Organize to Innovate: Intellectual Property Regimes, Technology Adoption and Firm Structure[1]

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Abstract

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How do firms choose their organizational design to innovate better? We use **The Patents (Amendment) Act, 2002** which initiated a stronger patents regime in India as a quasi-natural experiment to identify the causal effect of incentives for innovation on firm structure. We find that: stronger IP protection leads to a significant increase in both employment and total compensation of managers relative to non-managers. This increase in managerial compensation is due to a sharp increase in incentive pay for middle managers rather than top managers. While both the number of managerial layers (vertical growth) and the span of control (horizontal growth) of an average manager increased because of the reform, the increase in managerial compensation is positively and robustly associated with horizontal growth rather than vertical growth of the firms. All these effects are significantly stronger for the firms that were technologically advanced before the reform. Our findings suggest that stronger IP leads to an increase in both within-firm and between-firm income inequality between managers and non-managers, with stronger evidence for between-firm inequality.

Keywords: Intellectual Property Regimes, Technological change, High-tech and Low-tech firms, Managerial Compensation, Span of Control

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1 Introduction

There is a growing body of evidence in economics that organizational structure is a crucial determinant of a firm's ability to innovate.[5] In particular, various indicators of innovation inputs or performance have been shown to be correlated with different aspects of firm structure, e.g., firm size (Schumpeter, 1942; Cohen and Levin, 1989) compensation schemes (Manso, 2011; Amabile, 1993 and 1996; Teece, 1994), structure of employee contracts (Cockburn et al., 1999; Azoulay et al., 2011), product scope (Brugelman, 1984), level of vertical integration (Azoulay, 2004), degree of centralization (Argyres and Silverman, 2004), number of layers or more generally, organizational complexity (Teece, 1994; Stein, 2002; Berger et al., 2005). However, as Azoulay and Lerner (2013) points out in their detailed survey on the topic, the existing empirical literature largely focuses on the *correlation* between organizational structure and innovation performance and fails to credibly identify causal channels.[6]

In this paper, we address the issue of causality by relying on the simple fact that firms choose or modify their organizational structure based on their capabilities in response to incentives provided by the market. We study a quasi-natural experiment affecting firms' future incentives to innovate and look at the firms' response in terms of changing their organizational structure. We interpret these responses as firms' conscious choice of organizational structure based on their technical capabilities to maximize their innovation potential.[7]

To establish a causal relation between innovation and organization of firms, we identify an exogenous change in India's intellectual property rights (IPR) regime. India changed its domestic patent policy towards a more TRIPs- (Trade Related Intellectual Property Rights) compliant IPR regime in 2002 by introducing **The Patents (Amendment) Act, 2002** (Act 38 of 2002). With this Act, India replaced its earlier process patent regime with product patent. By conferring monopoly rights over new products, this Act significantly raised the payoff to innovative activities. We use The Patents (Amendment) Act, 2002 as the quasi-natural

[5] Innovation is uncertain. Teece (1994) highlights that innovation involves searching, probing and re-probing of the technological as well as market opportunities, where much effort is spent traveling down the blind alleys. Koopmans (1957) on the other hand makes a useful distinction between primary and secondary uncertainty. He argues that the latter arises from lack of communication between the decision maker within a firm and plans made by others within a firm. Therefore, secondary uncertainty which would for example, involve investments in technology or innovation is a function of organizational form.

[6] "An essential difficulty facing large-sample empirical research has been an inability to distinguish between association and causation, and, in some cases, a failure even to think carefully about this distinction." – Azoulay and Lerner (2013), *Handbook of Organizational Economics*, pp 576.

[7] Technology also often evolve in path dependent ways and might be thought of as technological paradigms (Dosi, 1982). A paradigm identifies a problem and the solution(s) and therefore research efforts become important since technological discontinuities can occur when new paradigms emerge. New technologies are threatening to existing skills and capabilities if they embody a new paradigm, such as product and process developments. Thus, new organizational forms emerge with new technological paradigms.

experiment to investigate the effects of the change in IPR regime on labour adjustments within a firm, in terms of demand for executives and managers, and organizational design. We find that for a large cross section of Indian manufacturing firms, the Patent Act resulted in a significant increase in the demand for managers relative to non-managerial employees both at the intensive and extensive margin. Importantly, this effect is much stronger for firms which were a priori technologically advanced. Moreover, this difference in degree of increase in the share of managerial compensation for firms' closer to the technological frontier is due largely to two factors: (i) increase in incentive provision within the compensation scheme, and (ii) expansion in the span of control. Our finding provides new evidence in support of Aghion et al. (2015), who argues that innovation can create income inequalities.

