg and Saloner show how a visionary leader with strong beliefs affects incentives of followers and implementation of innovative projects within firms. Van den Steen shows that a stronger belief of the visionary leader influences the choice of projects undertaken by the followers and increases the effort and utility of employees who agree with her. However, there are no prior empirical studies in the economics literature that have looked at the effect of a visionary leader appointing followers.

Our empirical setting is comprised of 42 state-owned labs in India, all reporting to a single parent organization, The Council of Scientific and Industrial Research (CSIR) that has a vision-setting role for the individual labs. Collectively the labs employ 12,500 scientific and technical staff. We collected data for the 42 labs under the CSIR fold over 1995 to 2006, providing cross-sectional and time series variation. For each lab, we collected annual data on lab director change, government budgetary support, licensing revenue from multinationals, patenting, and control variables related to the location and the nature of science pursued by each individual lab. The 42 labs started from a base of negligible foreign patents and ended up with more patents than all domestic private firms combined. The labs were then able to license several of these patents to multinational firms, and revenue from multinationals increased from 3% to 15% as a fraction of government budgetary support. This performance improvement did not adversely affect citation-weighted publications, so it did not manifestly come at the expense of the public science role of the labs.

We document that this transformation was triggered by organizational change at two levels—with the advent of a new visionary leader at the top of the parent organization and with changes in individual lab directors. All lab directors were appointed by the visionary leader. Rigid government employment rules led to lab director changes whose timing was exogenous and provides the basis of identification. Lab directors could be replaced only when the incumbent director retired or completed the contract period which was of a fixed duration of six years. Incumbent directors could not be replaced because of nonperformance or because of disagreement with the new vision of intellectual property (IP) commercialization. Under these employment rules, we find that for individual labs, foreign patent filings and revenue from multinationals increased sharply in response to director changes.

Our findings also inform the literature on public R&D. The innovation and public R&D literature, that includes Henderson et al. (1998), Jaffe and Lerner (2001), Lach and Schankerman (2008), etc., documents higher levels of IP creation by public R&D entities in the U.S. in response to incentive and organizational change. However, there are no prior empirical studies on how leadership change affects IP commercialization within public R&D labs and other state-owned entities (SOEs).

This paper is organized as follows: Section 2 summarizes the related literature on leadership change, state owned entities and public R&D; Section 3 outlines the empirical setting; Section 4 presents our empirical specifications and data; Section 5 presents the results; and Section 6 interprets the results. All tables and figures are presented at the end.

2. Theory

We build on the growing theory literature on leadership in economics, notably on two relatively recent models developed by Rotemberg and Saloner (2000) and Van den Steen (2005). Both these models exemplify a biased leader with strong beliefs influencing her followers.

Work by Rotemberg and Saloner (2000) has shown how a 'visionary' leader affects the incentives of employees and the implementation of innovative projects within firms. In this model, a visionary leader is biased toward certain kinds of projects and against others. The followers then know that the organization is likely to favor investments that are consistent with this vision and, thus, they work hard on such projects, particularly if they can be rewarded for their efforts only when their projects are implemented. The authors model a firm with two employees, or product divisions, working on two different projects. They model 'vision' as the bias of the leader towards one particular project. Such vision improves the incentives of one of the employees and reduces the incentives of the other.

Van den Steen (2005) builds on this and additionally considers a sorting effect. The beliefs of the leader influence the choice of projects undertaken by the followers. He shows that a stronger belief of the leader increases the effort and utility of employees who agree with her. Such employees get easier approval for their projects they undertake, and end up with a higher expected return on their efforts. His model also shows that this decreases the effort and utility of employees who disagree with the leader. These differential effects on utility then give rise to sorting: a firm attracts employees with beliefs that are similar to those of its leader. The author defines 'vision' as a strong belief by the leader about the future and about the right course of action for the firm. To quote the author, such vision will be most effective with high uncertainty and low contractibility. This suggests that vision will be more important for, for example, high-tech industries and startups than for established firms in mature industries.[1]

[1] In other work Van den Steen (2010) has shown how shared beliefs and values, originate through screening, self-sorting, and manager-directed joint learning. Van den Steen (2008) has also looked at the allocation of control when there is disagreement about the right course of action. In a related paper, Dessein (2007) shows that committees that favor a leader with authoritative decision making rights reduce rent seeking discussions and often reach a higher decision quality than committees with majority decision making

In an earlier model developed by Hermalin (1998), the leader, with concentrated information and 'leading by example,' can yield an outcome that is superior to the symmetric information outcome. In this model, the hidden information problem counteracts free riding by the team: followers work hard based on more optimistic beliefs about the leader's information.[2]

However on the empirical side, we could not find any studies that consider the visionary leader and her followers. In fact, there are only a very few empirical studies on leadership in economics. A few notable exceptions are Karpoff (2001), Bertrand and Schoar (2003) and Hayes, Oyer and Schaefer (2005). Karpoff (2001) conducted a cross-sectional comparison of 35 government-funded and 57 privately funded Arctic expeditions and found that the government expeditions had higher failure rates, attributable to poor leadership structures and perverse incentives. Bertrand and Schoar (2003) find that manager fixed effects matter for a wide range of corporate decisions. A significant extent of the heterogeneity in investment, financial, and organizational practices of firms can be explained by the presence of manager fixed effects. The authors find that heterogeneity in corporate practices across managers arise in models that explicitly allow managers to differ in their preferences, risk aversion, skill levels, or opinions. Hayes, Oyer and Schaefer (2005) demonstrate that when a key member of the team, i.e. the chief executive officer (CEO) departs, the probability of non-CEO top manager turnover increases markedly. They also demonstrate that the probability of the non-CEO manager leaving increases with an increase in 'co-worker complementarity' between this individual and the CEO. However, we could not find any prior studies that consider the effect of an incoming visionary leader with strong beliefs on her appointed followers.

One way to test out the effect of a visionary leader on her followers would be to consider the recruitment of followers by a visionary leader. It would be interesting to test whether the vision is implemented post such recruitment. However in a wide range of empirical settings, the timing of such recruitment might be endogenous to other changes happening in the organization. As we will explain later, we address this issue by exploiting a bureaucratic rule related to the timing of when Indian public R&D lab directors can be appointed.

Given that we are studying leadership in public R&D labs, we are also motivated by insights from two other literatures—the state owned entity reform literature and the innovation and public R&D literature. Both the theory and empirical literature on state-owned entities (SOEs)—notably Shleifer (1998) and Dewenter and Malatesta (2001)—overwhelmingly support privatization.[3] However, this may

[2] Komai et al. (2007) extend the Hermalin (1998) model to show that a leader not revealing all her information can achieve the first best.

[3] Several inefficiencies of state-owned firms (e.g., principal agent issues, lack of residual claimant, absence of motivation and monitoring, soft budget constraints) have been documented in the agency theory and property rights literature. An excellent survey of the SOE privatization and reform literature is provided by Megginson and Netter (2001).

not be a feasible policy option for a large number of SOEs, including public R&D labs.[4] There are a few empirical papers focused on China that look at policy alternatives and complements to privatization. In the case of Chinese SOEs, Groves et al. (1994) have shown that incentives and other organizational changes (e.g., selecting managers by auctions) are positively related to worker incomes and investment.[5] In comparison to the Chinese SOE reform papers, our study offers three major departures. First, the Chinese studies are mostly focused on firms in the manufacturing sector. In contrast, we studied Indian state-owned R&D entities where IP is the major output. Second, unlike any of the prior studies, we analyzed the impact of leadership change on IP commercialization. Third, unlike the Chinese studies, we document that collaboration between the state and private sector formed the engine of change in the Indian context.