There has been a recent literature, both theoretical and empirical, on how different macroeconomic policy shocks affect firm organization. This literature looks at the effects of globalization or product market competition or input-trade liberalization (Guadalupe and Wulf, 2010; Caliendo and Rossi-Hansberg, 2012; Chakraborty and Raveh, 2016; Keller and Olney, 2017; Caliendo et al., 2017) on firm management and organization. On the other hand, there is also a big and continuously growing literature on how different kind of policy or trade shocks influence the composition of labour force and wage premium. To the best of our knowledge there remains little or no evidence to date on the effects of the change in the IPR regime on the relative demand for certain categories of labour and on organizational structure.

We show robust and significant relationship between technological intensiveness of a firm and the magnitude of response to IPR regime change in terms of employee composition, compensation scheme, and firm structure. We measure technological intensiveness by research and development (R&D) expenditure and expenditure towards information-enabled technology services (internal technology development), technology transfer and import of capital goods (external technology acquisition). Firms that were technology intensive *before* the reform had a lower marginal cost of innovation because they had already developed a stock of human and physical capital as well as the culture and processes suited towards technological advancement and new product development. Therefore, while stronger IP rights provided all firms an incentive to innovate, such incentives were stronger for firms' closer to the technological frontier.

Product innovation requires firms to change existing ways of functioning. And, this requires firms either to re-train their existing employees or to hire people with specialized knowledge.

Caliendo and Rossi-Hansberg (2012) show that re-training existing employees is the more inefficient of the two options. Teece (1994) on the other hand argues that new technological pathways require new skills and capabilities. This is one explanation of why relative demand for managers increases. An alternative explanation is found in the work by Garicano (2000) which considers an organization as a problem-solving entity. In this theory, managers provide solutions to non-routine problems encountered by production workers. Innovative activities (e.g., research or new product development, etc.) necessarily involves complex, non-routine problems leading to an increase in the value of existing managers as well as a demand for more managers. This idea provides support for the result that both the price and volume of managers increases.

Our second result points out that firms use sharper incentives to motivate managers. There is considerable debate in the literature about how and whether incentives motivate innovation and creativity (Holmstrom, 1989). Earlier work (e.g., Teece, 1994; Amabile, 1996) suggests that high powered incentives stifle creativity and innovation, whereas current literature (e.g., Manso, 2011; Ederer and Manso, 2011; Azoulay et al., 2011) focus on forms of long-term incentive mechanisms that motivate innovation. In our case, we find that increased incentive pay is necessitated by the particular way that IP reform affects innovation incentives. A strong IP regime induces patent races which reward not just the innovation but also the time to innovate. Motivating quicker innovation requires aggressive managerial incentives.

Lastly, we find that the span of control of managers, as measured by the product scope, increases the share of managerial compensation. We interpret this to be happening due to establishments of new divisions due to new product development. This is also consistent with the idea that decentralized structure is more suitable to innovation (Caroli and Van Rennen, 2001).

We re-iterate that all these effects are significantly pronounced for firms which were technologically advanced prior to the reform. In other words, incentives to innovation may tend to increase the gap between firms which are closer to the technological frontier with the rest. Two papers point out such increase in gap between different groups as a result of different kind of shocks. Aghion et al. (2005) while investigating the relationship between competition and innovation highlights that the average technological distance between the technological-leaders and -laggards increases with competition. In a slightly different context, Galor and Moav (2000) points out that an increase in the rate of technological progress raises the return to ability

and simultaneously generates an increase in wage inequality between and within groups of skilled and unskilled workers.

We focus on the complementarity between the change in the intellectual property regime, technology adoption and its implication for organization of firms. By doing so, we emphasize three important questions: (a) how imposition of stronger patent rights impacts the demand for different kinds of workers (in our case managers and non-managers) differently; (b) how this change in relative demand is reflected between- and within- firms; and (c) how it impacts the organizational design of a firm. Organizational structure is virtually absent in all theories related to change in property rights regime. Our primary contribution is to understand the connection between innovation and organizational economics by instrumenting innovation through imposition of stronger patent rights. Additionally, we also add to the literature on how change in organizational structure affects wage inequality in the economy.

Another important contribution of our paper is the identification of the specific event that provided the structural break amidst the decade long process of transformation of Indian IP regime. Indian patent policy, before it became a member of the World Trade Organization (WTO) in 1995 was based on **The Indian Patent Act, 1970**. The main characteristics of the Act are that it granted process and not product patents with a much shorter term of patentability and several areas were excluded from the patents (e.g., any process which can increase the economic value of products). The Indian Patent Act of 1970 was primarily emphasised towards public interest over monopoly rights (Ramanna, 2002).

India's patent policy started to shift towards greater protection of intellectual property rights as a result of the emergence of Trade Related Intellectual Property Rights (TRIPs, hereafter) in the WTO (after 1995). India got a 10-year transition period to shift from its existing IPR regime to product patent respecting TRIPs-complaint IPR regime. The policy shift took place only after several rounds of discussions in the Indian parliament[8] (Reddy and Chandrashekaran, 2017). In June 2002, India passed a legislation which is the second amendment to the 1970 Act known as The Patents (Amendment) Act, 2002 (Act 38 of 2002). This Act came into force on 20th May 2003 with the introduction of the new Patent Rules, 2003 by replacing the earlier Patents Rules, 1972. It proposed a new definition of the term 'invention' which changed patent rights from process to product innovations, increased the term of patents from 14 to 20 years, brought all fields of technology to be patentable and fastened the process of patent grant (a

[8] A majority group was against the implementation of the IPR-compliant reform

patent is granted within two years of filing an application). This act ended the earlier policy uncertainty and provided the necessary impetus to firms to make the fixed investments in new technology to harness the benefits of the new IP regime. **Figure 1** demonstrates a sharp increase in investments in technology adoption by a large sample of Indian manufacturing firms.

The empirical literature on organizational structure of firms is scarce due to limited data availability. A significant number of related studies is based on survey data such as the World Management Survey (innovative survey tool to collect data on management practices of firms across various countries) used by Bloom and Van Rennen (2007, 2010), Bloom et al. (2014) and other surveys on corporate firms such as Cunat and Guadalupe (2009), Guadalupe and Wulf (2010). However, using survey data could limit oneself to explore different kinds of associations between organization and other dimensions of firms, such as technology adoption in our case. This is due to the reason that survey data on management practices and compensation do not report data from balance sheet. To understand such kind of relationships, we employ a firm level panel dataset from the PROWESS database of the Centre for Monitoring of the Indian Economy (CMIE). The dataset is unique in a sense that it contains direct measures of spending on several dimensions of technology adoption, namely R&D expenditure, royalty payment for technical knowhow or technology transfer, import of capital goods and fees for adoption of information technology (IT). This allowed us to build a direct and comprehensive measure of investment in technology instead of relying on some subjective or other measures potentially identified with measurement errors. It also reports detailed labour compensation, divided into managerial and non-managerial, with the former divided into several management layers. In addition, the dataset gives exports, imports, spending on raw materials, capital employed and other important firm and industry characteristics. The panel format of the data enables us to track how much a firm is investing in technology adoption and spending on different kinds of employee compensation, thereby allowing for a dynamic specification in which technological investments and other firm decisions can potentially affect demand for managers.

Even with the kind of detailed micro-data we have, establishing the relation between intellectual property regimes, technological change and organizational change at the firm level is not trivial. First, technological differences between firms are not directly observable. The advantage of our dataset is that we can directly observe the different aspects of technological differences rather than rely on estimating an unobservable productivity term. In doing so, we are able to divide the firms into two different groups based on their technological capabilities

and investigate the differential effect of the intellectual property regimes on their organizational design. Second, unobservable characteristics of a firm might drive both demand for managers and investments in technology posing challenges to identification. We use a quasi-natural experiment in terms of patent policy change to tackle such an identification problem. Third, there might be a problem of reverse causality, if having a high share of managers itself affects the likelihood of undertaking new investments in innovation or technology. To counter such type of issues, we use a difference in difference approach which exploits the timing of firm level decisions to pin down the direction of causality. The approach also isolates the effect of the change in the innovation policy on organization from the effect of globalization and other activities that might be complementary to policy change.

We begin our analysis by dividing firms into two groups, 'high-tech' and 'low-tech', following Branstetter et al. (2006) and applying to our case. In particular, we classify a firm as high-tech, if a firm's average expenditure on R&D, ITES (information-enabled technology services), technoloy transfer and import of capital goods between 1990-2001 is greater than the median of the industry's investments on technology to which the firm belongs. By doing so, we create a 'treatment' and 'control' group where the control group is the low-tech firms. The idea behind this is that a patent policy change will induce the a priori high-tech or the treated group of firms to invest more technology in the post-policy period than the low-tech firms (since the high-tech firms value technology more than the others) and therefore the relative demand for managers for the high-tech firms will be proportionately different from the low-tech ones. We create a dummy for The Patents (Amendment) Act, 2002 which takes a value 1 if the year is greater than or equal to 2002 and zero otherwise. We interact this dummy with the other dummy for the high-tech firms and the interaction term measures the complementary effect of the change in intellectual property regime and technology adoption on organizational change. This interaction term helps us to understand the differential effect of the 2002 patent reform on high-tech vis-à-vis the low-tech firms.