In the innovation and public R&D literature, Henderson et al. (1998), Jaffe and Lerner (2001), Jensen and Thursby (2001), and Lach and Schankerman (2008) have looked at the impact of incentive and organizational reform on IP creation at public R&D entities. Henderson et al. (1998) studied the effect of the Bayh-Dole Act that allowed universities and nonprofit institutions to retain titles to patents derived from federally funded R&D. This reform also allowed government-owned labs to grant exclusive licenses on government-owned patents. Jaffe and Lerner (2001) studied the impact of the initiatives since 1980 to encourage patenting and technology transfer at the U.S. national laboratories. Their analysis is based on 23 federally funded research and development centers (FFRDCs) from 1977 to 1997. Specifically, they studied the effect of the 1986 reform that encouraged patenting and technology transfer by labs, and they report that patenting post-1986 was 50% greater than patenting prior to 1986. Lach and Schankerman (2008) studied incentives and invention in U.S. universities and showed that faculty respond to royalties both in the form of cash and research lab support, indicating both pecuniary and intrinsic research motivations. Collectively this literature documents that public R&D entities exhibit higher IP creation and commercialization in response to incentive and organizational reform. However, this literature has not empirically studied how leadership change can help unlock IP commercialization.

[4] As Dastidar et al. (2008) point out, governments may not privatize firms either because they are unprofitable or because of political interests. Kapur and Ramamurti (2002) document the reluctance of governments to privatize SOEs in the strategic sector. Jones et al. (1999) document that in a sample of share-issue privatizations from 59 countries, just 11.5% of the firms sold all of their capital and less than 30% sold more than half of their capital.

[5] Li (1997) documents improvements in factor productivity of Chinese SOEs following improved incentives and compensation. Lau et al. (2000) document the "contract responsibility system" introduced in Chinese urban SOEs. Brandt and Zhu (2000) analyze Chinese SOEs from 1986 to 1993 both to document the role of "soft budget constraints" for Chinese SOEs and the eventual decentralization of credit. Jin and Qian (1998) look at public versus private ownership of firms in rural China. Aivazian et al. (2005) document performance improvement in Chinese SOEs following corporatization.

3. Empirical Setting

India's 42 state-owned national laboratories are organized under an autonomous umbrella organization, The Council of Scientific and Industrial Research (CSIR), and collectively they have around 12,500 scientific and technical employees. The laboratories, covering all major scientific and engineering disciplines, were created in the 1940s and 1950s. Until the 1980s, the main goal of the labs was to indigenize imported technologies in areas such as tractors, food processing, pharmaceuticals, and polymers.[6]

3.1. Visionary Leader and His Beliefs

Around 1994, the labs started a major transformation process under the leadership of a new director general, Dr. Raghunath Mashelkar. The director general of CSIR has oversight and a vision-setting role for all 42 labs. Dr. Mashelkar articulated his beliefs around the importance of Intellectual Property commercialization through several speeches delivered around this time and through the 'CSIR 2001 Vision' document, published in January 1996. This document outlined ambitious goals aimed at reducing dependence on government budgetary support. He coined the phrase "patent, publish and prosper" and repeatedly articulated his central belief that "patents are wealth creators".[7]

In his prior assignment as director of one of the CSIR labs (National Chemical Laboratory or NCL, based in Pune), Dr. Mashelkar had great success in securing U.S. patents on polymers and licensing these patents to multinationals like GE. In 1994, NCL had 88% of the foreign patents granted to the 42 labs. However, replicating NCL's success on a broader scale had significant constraints. For example, on the organizational side, salaries of scientists are determined by Indian central government rules and CSIR management had no flexibility in modifying these salaries. Salaries for all government employees in India are centrally determined by the Central Pay Commission and CSIR management has to reimburse scientists at the pay scales determined by the Central Pay Commission. Also importantly, there were no central salary revisions during the course of our study. In this context, there were two major policy changes that were implemented under the new leadership that deserve attention.

[6] Krishna (2007) provides an exhaustive account of the growth in CSIR laboratories and elucidates a major issue facing the labs in the 1980s. The author quotes Ward Morehouse's (1978, p. 374) case study of a CSIR laboratory: "one of the major limitations affecting industrial research in India has been the lack of work after the laboratory stage, which is essential if laboratory know-how is to be translated into commercially usable form."

[7] Source: http://www.socialcause.org/getarticlefromdb.php?id=149. Website accessed on July 23 2012

3.2. One Time Change in Employee-Level Incentives Across all Labs

Until the 1970s, India's national laboratories had a policy of sharing licensing revenue with individual inventors; this policy was discontinued in September 1977.[8] However on June 15, 1994, a committee chaired by Dr. Mashelkar announced that 40% of licensing revenue and fees from corporate R&D projects would be shared among scientists.[9] Of the total remuneration, 35% would go to innovators, 35% to other team members, 15% to other staff indirectly involved in the project, 10% would be shared among all employees of the lab in question, and 5% would go to a fund focused on socially responsible projects. One could argue that this incentive reform addressed several of the agency and property rights issues linked to patenting and licensing technologies. Also, by implementing this incentive policy, the new leadership found an indirect way to increase the remuneration of scientists. Though constrained by the Central Pay Commission pay scales in not being able to increase the fixed component of scientist salaries, the new policy led to a variable compensation component for scientists who were successful in commercializing technologies. Our analysis shows that in the long run, this had an economically significant impact on the take-home remuneration for a large number of scientists.[10]

3.3. Visionary Leader Appointing Lab Directors

The change of director at individual labs is the main empirical event we studied. Lab directors were appointed by the director general of the parent organization (Dr. Mashelkar in this case) and were responsible for allocating the government budgetary funds to various projects within a lab. It is conceivable that the visionary leader appointed lab directors who shared his vision about IP commercialization. In fact, the role of the lab director was critical in implementing the new vision of IP commercialization. It was not sufficient to have individual scientists incentivized in developing IP that could be licensed; the IP commercialization projects needed resources that were allocated by the lab directors.

Importantly for our identification strategy, leadership change at individual labs was an event whose timing was exogenous, given rigid government employment rules. New directors could be appointed only at the end of the six-year contract period of the incumbent director or if the incumbent director had reached the retirement age of 60 years, whichever came first. The new director general had no control over when lab directors could be replaced; but he/she had control over who was to be appointed as the new director when the change happened. If a new director had a positive influence on IP commercialization, we should observe a spike in patenting and licensing revenue in years after the lab

[8] Source: CSIR circular 9/203/92-TU, May 8, 1992.
[9] Source: CSIR letter 9/203/94-TU, June 15, 1994.
[10] We have data on 156 patents licensed from 2001 to 2006, and the average remuneration to an individual inventor is approximately $2,200. This works out to about 40% of the average senior scientist's 1999 annual salary.

director change. Patent filing should increase immediately after the lab director change. However, we expect to observe a lag in the growth of licensing revenue given the lead time needed to search for buyers of IP and the time needed to finalize licensing contracts.

During his tenure as the leader of CSIR, Dr. Mashelkar was able to implement leadership changes at 36 of the 42 laboratories. Figure 3 outlines all leadership events at the labs from 1995 to 2005 and there are a total of 62 such leadership change events. Twenty-six labs experienced a total of two leadership changes from 1995 to 2005, 10 labs experienced a single leadership change in this period, and six labs experienced no leadership change. We explored why six of the labs did not experience a director change and found various reasons: for instance, four labs were merged into other labs as a result of organizational restructuring and one lab ceased to exist.[11]

3.4. Followers and Detractors

Interviews with CSIR scientists revealed that several new directors played an important role in implementing the new vision of IP commercialization. Though the new directors had no flexibility in increasing the government budgetary support for a lab, they could direct resources toward projects that had higher likelihoods of being commercialized. As an example, new directors like J.S. Yadav and K.V. Raghavan at IICT Hyderabad directed resources toward several projects aimed at supporting IP commercialization. Some of these projects included supporting a new Biotechnology Incubation Center (BTIC), setting up a Centre for Analysis of Chemical Toxins (CACT), setting up a Pre-Biotechnology Incubation Centre (PBIC), and investing in data mining and data warehousing for IP commercialization.