Figure 2 plots technology adoption (sum of R&D expenditure, ITES, technology transfer and import of capital goods) for our sample of Indian firms for the period 1990-2006 by dividing into high-tech and low-tech firms. The figure clearly shows similar trend for high-tech and low-tech firms before the adoption of the patent reform but quite the opposite after. The technology adoption expenditure for the high-tech firms nearly doubled between 2002 and 2006, whereas for low-tech firms it shows a decline. **Figures 3** and **4** plots average share of managerial compensation in total compensation and the same for the two groups of firms (high-

tech and low-tech), respectively. Both the diagrams show a similar trend in managerial compensation in total compensation; while the share of managerial compensation increased in case of both type of firms during the same period, the increase for a high-tech firm is double that of a low-tech. These two diagrams give some indications toward a possible association between patent reform, technology adoption and demand for managers and paves the way for causal inferences.

To test whether there the relative demand for managers or executives in the post-2002 period can be associated with The Patents (Amendment) Act, 2002, we exploit the uncertain or exogenous nature of the imposition of the Act of 2002 in conjunction with a rich dataset on Indian manufacturing firms that uniquely reports data on investments on technology firms' and disaggregates total labour compensation into managers and non-managers over a period of one and half decades.

Our paper has three set of results. The first part estimates the reduced form impact of change in innovation policy complemented with technological adoption of firms on the relative demand for managers. We find a remarkably robust, persistent and economically meaningful positive effect of The Patents (Amendment) Act, 2002 on the relative demand for managers, both at the intensive and extension margin; with the difference in the effect between high-tech and low-tech firms significant and positive. Our benchmark estimations indicate that The Patents (Amendment) Act, 2002 led to an increase in the share of managerial compensation of the high-tech vis-à-vis the low-tech firms by around 1.6-1.7%. The effect is robust to various controls, specifications, estimation techniques and time periods. This evidence suggests that the reform leads to an increase in inequality of different kinds: (i) the technological gap between high-tech and low-tech firms increases; and (ii) both within- and between- firm wage inequality increases between managers and non-managers within a firm.

Moving on to the second aspect, we divide the compensation scheme into wages (fixed component) and incentives (variable component). We find that the increase in managerial compensation is completely driven by increase in incentive provisions and not wages. Interestingly, much of this effect comes from middle managers rather than top managers. This pattern, increases in managerial compensation through incentives, is consistent with existing evidence (e.g., Cunat and Guadalupe, 2009). This result is also consistent with the idea in Keller and Onley (2017) that since managers set the pay structure, they pay themselves large bonuses while managing change in response to external shocks. However, the finding that most of the

effect is attributable to middle rather than top managers goes against the spirit of the idea of self-serving bonus payments by those who design the compensation scheme, i.e., the top management.

Third, we investigate effect of the patent reform on the horizontal and vertical changes in a firm's structure. We proxy the horizontal dimension or span of control of a firm through the variety of products produced, whereas for the latter we create the number of organizational layers, based on the notion of hierarchies. We find that the change in the incentives to innovation lead to an expansion of a firm both in the horizontal and vertical dimensions. However, when looking at the correlation between firm organization and share of managerial compensation, we see that the increase in managerial compensation is entirely driven by increase in span of control and not hierarchical layers.[9]

There are at least two channels through which innovation policy affects firm organization through technology adoption. First, a stronger patent protection lead firms to invest in exploring new avenues like product development, research activities, marketing activities for brand development, etc. all of which lead to horizontal expansion of a firm. Second, existing processes are also pushed closer to the technological frontier through technology transfer, import of capital goods, etc. Both these effects increase the demand for managers and result in technological deepening. Notice that due to the inherent complementarities in technological advancement, both these effects are stronger in firms that are already technologically superior. As a result, we observe that a stronger patent regime leads to an increase in the inequality across firms in technology intensiveness as well as share of managerial compensation in total compensation.

The paper contributes to several strands of literature. First, we relate to the literature on how organizational design of a firm changes due to shocks, such as technology adoption (Bresnahan et al., 2000), communication technology (Garicano, 2000), globalization (Guadalupe and Wulf, 2010; Chakraborty and Raveh, 2016), etc. A significant portion of the literature argues that some kind of technological adoption is complementary to organizational change and raises the employment shares or relative demand for skilled workers over workers (Caroli and Van Rennen, 2001) or managers over workers (Lee and Shin, 2017). However, as mentioned above

[9] There is a debate about whether vertical hierarchies are conducive to innovation. While some papers (e.g., Teece, 1994; Caroli and Van Reenen; 2001) advocate that delayering and decentralization are conducive to innovation, others (e.g., Argyres and Silverman, 2004; Lerner and Wulf, 2007) suggest the opposite. While we find a significant increase in vertical layers due to the reform, there is no evidence that this vertical expansion contributes to the increase in the share of managerial income.

all the studies establishes a correlation, while we show causal relation between innovation and organizational change.

The paper also relates to the growing literature of looking at both within- and between-firm inequality. Song et al. (2016) show that a large majority of the overall inequality is driven by increasing dispersion between, not within, firms. Our results provide support that a large part of the increase in relative demand for managers is due to between-firm changes and not within-firm. Our result supports and complements the recent findings of Boler (2015) who uses a R&D tax credit scheme by Norway to find that innovation significantly increases the demand for skilled workers and the increase in demand is due to a change in within-firm skill-biased productivity growth. Our results complement these findings by analysing how firm management and organization change occur because of innovation policy.

The paper also relates to the growing literature on international trade, technology, skill premium and polarization of jobs. Several studies have documented an increase in skill premium in some developing economies, as a result of trade liberalization exercises, during the 1980s and 1990s (Goldberg and Pavcnik, 2007) due to the following explanations: trade-induced skill-biased technical change (Acemoglu, 2003); capital-skill complementarity (Burstein et al., 2013); credit constraints (Bonfatti and Ghatak, 2013); import composition (Raveh and Reshef, 2016); improved exports (Zhu and Trefler, 2005); quality upgrading (Verhoogen, 2008); and automation (Maloney and Molina, 2016). In a similar context, Ugur and Mitra (2017) maps the qualitative and empirical evidences to report that the effect of technology adoption on employment is skill-biased and more likely to be observed when technology adoption favours product as opposed to process innovation. Vashisht (2017) in a similar context examine the impact of technology on employment and skill demand for the Indian manufacturing sector. The results show that adoption of new technology has increased the demand for high skilled workers suggesting that technology has reduced the routine task content of manufacturing jobs in India. This finding is consistent with ours, as we show that adoption of more technology, because of change in patent regime, leads to demand for workers who are specialized in non-routine tasks.

Finally, the paper relates to the effect of IPR reform on innovative activities of countries, industries, firms. The effect of an IPR reform has been significantly addressed at multiple levels: country (Park and Lippoldt, 2004; Chen and Puttitatun, 2005; Branstetter et al., 2006; Qian, 2007) or industry-firm (Sakakibara and Branstetter, 2001; Allred and Park, 2007; Yang

and Maskus, 2009; Lo, 2011). We extend and complement this literature by looking at the effect of an IPR reform on within- and between-firm dimensions of management and organization.

The paper is organized as follows. The next section gives the details of the reform and makes a case for its exogeneity. We provide details about the data, stylized facts in Section 3. The empirical strategy is explained in Section 4. In Section 5, we describe and discuss our results, showing the effect of higher incentives to innovation on relative demand for managers through higher technology adoption and demonstrate how it simultaneously affects firm organization. The last section concludes.

2 Institutional Background

Patent policy in India has a long history, dating back to 1856. However, the actual attention of policymakers toward patent rights started after India gained independence in 1947. Two committees were set up to study patents and provide suggestions on the type of patent system that India should implement since India continued with the British Patents Act of 1911 after independence. The **Patent Enquiry Committee (1948-50)** and the **Ayyangar Committee (1957-59)** reports two major observations: (i) the Indian patent system has failed to stimulate and encourage the development and exploitation of new inventions for industrial purposes in the country; and (ii) foreign patentees were acquiring patents not in the interests of the domestic economy but with the objective of protecting an export market from competition of rival manufacturers. The reports also concluded that the foreigners held 80-90% of the patents in India and were exploiting the system to achieve monopolistic control of the market (Ramanna, 2002). Based on the recommendations of these committees, The Indian Patent Act, 1970 which found support among domestic firms and political parties was implemented. It focused on access to resources at lower prices which could potentially be beneficial for India. This Act had the following characteristics: (i) process patents would be granted and not product patents; (ii) fixed the term of patents to 14 years (5-7 years in chemicals and drugs); (iii) compulsory licensing and license of right; (iv) several areas were excluded from patents; and (v) govt. could use patented invention to prevent scarcity.