Our qualitative analysis also indicated that several incumbent lab directors, with longer tenures at the organization, resented this move toward IP commercialization. Senior scientists from the pre-Mashelkar era expressed fear that CSIR in general and NCL in particular, might become "a lab on rent" for multinationals.[12] Mashelkar was criticized within the CSIR for being on a World Intellectual Property Organization (WIPO) panel and for pushing for product patents. His critics within CSIR said that this would lead to an “astronomical increase in the prices of agro seeds and pharmaceutical medicines”.[13]

[11] In robustness checks, we excluded such labs from the regression analysis; the results remained consistent.
[12] Source: http://reflections-shivanand.blogspot.com/2007/08/r-mashelkar-catalyst-for-change.html. Web site accessed on February 24, 2012.
[13] Source: http://www.outlookindia.com/printarticle.aspx?233803. Website accessed on February 24. 2012

4. Empirical Specifications and Data

4.1. Effect of Lab Director Change on Revenue and Patenting

We analyzed the impact of lab director change on foreign patenting and licensing revenue. As discussed earlier, based on director appointment rules at Indian national labs, we conceptualized director change at labs as an event whose timing was exogenous. However, each director change event led to an opportunity to replace the existing director with an individual who was more aligned to the new goals of IP commercialization. Also, in contrast to the one time incentive policy reform that happened simultaneously for all labs in 1994, lab director change is an event that happens at different time points for different labs.

We collected data on all director changes at the 42 labs from 1995 to 2005. We then constructed the following dummy variables to indicate the five years following each director change: *1_year_post_director_change*, *2_years_post_director_change*, *3_years_post_director_change*, *4_years_post_director_change*, and *5_years_post_director_change*. In the specifications presented below, we use the symbols $D_{i,\tau+1}$, $D_{i,\tau+2}$, $D_{i,\tau+3}$, $D_{i,\tau+4}$, and $D_{i,\tau+5}$ to indicate these five dummy variables for lab 'i.'

We also constructed the following variables to indicate the five years prior to each director change: *1_year_prior_to_director_change, 2_years_ prior_to _director_change, 3_years_ prior_to _director_change*, *4_years_ prior_to _director_change*, and *5_years_ prior_to _director_change.* In the specifications presented below we use the symbols $D_{i,\tau-1}$, $D_{i,\tau-2}$, $D_{i,\tau-3}$, $D_{i,\tau-4,}$ and $D_{i,\tau-5}$ to indicate these five dummy variables for lab 'i.'

Since we are interested in the effect of lab leadership change on patenting and IP commercialization, we used the log of foreign patent filings and the log of revenue from multinational firms as the two dependent variables. Patent filings are more reflective of concurrent patenting activity and were used in the base case, though we used patents granted as a robustness check.[14] In the base case, we used a fixed effects model with robust standard errors clustered at the level of a lab. We also ran a quasi-maximum likelihood conditional fixed effects Poisson model (as described by Wooldridge, 1999) with standard errors clustered at the lab level as an alternative model.[15] Finally, we repeated the analysis with OLS and log of foreign patent filings and log of revenue from multinational firms. For all logged variables, we added a 1 to the variable given that both foreign patent filings and revenue from multinationals took values equal to zero. We added time-varying lab-level covariates to the specification. The main time variant control variable is the level of government budgetary support (*govt_budget_support*). Inclusion of this variable allowed us to control for the size of individual labs, given that government budgetary support

[14] This is consistent with Jaffe and Lerner (2001), who used patent applications as their dependent variable.
[15] Wooldridge (1999) shows that the quasi-conditional maximum likelihood estimator is consistent if the conditional mean is correctly specified.

is related to the size of a lab. We also checked for whether the level of government budgetary support was determined based on external licensing revenue and did not find any reason to believe that this was the case.[16]

To test the effect of director change on foreign patent filings, we ran the following specification:

(1)

$$\log(foreign\_patents\_filed_{i,t}+1) = \beta_1 D_{i,\tau+1} + \beta_2 D_{i,\tau+2} + \beta_3 D_{i,\tau+3} + \beta_4 D_{i,\tau+4} + \beta_5 D_{i,\tau+5} + \beta_6 D_{i,\tau-1} + \beta_7 D_{i,\tau-2} + \beta_8 D_{i,\tau-3} + \beta_9 D_{i,\tau-4} + \beta_{10} D_{i,\tau-5} + \beta_{11}\log(govt\_budget\_support_{i,t} + 1) + \sum_{i=1}^{12} Y_i + \sum_{i=1}^{42} L_i$$

Y_i indicates year dummies and L_i indicates lab dummies. The year dummies capture both the effect of passage of time and the effect of incentive policy change. If the incentive policy change had an immediate effect, the year dummies immediately after 1995 should be significant. On the other hand, if the incentive policy change did not have an immediate effect, the year dummies should be significant only for the later years. In both specifications, robust standard errors were clustered at the level of the lab.

To test the effect of director change on revenue from multinationals, we ran the following specification, additionally controlling for foreign patent filings by the lab:

(2)

$$\log(revenue\_MNC_{i,t}+1) = \beta_1 D_{i,\tau+1} + \beta_2 D_{i,\tau+2} + \beta_3 D_{i,\tau+3} + \beta_4 D_{i,\tau+4} + \beta_5 D_{i,\tau+5} + \beta_6 D_{i,\tau-1} + \beta_7 D_{i,\tau-2} + \beta_8 D_{i,\tau-3} + \beta_9 D_{i,\tau-4} + \beta_{10} D_{i,\tau-5} + \beta_{11}\log(foreign\_patents\_filed_{i,t}+1) + \beta_{12}\log(govt\_budget\_support_{i,t} + 1) + \sum_{i=1}^{12} Y_i + \sum_{i=1}^{42} L_i$$

4.2. Data

For 42 CSIR labs, we collected data on patent filings and patent grants, revenue from multinationals, government budgetary support, and other laboratory characteristics like age, location, nature of science pursued, etc., from 1995 to 2006, as indicated in Table 1.[17]

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[16] Anecdotal evidence suggests that government budgetary support is based on the size of the lab, number of scientists, etc. In the regression analysis, we also drop government budgetary support from the analysis and our results remain consistent. There is only a very weak correlation between government budgetary support and licensing revenue. The correlation becomes even weaker if we consider licensing revenue and government budgetary support in subsequent years. Moreover, for most of the labs the share of government budgetary support remains fairly stable over time.

[17] For certain variables, we were able to collect data for 1993 to 2006. A bureaucratic process decides on the level of government budgetary support for individual labs based on past year expenses and size of the lab; this process did not change significantly

We would like to bring to focus a limitation of the data. In the case of Specifications 1 and 2, we were not able to include years prior to 1995 in the analysis. Prior to 1995, foreign patenting at CSIR was driven by one single lab, NCL. This lab (where Dr. Mashelkar was prior to his taking over the role at CSIR) had 88% of CSIR foreign patents in 1994, though this share came down to 18% over time.[18] For all labs except NCL, patenting would be zero before and after director changes prior to 1995 and, hence, we could not include years prior to 1995.

5. Results

5.1. Summary Trends

Figure 1 shows that for CSIR labs, foreign patents filed and foreign patents granted increased sharply from 1995 to 2006. We also analyzed trends in revenue earnings from multinational companies and government budgetary support to CSIR labs (Figure 2). Combining trends from the two panels in Figure 2, one can infer that revenue from multinationals increased from 3% of government budgetary support in 1995 to 15% of government budgetary support in 2006.[19] Government budgetary support to CSIR labs declined consistently from 1995 to 1998; it declined again from 1999 to 2000, from 2003 to 2004, and from 2005 to 2006.