However, the 1970 Patent Act soon started facing international resistance as discussions on free trade started getting linked to IPR. At the 1986 Uruguay Round of General Agreement on

Tariffs and Trade (GATT)[10], the U.S. first proposed the inclusion of Intellectual Property Rights (IPR) through Trade Related Intellectual Property Rights (TRIPs). One of the main motivations for such a move as candidly admitted by the Pharmaceutical Research and Manufacturers of America (the nodal association of the pharmaceutical innovator firms) was that "the Indian patent system was the most direct motivation for the U.S. efforts in the Uruguay Round negotiations relating to patents".[11] The Indian Patent Act, 1970 respecting only process patents and reduced duration of protection were a key reason, especially when these patents were being subjected to "licenses of right" for a fixed royalty of 4% (Chaudhuri, 2005). India allowed the discussions to link IPR to trade as it was itself transiting through a process of opening of its markets under the stewardship of the then Prime Minister Mr. Rajiv Gandhi since the mid-1980s (Panagariya, 2005).

In 1991, India ran into its much-discussed balance-of-payments (BOP) crisis and turned to International Monetary Fund (IMF) for assistance. The later conditioned such assistance on an implementation of a major adjustment program that included several liberalization steps and becoming a member of the World Trade Organization (WTO). In April 1993, the Indian Parliament constituted a committee headed by Mr. I. K. Gujral to study the Dunkel draft in detail that commented on the IPR situation under GATT. The committee came up with a report in 1994 documenting Indian unwillingness to budge to developed country interests and revoke India's existing process patent respecting regime.[12] However, the final text of TRIPs agreed to by India did not adhere to any of these recommendations of the committee. In 1994, India signed the Marrakesh Agreement (which established the WTO), eight years after the **Uruguay Round** of Talks began and agreed to be bound by TRIPs. It enabled India to get a 10-year transition period (1995-2005) to shift from its existing IPR regime to stronger product patent respecting TRIPs-compliant IPR regime. At the concluding ministerial meeting of the WTO talks in Marrakesh, Morocco in April 1994, Mr. Pranab Mukherjee, India's then Minster of Commerce, told his counterparts that India had "negotiated in good faith" and while it was acceding to implementing stronger IPR in India it remained concerned about pharmaceutical prices that might rise as a result. Like what preceded 1994, the transition also had its own hiccups, with uncertainty around the new regime's implementation clearing only by 2002 as we explain below and this provides us the structural break that we exploit in our study.

[10] A multilateral agreement signed in 1947 by 23 countries.
[11] "Special 301" Report on Intellectual Property Barriers, *Submission of the Pharmaceutical Research and Manufacturers of America* (Feb. 16, 1999).
[12] India, Rajya Sabha, Parliamentary Standing Committee on Commerce, DRAFT DUNKEL PROPOSALS at 46 (December 14, 1994).

Between 1995 and 2005, implementation of stronger IPR in India transitioned through three broad stages. First, a denial and refusal to comply with international obligations; second, India lost at the Dispute Settlement Board (DSB) of WTO-TRIPs and realised that it had no choice but to follow the law if it wants to continue as a member of the WTO; third, India looked for ways to exploit the flexibilities of TRIPs to outsmart developed countries especially using the compulsory licensing provisions of WTO-TRIPs (for a detailed discussion see Chatterjee et al., 2015). India's initial transition since 1994 started with the failed Patents (Amendment) Ordinance of 1994 that was brought about by a weak coalition government in power amending The Indian Patent Act, 1970.

It allowed for a 'mailbox' provision through which product patent applications could be filed with the priority date for them remaining static and undecided until India amended its patent laws to comply with TRIPs. The ordinance also granted exclusive marketing rights (EMRs). With this ordinance, while India started its transitional journey to a TRIPs-compliant IPR regime, assessments about the final outcome remained uncertain. This was because as per Indian constitutional law, ordinances are valid for only six months from the day of promulgation, or six weeks from the day Indian Parliament reconvenes after the ordinance is promulgated. If the ordinance lapsed, India would be in violation of its TRIPs obligations, therefore a law was needed which forced the Govt. of India to introduce **The Patents (Amendment) Bill, 1995** in the Parliament. As per Indian law, a bill must pass through both houses of the parliament. While the Upper House passed it, once the bill was in the lower house of the parliament, a new expert committee was formed to debate the merits and demerits of The Patents (Amendment) Bill, 1995. As all of this was going on, the Indian parliament was dissolved for national elections (it was a coalition govt. and some of the political parties withdrew their support because of ideological differences leading to a fall of the govt.) and The Patents (Amendment) Bill, 1995 automatically lapsed leaving the uncertainty around IPR transition alive in the country. This meant that the country was again in violation of its TRIPs agreement for stronger IPR and was vulnerable to be referred to the WTO's DSB in 1996.[13]

Infact this was indeed what the U.S. invoked in 1996, filing complaints to the DSB against India.[14] India lost this case despite an appeal, with the U.S. further bolstered by a European

[13] See generally World Trade Organization, Understanding the WTO: Settling Disputes, available at https://www.wto.org/english/thewto_e/whatis_e/tif_e/disp1_e.htm (last visited on September 18, 2016).