5.2. Results: Effect of Lab Director Change

Table 3 reports the impact of lab director change on the level of foreign patent filings.[20] Foreign patents filed by a lab increased in the years following a director change; this relationship is positive and significant for Year 1 post-director change and Year 4 post-director change. All else being equal, patent filing was 39% higher in Year 1 post-director change and 42% higher in Year 4 compared to the baseline director change year.[21] This indicates that there is an immediate increase in patent filings post-director change, but the maximum increase comes in Year 4 post-director change. There is no statistically significant effect between the dummies indicating years prior to the director change and foreign patent filing. Columns III and IV of Table 3 repeat the analysis, but instead of considering individual year

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from 1993 to 2006. We also had to match laboratory names across multiple data files and track laboratory name changes, laboratory mergers, lab closures, etc.

[18] The trend of NCL's share of CSIR foreign patents is available from the authors.

[19] The 15% figure is the average from 2003 to 2006. Summary data also reveals that while the number of U.S. patents granted and the revenue from multinationals increased by 13 and 29 times, respectively, from 1995 to 2006, the level of Indian patents granted and government budgetary allocation increased by only three times and 1.5 times, respectively.

[20] In addition, we also conducted univariate t-tests for patents, government budgetary support, and revenue from multinationals for pre- and post-director change lab-years, reported in Table 2.

[21] Given that in Table 3 the dependent variable is log of foreign patents filed, to compute marginal effects, we took the exponent of the coefficients reported in Table 3.

dummies prior to and after the director change event, we considered two-year windows pre- and post-director change.[22]

In Table 4, the dependent variable is *ln_revenue_MNC*, i.e., log of revenue from multinationals.[23] Column I presents the baseline results, while Columns II and III additionally control for government budgetary support and foreign patent filing. The results indicate that there is a positive and statistically significant relation between revenue from multinationals and the dummy variables for Years 4 and 5 post-director change. In Columns II and III, we also find that there is a positive and significant effect between revenue from multinationals and the dummy variable for Year 3 post-director change.

All else being equal, revenue from multinationals is 84% higher in Year 4 post-director change compared to the baseline director change year and is 57% higher five years later.[24] Among the control variables, we found a negative effect between government budgetary support and revenue from multinationals post-director change. Labs that had larger government budgetary support may have been less inclined to generate revenue from multinationals compared to the labs that had less budgetary support. We also controlled for foreign patent filings and found a positive relationship between foreign patent filings and revenue from multinationals, though this relationship is not statistically significant.

These results indicate that individual lab directors played an important role in the increase in foreign patents and licensing revenue at these labs. As theorized, we observed a lag in lab director change and the increase in revenue from multinationals, while foreign patent filing increased immediately after the director change. These results are further reinforced by the coefficients of the year dummies in Tables 3 and 4 (reported in Figure 4). We find that the year dummies are statistically significant only starting in 2000 for the foreign patents filed regression and starting in 2003 for the revenue from multinationals regression. This shows that installing a visionary leader at the top of the parent organization of the 42 labs did not lead to an immediate uptake in patenting or licensing. It was only when the individual lab directors were replaced that the labs saw an increase in the creation and commercialization of IP.

We conducted additional analysis focused on the lab director change event. We collected CVs of 61 directors across 36 labs and compared the pre-Mashelkar era directors ('old') and the Mashelkar appointed directors ('new') across the following parameters—age, total number of Indian and foreign patents prior to joining the lab as director, number of countries visited, number of awards, and number of research papers in domestic and international journals. Directors were classified as "old" if they joined their position prior to 1994 and "new" if they joined the lab as director starting in 1995.[25] For each

[22] We considered years 1 and 2 as one dummy; years 3 and 4 as one dummy and year 5 as a separate dummy variable.
[23] We added a 1 before taking logs to account for zeros in the data.
[24] Given that in Table 4 the dependent variable is log of revenue from multinationals, to compute marginal effects, we took the exponent of the coefficients reported in Table 4.
[25] We dropped 1994 from the analysis as we were not sure whether or not Mashelkar had a say in director changes made in that year

director, we computed these measures at the beginning of their tenure. Table 5 reports the results. On average, new directors are younger, are more well travelled, and have more research papers.

We further explored whether the director change effect was related to greater "affinity" between Dr. Mashelkar and the newly appointed directors. This is to test whether or not Dr. Mashelkar appointed his close confidantes as the new lab directors. Using the data available in the CVs, we were able to construct a measure of affinity between Dr. Mashelkar and each director both before and after the director change event. We used the data in the CVs to identify whether the individual directors had ethnic, educational, or professional ties to Dr. Mashelkar, and we constructed the measure of affinity as an average of these three types of ties.[26] Assuming that the affinity between Dr. Mashelkar and each old lab director prior to 1994 was exogenously determined, we then explored how affinity changed after the director change. There were 17 lab director changes for which we were able to collect both pre- and post-director affinity. In four cases, affinity scores went down after the director change; in two cases, affinity scores increased; and in the other 11 cases, the affinity measure remained the same. All prior regression results were also robust to change in affinity, indicating that the positive effect of leadership change was not related to increased affinity between Dr. Mashelkar and the new lab directors. In summary, the new lab directors might have had more aligned beliefs with their leader but were not his close confidantes.

We also investigated whether leadership change could be used as a repeated tool to help technology commercialization at these labs. For that purpose, we divided the 62 labs director changes in the period 1995 to 2005 into "first-time director changes" (i.e., the first director change in the Mashelkar era starting in 1995) and "second-time director changes" (i.e., subsequent director changes in the Mashelkar era). In summary, we found 36 first-time lab director changes and 26 second-time lab director changes. We then regressed foreign patent filings and revenue from multinationals against interaction dummies for each first lab director change and each second lab director change.

Results are reported in Tables 6 and 7 and indicate that the lab director change effect was being driven by the first lab director change at these labs and not the second lab director change. The first director change has a statistically significant effect on both foreign patenting and revenue from multinationals. The second director change event, however has no statistically significant effect on foreign patenting or revenue from multinationals in the post-director change years. This indicates that leadership change in this context is effective only when it is implemented for the first time under the new regime and may not be effective when the new steady state has been achieved. It is conceivable that the first set of lab directors appointed by Dr. Mashelkar were unlocking the stock of existing IP to potential buyers.

[26] The overall measure of affinity was coded between 0 and 1. Analyses are available from the authors.

5.3. Robustness checks

We subjected our results to a battery of robustness tests. To check whether the administrative rules predict director changes, we went through each of the director changes from 1995 to 2005 to confirm that the two administrative rules, completion of six-year contract period or incumbent retirement predicted the change.[27] We also regressed the director change event on the level of government budgetary support, level of patents, number of publications, etc., of individual labs, and found no correlation. We also checked for collinearity between the director change dummy and year dummies with government budgetary support as well as percentage change in government budgetary support, and found no correlation.[28]

To ensure that our results were not being confounded by any policy change at CSIR other than that reported, we collated an exhaustive set of internal circulars and memoranda that outlines policy changes at CSIR laboratories from 1994 to 2004. As part of government rules, CSIR laboratories are mandated to publish each and every policy change as an official "circular." We collected and analyzed 159 circulars from the years 1994 to 2004 and, in summary, found no such confounding effect.

We also explored external policy changes that might affect our results and noted a major Indian patent law reform in 1999. Prior empirical studies that examined the impact of domestic patent reform include Sakakibara and Branstetter (2001) and Lerner (2002); all of these studies report that patenting by domestic residents either declines or remains stagnant post-patent reform. The Indian patent reform should have made it more attractive for all entities, including CSIR labs, to patent in India; however, our analysis shows that CSIR labs moved their patent mix toward U.S. patents post-1999. We also conducted robustness checks that show multinational revenue at labs increasing in response to increasing U.S. patents, but not in response to higher domestic patents.

To test for the passage of time effect, we compared the U.S. patent grants of the CSIR labs to U.S. patents granted to other Indian public R&D labs and to Indian private firms and find that CSIR labs out-perform all other Indian entities in the time period 1994-2004.[29]

We repeated Tables 3 and 4 using two additional specifications—a quasi-maximum likelihood conditional fixed effects Poisson model with standard errors clustered at the lab level and OLS with log(*foreign patents filed*+1) and log(*revenue_MNC*+1) and standard errors clustered at the lab level. The results remained consistent. We also used additional control variables and controlled for the number of Indian patents granted and filed by labs, and the results remained consistent. In addition, we accounted for

[27] This analysis is available with the authors. Specifically, we went through the 26 labs that experienced two director changes from 1995 to 2005. The time between all these director changes is exactly six years, as predicted by the rules.
[28] This analysis is available in the appendix.
[29] For this analysis, we compared U.S patent grants to CSIR laboratories to U.S. patent grants to other Indian public R&D labs and Indian domestic private firms. For each patent, we code the variable "ownership." The variable can take the following values: CSIR, Indian private, or Other Public R&D. In this analysis, we use firm ownership information from the CMIE Prowess database. We code 1,344 U.S. patents (1994-2004) with data from the USPTO

additional control variables like type of science being pursued and lab location, and the results remained consistent.[30] Our results are also robust to choice of dependent variable. We used patents granted instead of patents filed.

Finally, CSIR's move toward greater commercialization raises a question of whether or not the labs consequently compromise on their public science and R&D role, that of creating and disseminating scientific knowledge for the public good. We collected data on publications and the quality of publications at CSIR labs. Analysis shows that CSIR labs did not compromise on their public science role during the study period.[31] Results are reported in Table 8 and indicate that citation-weighted publications increased consistently starting in 2000. Even from 1996 to 1999, citation-weighted publications increased compared to the baseline year of 1995, though the result is not statistically significant. However, we are aware of limitations of this analysis. First, it is possible that publications could have increased even more if there was no focus on commercializing revenue. Second, it is conceivable that the new directors were unlocking the commercial potential of older technologies locked up in older publications. We do not have a way to test whether the licensed patents related to old or new publications. We also checked for the effect of director change on patent quality and found that patent quality measured using forward citations per patent increased after the director change event.

6. Conclusion

Our study is one of the first empirical studies of in the economics literature that looks at a visionary leader appointing followers to implement her vision. We build on the theory literature on leadership in economics, notably Rotemberg and Saloner (2000) and Van den Steen (2005), both of which outline the relation between a visionary leader with strong beliefs and her followers.

Our main empirical event is the appointment of lab directors to Indian public R&D labs. The lab directors were appointed by a visionary leader heading the parent organization of the labs and it is conceivable that they shared the leaders' vision of IP commercialization. We demonstrate that incentive policy reform initiated by a visionary leader of the parent organization for 42 Indian public R&D labs did not lead to immediate results in IP commercialization. However, foreign patents filed and licensing revenues both increased when individual lab directors were replaced by the visionary leader. Our results are suggestive of the complementary nature of changes in incentives and changes in managers who can implement the vision of their leader. These results are also suggestive of the role of personnel appointments as a tool to implement CEO vision.

[30] To account for these time invariant variables, we ran random effects models.

[31] In the public R&D literature, Azoulay et al. (2005) classify "publications" as a measure of "fundamental pursuit of knowledge" as opposed to patents that embody "applied research."

Our results contribute to the broader emerging literature on leadership in economics. While Bertrand and Schoar (2003) demonstrate that leaders affect practices and while Hayes, Oyer and Schaefer (2005) demonstrate that managerial attrition is related to the attrition of the leader, our results suggest that leaders affect practices by appointing followers.

Our identification strategy is based on the fact that the timing of lab director change was exogenously determined under Indian bureaucratic rules. This implies that the visionary leader of the parent organization could not change a lab director based on nonperformance or disagreement over implementing the vision, but had to wait for the incumbent to retire or complete the contract period. Under these rules, we found that patent filings were 39% higher in Year 1 post-director change compared to the baseline lab director change year. This is similar to the 50% increase in patenting at the U.S. federal labs result reported by Jaffe and Lerner (2001). We also found that four years post-director change, revenues from multinationals increased by 84%.

We then study possible reasons for why new lab directors were successful in implementing the vision of their leader and find qualitative evidence that suggests that the new directors were more likely to be aligned to the vision of their leader as compared to some of the old guard. Our qualitative analysis also shows that successful new lab directors directed resources toward IP commercialization projects and several old directors and old scientists resisted IP commercialization. We also find that new lab directors were younger, better travelled, and had more research papers. On a separate note, we also report that repeated leadership change may not lead to incremental technology commercialization when the new steady state has been achieved.

In conclusion, our findings are directly relevant to public R&D entities across emerging markets, a few examples of such entities being Embrapa and Fiocruz in Brazil, the Indian Council of Medical Research, and the Council for Scientific and Industrial Research in South Africa. Our findings are also widely relevant to organizations undergoing change under visionary leadership.

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Table 1 Summary Statistics of Lab-Level Variables

Variable	Description	Obs	Mean	Std. Dev.	Min	Max
age_{it}	Age of lab "i" in year "t"	432	40.92	13.2	11	65
Year	Year	504	2000	4.04	1993	2006
$patents\_filed\_foreign_{it}$	Number of foreign patents filed by lab "i" in year "t"	432	12.0	21.4	0.0	160.0
$patents\_granted\_foreign_{it}$	Number of foreign patents granted to lab "i" in year "t"	432	3.5	7.5	0.0	49.0
$revenue\_MNC_{it}$	Revenue from multinationals to lab "i" in year "t"	305	10.6	18.7	0.0	131.0
$govt\_budget\_support_{it}$	Budgetary support from government to lab "i" in year "t"	430	50.6	69.7	4.1	693.5

Notes: The variable (age_{it}) represents age of the lab measured from the year of incorporation. The variable *revenue_MNC* represents revenue earnings from multinational firms. The variable *govt_budget_support* represents the government budgetary support received by a lab. All monetary variables are in Rs. million. For most of the variables the data was collected for 1995-2006; for a few variables we have additional data for 1993 and 1994. Source of all data is CSIR.

Table 2 Univariate Tests: Pre- and Post-Director Change Lab-Years

	Pre-director change average	Observations	Post-director change average	Observations	t-statistic for difference
$patents\_granted\_foreign_{it}$	1.48	148	4.57	284	4.12
$patents\_granted\_US_{it}$	0.70	211	2.63	279	4.62
$govt\_budget\_support_{it}$	39.90	148	56.15	282	2.30
$revenue\_MNC_{it}$	5.55	86	12.64	219	3.02

Note: This table provides comparisons of patents granted abroad, patents granted in the U.S., government budgetary support and revenue from multinationals for pre-director change and post-director change lab-years. We code pre-director change years as the years prior to the first director change in any of these labs after 1995. All monetary variables are in Rs. million.

*Significant at the 10% level.
**Significant at the 5% level.
*** Significant at the 1% level.