[14] See: World Trade Organization, *Chronological list of disputes cases*, available at https://www.wto.org/english/tratop_e/dispu_e/dispu_status_e.htm (last visited on September 18, 2016) and World Trade Organization, *India — Patent Protection for Pharmaceutical and Agricultural Chemical Products*, WT/DS50/1, available at https://www.wto.org/english/tratop_e/dispu_e/cases_e/ds50_e.htm (last visited on September 18, 2016) (Request for consultation made by USA on July 2, 1996).

Community complaint. India then negotiated with the U.S. for a fifteen-month window to return to amending its patent law by April 1999.[15] Finally, despite civil society concerns, India did implement **The Patents (Amendment) Act, 1999** which was the first of the three formal legislations passed between 1995 and 2005 to ensure the country's transition to a strong IPR regime. However, this ordinance was brought into force only retrospectively because of the failed The Patents (Amendment) Bill, 1995. This amended Act had the provision for filing of applications for product patents in the areas of drugs, pharmaceuticals and agro-chemicals, though such patents were not allowed and the applications were only to be reviewed after 31st December, 2004. Further, the applicants could be allowed EMR to sell or distribute these products in India, but subject to fulfilment of certain conditions. The implementation of The Patents (Amendment) Act, 1999 did not encourage much innovative and related activities within India as it was basically a post factum of the failed Act of The Patent (Amendment) Bill, 1995 and too many conditions were attached for a smooth transition to a greater patent protection regime.

It was soon followed with a much needed second legislation, **The Patents (Amendment) Act, 2002**. It laid the foundation stone and gave the impetus to change the intellectual property regimes in India. According to the Controller General of Patents, Design and Trademarks, Govt. of India, The Patents (Amendment) Act, 2002,[16] replaced the earlier patent rules implemented by the 1970 Act.[17] This second legislation proposed a new definition of the term "invention", implemented products patents in all fields of technology, increased the term of patents from 14 to 20 years (complying with TRIPs), deleted the "license of rights" provisions, limited scope for compulsory licensing and governments to use patented inventions, and recognised parallel imports of patented products. This Act really broadened the scope for the implementation of the TRIPs complying IPR regime that India committed to adopt during the ministerial meeting of the WTO talks in Marrakesh, Morocco in April 1994. It additionally introduced the "Bolar" exception, inspired by US law exempting manufacturers from infringement if they develop products, conduct research and submit test data for regulatory purposes. A joint parliamentary committee was constituted which submitted a report to the lower house of the Indian parliament; while its research was thorough, political circumstances ensured that the 2002 bill faced lesser difficulties than the earlier legislation and thus The

[15] Dispute Settlement Body, *India - Patent Protection for Pharmaceutical and Agricultural Chemical Products - Reasonable period of time for implementation of the DSB's recommendations*, WT/DSB/M/45 (Jun. 10, 1998), at 16.
[16] This act came into force on 20th May, 2003
[17] http://www.ipindia.nic.in/history-of-indian-patent-system.htm

Patents (Amendment) Act, 2002 was enacted. The political situation is also important to note here, as India signed the TRIPs agreement under the Indian National Congress (INC), which was then (in 2002) in opposition, while the Bharatiya Janata Party (BJP) a political party with more market-oriented approach was in power.[18] Three years later India was able to push this second legislation further with the addition of 3(d), the compulsory licensing provision, and implemented The Patents (Amendment) Act, 2005 to comply with all the provisions of the TRIPs complying IPR regime (see Chatterjee et al., 2015 for more details on 3(d)).