Table 3 Effect of Director Change on Patenting

	Dependent variable = ln_patents_filed_foreign			
Explanatory variables	(I)	(II)	(III)	(IV)
1 year post director change	0.33** (0.13)	0.31** (0.13)	-	
2 years post director change	0.21 (0.16)	0.16 (0.17)	-	
3 years post director change	0.23* (0.13)	0.19 (0.14)	-	
4 years post director change	0.35** (0.15)	0.35** (0.15)	-	
5 years post director change	0.24 (0.17)	0.22 (0.17)	-	
1 year prior to director change	0.24 (0.22)	0.24 (0.22)	-	
2 years prior to director change	-0.03 (0.30)	-0.02 (0.30)	-	
3 years prior to director change	0.18 (0.33)	0.21 (0.33)	-	
4 years prior to director change	0.29 (0.44)	0.29 (0.42)	-	
5 years prior to director change	0.44 (0.36)	0.42 (0.36)	-	
Years 1-2 post director change	-	-	0.27** (0.12)	0.24* (0.13)
Years 3-4 post director change	-	-	0.28** (0.12)	0.26* (0.13)
Year 5 post director change	-	-	0.24 (0.16)	0.22 (0.17)
Years 1-2 prior to director change	-	-	0.12 (0.23)	0.12 (0.23)
Years 3-4 prior to director change	-	-	0.23 (0.33)	0.24 (0.32)
5 years prior to director change	-	-	0.45 0.34)	0.43 (0.34)
ln_govt_budget_support	-	0.16 (0.14)	-	0.16 (0.14)
Year dummies	Yes	Yes	Yes	Yes
Lab fixed effects	Yes	Yes	Yes	Yes
N	432	430	432	430

Notes: This table reports results of lab fixed effects regressions of logged foreign patent filings on the post-director change dummy interacted with indicator variables for the year relative to the year of director change. The sample is all CSIR labs. For Columns I and II, the explanatory variables are post-director change dummy interacted with the indicator variables for years relative to year of director change. For Columns III and IV, we consider two-year windows prior to and after the director change. Standard errors are robust and clustered at the lab level. *Significant at the 10% level. **Significant at the 5% level. *** Significant at the 1% level.

Table 4 Effect of Director Change on Revenue from Multinationals

Explanatory variables	(I)	(II)	(III)	(IV)	(V)	(VI)
	Dependent variable = ln_revenue_MNC					
1 year post director change	-0.09 (0.22)	-0.04 (0.22)	-0.07 (0.22)	-		-
2 years post director change	0.12 (0.24)	0.18 (0.25)	0.18 (0.25)	-		
3 years post director change	0.38 (0.24)	0.44* (0.24)	0.42* (0.25)	-		
4 years post director change	0.61** (0.26)	0.65** (0.27)	0.62** (0.27)	-		
5 years post director change	0.45* (0.26)	0.45* (0.25)	0.43* (0.25)	-		
1 year prior to director change	0.15 (0.33)	0.14 (0.32)	0.15 (0.32)	-		
2 years prior to director change	-0.49 (0.45)	-0.54 (0.44)	-0.47 (0.48)	-		
3 years prior to director change	-0.71 (0.59)	-0.74 (0.55)	-0.73 (0.56)	-		
4 years prior to director change	-0.55 (0.71)	-0.64 (0.69)	-0.65 (0.76)	-		
5 years prior to director change	-1.32** (0.50)	-1.12** (0.51)	-1.15** (0.53)	-		
Years 1-2 post director change	-	-	-	0.01 (0.21)	0.06 (0.21)	0.05 (0.21)
Years 3-4 post director change	-	-	-	0.46** (0.21)	0.50** (0.22)	0.49** (0.22)
Year 5 post director change	-	-	-	0.43 (0.26)	0.42* (0.25)	0.41 (0.25)
Years 1-2 prior to director change	-	-	-	-0.11 (0.33)	-0.13 (0.31)	-0.09 (0.32)
Years 3-4 prior to director change	-	-	-	-0.62 (0.54)	-0.66 (0.50)	-0.65 (0.52)
5 years prior to director change	-	-	-	-1.37** (0.52)	-1.18** (0.53)	-1.21** (0.54)
ln_govt_budget_support	-	-0.31** (0.14)	-0.30** (0.14)	-	-0.30** (0.13)	-0.29** (0.13)
ln_patents_filed_foreign	-	-	0.10 (0.09)	-	-	0.11 (0.09)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Lab fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	305	305	305	305	305	305

Notes: This table reports results of lab fixed effects regressions of logged revenue from multinationals on post-director change dummy interacted with indicator variables for the year relative to the year of director change. The sample is all CSIR labs. For Columns I-III, the explanatory variables are post-director change dummy interacted with the indicator variables for years relative to year of director change. For Column IV-VI, we consider two-year windows prior to and after the director change. Standard errors are robust and clustered at the lab level.
*Significant at the 10% level. **Significant at the 5% level. *** Significant at the 1% level.

Table 5 Comparison of Lab Director Observables

	N	Age	Patents	Number of countries visited	Number of awards	Research papers
New Directors (post 1994 appointments)	52	49.3	8.8	7.3	1.8	112.0
Old Directors (pre 1994 appointments)	9	52.3	7.3	3.7	1.0	66.0
t-statistic of difference in means		2.03**	0.57	5.45***	0.66	8.02***

Notes: This table compares old lab directors to new lab directors on observables. Directors are classified as old if they were appointed as lab director prior to the Mashelkar era and new if they were designated lab director during the Mashelkar era. The source of the data is hand-collected CVs sourced from CSIR and through Web-based searches.

*Significant at the 10% level
**Significant at the 5% level
*** Significant at the 1% level

Table 6 Effect on Patent Filings: First and Second Director Change

	Dependent variable = ln_patents_filed_foreign			
Explanatory variables	(I)	(II)	(III)	(IV)
1 year post first director change	0.45** (0.20)	0.42* (0.21)	-	-
2 years post first director change	0.34 (0.22)	0.31 (0.22)	-	-
3 years post first director change	0.30 (0.18)	0.27 (0.18)	-	-
4 years post first director change	0.40** (0.16)	0.38** (0.16)	-	-
5 years post first director change	0.20 (0.17)	0.20 (0.16)	-	-
1 year prior to first director change	0.37 (0.22)	0.36 (0.22)	-	-
2 years prior to first director change	0.12 (0.29)	0.12 (0.28)	-	-
3 years prior to first director change	0.36 (0.31)	0.37 (0.31)	-	-
4 years prior to first director change	0.50 (0.39)	0.48 (0.38)	-	-
5 years prior to first director change	0.67** (0.30)	0.63** (0.30)	-	-
1 year post second director change	-	-	0.24 (0.22)	0.23 (0.22)
2 years post second director change	-	-	0.01 (0.28)	-0.04 (0.28)
3 years post second director change	-	-	0.04 (0.31)	-0.01 (0.32)
4 years post second director change	-	-	0.02 (0.42)	0.07 (0.47)
5 years post second director change	-	-	0.01 (0.49)	-0.01 (0.49)
1 year prior to second director change	-	-	0.38 (0.24)	0.37 (0.24)
2 years prior to second director change	-	-	0.63*** (0.22)	0.61*** (0.22)
3 years prior to second director change	-	-	0.52** (0.25)	0.49* (0.26)
4 years prior to second director change	-	-	0.63** (0.26)	0.58** (0.27)
5 years prior to second director change	-	-	0.40** (0.20)	0.37* (0.21)
ln_govt_budget_support	-	0.15 (0.14)	-	0.13 (0.14)
Year dummies	Yes	Yes	Yes	Yes
Lab fixed effects	Yes	Yes	Yes	Yes
N	432	430	432	430

Notes: Sample is all CSIR labs.
*Significant at the 10% level. **Significant at the 5% level. *** Significant at the 1% level.

Table 7 Effect on Revenue from Multinationals: First and Second Director Change

Explanatory variables	Dependent variable = ln_revenue_MNC (I)	(II)	(III)	(IV)
1 year post first director change	-0.12 (0.38)	-0.02 (0.38)	-	-
2 years post first director change	0.34 (0.32)	0.43 (0.33)	-	-
3 years post first director change	0.70** (0.31)	0.77** (0.30)	-	-
4 years post first director change	0.68** (0.27)	0.70** (0.26)	-	-
5 years post first director change	0.52* (0.29)	0.52* (0.28)	-	-
1 year prior to first director change	0.29 (0.28)	0.32 (0.27)	-	-
2 years prior to first director change	-0.29 (0.48)	-0.31 (0.48)	-	-
3 years prior to first director change	-0.50 (0.63)	-0.47 (0.60)	-	-
4 years prior to first director change	-0.29 (0.65)	-0.32 (0.63)	-	-
5 years prior to first director change	-0.96* (0.50)	-0.67 (0.53)	-	-
1 year post second director change	-	-	-0.37 (0.29)	-0.39 (0.29)
2 years post second director change	-	-	-0.50 (0.36)	-0.48 (0.34)
3 years post second director change	-	-	-0.55 (0.47)	-0.55 (0.46)
4 years post second director change	-	-	-0.01 (0.69)	-0.00 (0.67)
5 years post second director change	-	-	-0.51 (0.75)	-0.69 (0.72)
1 year prior to second director change	-	-	0.18 (0.36)	0.17 (0.36)
2 years prior to second director change	-	-	0.64** (0.29)	0.65** (0.29)
3 years prior to second director change	-	-	0.62* (0.34)	0.69** (0.33)
4 years prior to second director change	-	-	0.27 (0.41)	0.34 (0.41)
5 years prior to second director change	-	-	-0.03 (0.46)	0.04 (0.45)
ln_govt_budget_support	-	-0.32** (0.15)	-	-0.32** (0.15)
Year dummies	Yes	Yes	Yes	Yes
Lab fixed effects	Yes	Yes	Yes	Yes
N	305	305	305	305

Notes: Sample is all CSIR labs. *Significant at 10% level. **Significant at 5% level. *** Significant at 1% level

Table 8 Fixed Effects Regressions: Trend of Citation-Weighted Publications

	Dependent variable	
	ln_citation_weighted_publications	ln_citation_weighted_publications
ln_govt_budget_support	-	-0.01 (0.06)
1996	0.13 (0.08)	0.13 (0.08)
1997	0.06 (0.10)	0.06 (0.10)
1998	0.12 (0.12)	0.12 (0.12)
1999	0.13 (0.10)	0.13 (0.09)
2000	0.26** (0.09)	0.26** (0.09)
2001	0.30*** (0.09)	0.31*** (0.09)
2002	0.35*** (0.11)	0.36*** (0.11)
2003	0.65*** (0.11)	0.66*** (0.11)
2004	0.96*** (0.11)	0.96*** (0.11)
2005	1.06*** (0.13)	1.07*** (0.14)
2006	1.29*** (0.12)	1.28*** (0.13)
Lab fixed effects	Yes	Yes
N	420	418
Model	Fixed effects	Fixed effects

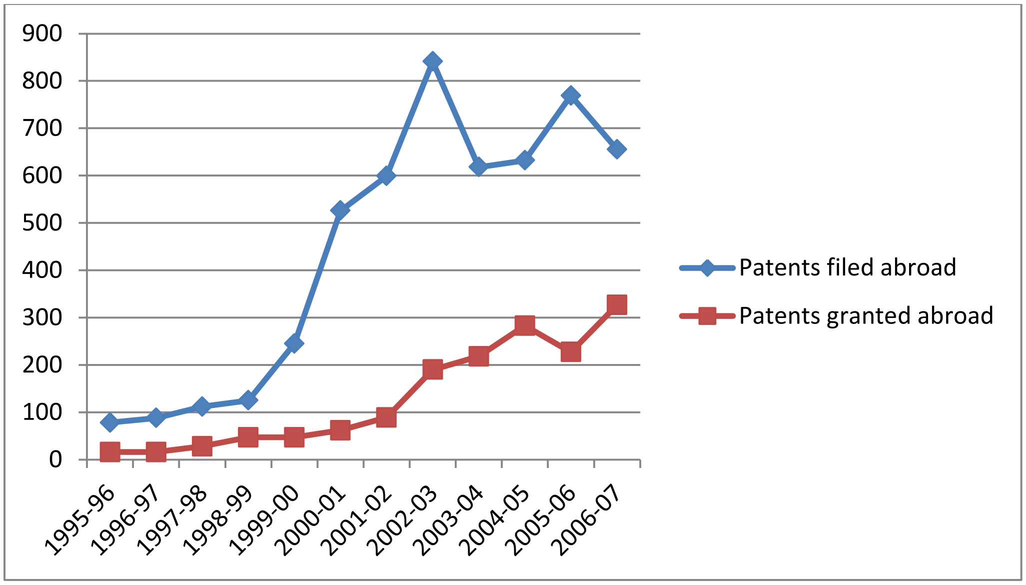
Notes: This table reports regressions results of how citation-weighted publications change over time. The baseline period is 1995 and the independent regressors are year dummies for 1996 to 2006. Sample is all CSIR labs. In the public R&D literature, publications have been thought as a measure of social impact of the labs and recent papers like Azoulay, Ding, and Stuart (2006) classify "publications" as a measure of "fundamental pursuit of knowledge" as opposed to patents that embody "applied research." The dependent variable (log of citation-weighted publications) is measured using number of publications and impact factor measures using Thomson indices. The results indicate that citation-weighted publications increase consistently starting in 2000. We use fixed effects, but results are robust to choice of specification. Robust standard errors are clustered at the lab level.

*Significant at the 10% level.

**Significant at the 5% level.

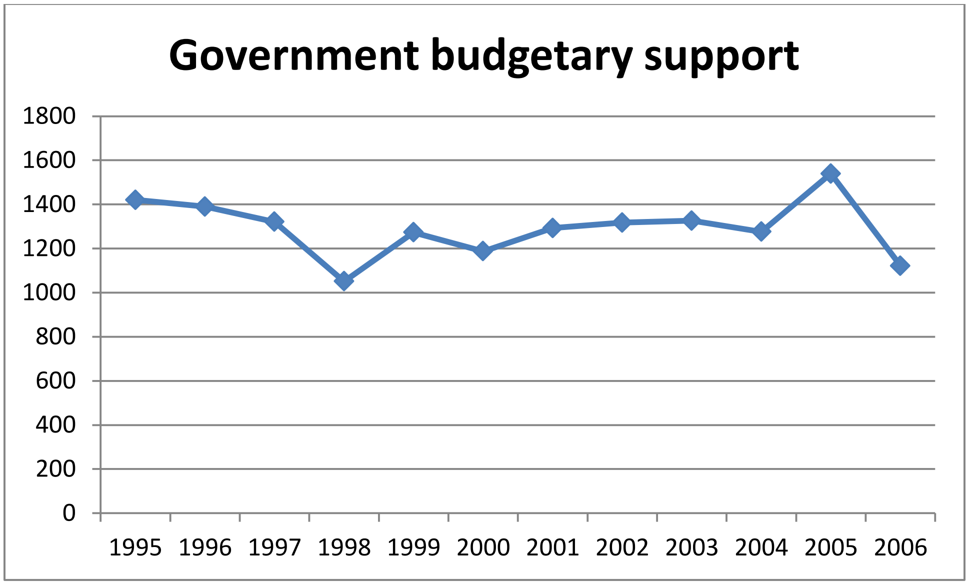
*** Significant at the 1% level.

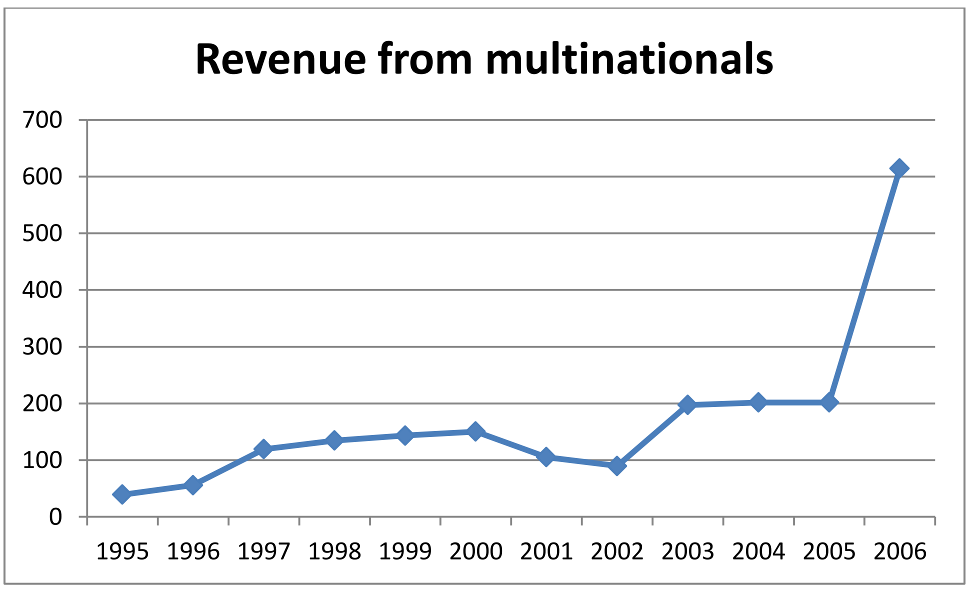
Figure 1 Patenting Trend at CSIR Labs



Notes: This graphic traces foreign patent filings and foreign patent grants to CSIR laboratories. Source: CSIR.

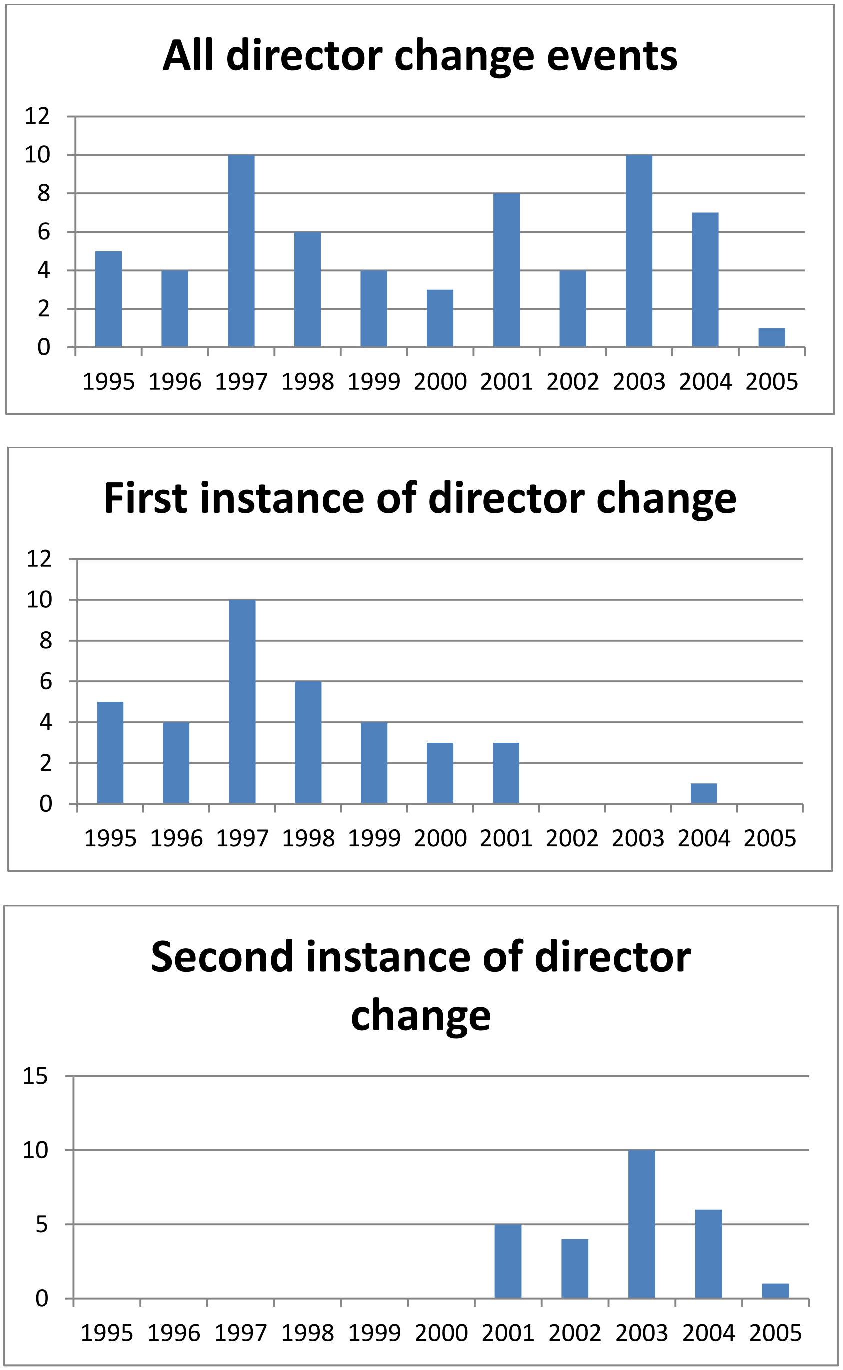
Figure 2 Trend of Government Budgetary Support and Revenue from Multinationals





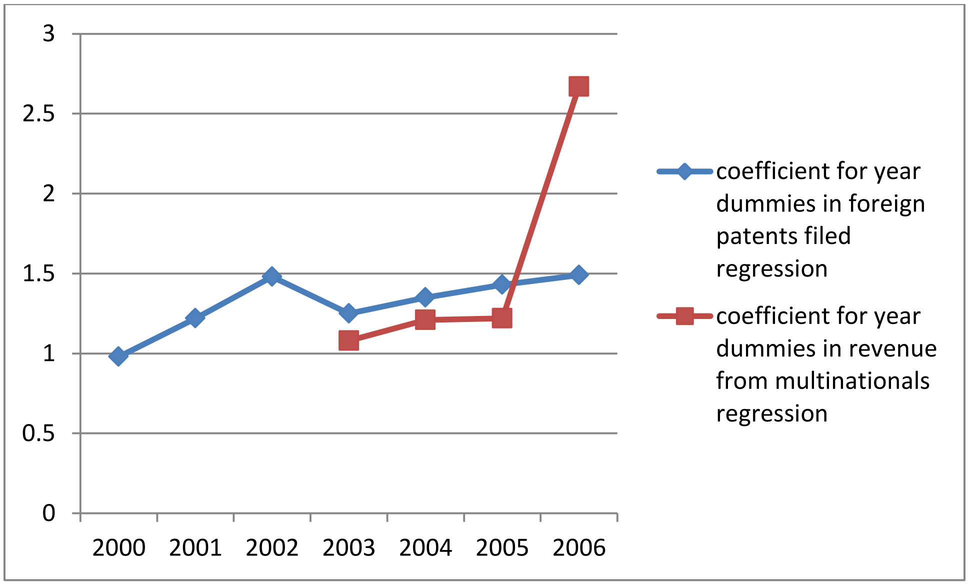
Notes: This graphic traces government budgetary support and revenue from multinationals expressed in millions of 1995 Rupees; inflation indices obtained from consumer price index series from International Monetary Fund (IMF) data. Source: CSIR.

Figure 3 Frequency Distribution of Director Change at CSIR Labs



Notes: This graphic outlines the frequency distribution of director changes at CSIR labs from 1995 to 2005. The top panel outlines the trend of all director change events at the labs. The middle panel outlines the distribution of the first director change that happened at these labs, starting in 1995. The bottom panel outlines the distribution of the subsequent (second) director changes that happened at these labs until 2005. In total, we report 62 lab director changes. Of the total 36 labs, 10 labs experienced a single lab director change and 26 labs experienced two director changes in the period 1995 to 2005.

Figure 4 Year Dummies in Foreign Patents Filed and Revenue from Multinationals Regressions (Tables 3 and 4)



Notes: This graph outlines the year dummies in the first columns of Tables 3 and 4. It shows the year dummies in the regressions of foreign patent filings and revenue from multinationals not reported in these two tables. The coefficients are shown on the graph only if they are statistically significant. Year dummies are statistically significant starting in 2000 for the foreign patents filed regression. The year dummies are statistically significant starting only in 2003 for the revenue from the multinationals regression.