While we spent some time in understanding the institutional milieu of TRIPs-compliance for a revised IPR regime in India, it is important to appreciate that this transition did not happen as soon as India signed the agreement, but went through considerable uncertainty in the transition period between 1994 and 2002. The amendment of the 1970 patent rules by the 2002 Act finally indicated the transformation of the Indian IPR regime to a stricter patent regime (TRIPs compliant). Ramanna (2002) points out that policy shift in relation to patents did not occur immediately after India signed the TRIPs Agreement, but took place only after a domestic constituency emerged in support of the patent reform. The support occurred on different levels: first, the impact of liberal ideas regarding economic reforms slowly led to a greater westernised notion of IPR; second, rise of a more 'modern', professionally managed and technologically advanced segment of industry in India; third, top Indian (e.g., Council of Scientific and Industrial Research, CSIR) research and scientific institutes felt that they could benefit from patents rather than publications.[19] While a section of the previous work in Indian patent regime might indicate that India changed to a TRIPs compliant patent regime after 2005, our detailed discussion of the events suggests that there was a significant amount of uncertainty in transition to a stronger IPR regime, which essentially cleared up with The Patents (Amendment) Act, 2002. We utilize this Act as a quasi-natural experiment to understand how the change in the intellectual property rights regime affects the organization of firms in terms of demand for managers or problem-solvers and thus facilitated their transformation in internal design. We conduct a variety of sensitivity checks and robustness tests to ensure that we address

[18] With economic liberalization starting in 1991, sections of the INC party began favouring changes in patent laws. The BJP after to power in 1998, abandoned its opposition to patent reform adopted a pro-patent position. Although there exists some resistance within both the parties to policy revisions, the BJP and the INC eventually ensured the dominance of groups within their parties and affiliations that favoured change on patent policy. For details, see 'Parties undecided on Patents Bill', Economic Times, December 21, 1998; 'BJP Eases Stand on Swadeshi Plank, Backs Government Policy', *Deccan Herald*, January 5, 1999; 'Congress Support to Ensure Passage of Patents Bill', *Economic Times*, December 23, 1998.

[19] ASSOCHAM (Associated Chambers of Commerce and Industry) also gave a written submission to the Committee on the need for phased introduction of product patents in India and pointed out that it was of the view that to attract increasing flow of Foreign Direct Investment, it is important for India to strengthen the patent system. This will ensure higher interaction in R&D as well as flow of foreign capital.

any confounding ex-ante and simultaneous impact (of other policy shocks) might have on the findings from our study.

3 Firm level Data

We examine firms in the Indian manufacturing sector. The firm level analysis is primarily based on the PROWESS database, constructed by the Centre for Monitoring Indian Economy (CMIE), which has been used in prior work in other contexts. We outline the features of this dataset in detail in this section.

The PROWESS database contains information on approximately 27,400 publicly listed companies, all within the organized sector, of which almost 11,500 are in the manufacturing sector.[20] It reports direct measures on a vast array of firm level characteristics including sales, exports, imports (disaggregated into four components – import of capital goods, import of raw materials, import of stores and spares and import of finished goods), R&D expenditures, technology transfer, production factors employed, gross value added, assets, ownership, and others which we outline further within our empirical analysis. The dataset covers both large and small enterprises; data for the former types is collected from balance sheets, whereas that for the latter ones, it is based on CMIE's periodic surveys of smaller companies.

PROWESS presents several features that makes it particularly appealing for the purposes of our study, and puts it at an advantage compared to other available sources, such as the Indian Annual Survey of Industries (ASI), for instance. First, unlike other sources, the PROWESS data is in effect a panel of firms, enabling us to study their behaviour over time; specifically, the (unbalanced) sample covers up to 8,000 firms, across 108 (4-digit NIC) manufacturing industries that belong to 22 (2-digit NIC) larger ones,[21] over the period of 1990-2006,[22] hence covering the 1990s reform period, being an essential part of our analysis that we discuss later.

Second, the unique feature of the data set, upon which our study is mainly based, is that it disaggregates compensation data to those received by managers and non-managers, with a further disaggregation of compensation to wages and bonuses. Specifically, the division is done to three layers: non-managers, directors, and executives; the latter two comprise the managers'

[20] While placed according to the 4-digit 2008 National Industrial Classification (NIC) level, firms are reclassified to the 2004 level to facilitate matching with the industry-level tariffs. Hence, all industry-level categorization made throughout the paper are based on the 2004 NIC classification.

[21] In terms of composition, approximately 20% of the firms in the dataset are registered under the Chemical and Pharmaceutical industries, followed by Food Products and Beverages (13.74%), Textiles (10.99%) and Basic Metals (10.46%).

[22] While our data covers the period of 1990-2011, we limit the main analysis to 2006 to avoid potential biases caused by the 2008 financial crisis. We do, however, extend our analysis to 2011 in the robustness section.

group.[23] While the definition of the former is that they do not manage other employees, directors are defined as managers without executive powers, as opposed to executives which do possess such responsibilities. Executives include, for instance, the CEO, CFO, and Chairman, whereas Directors may cover positions such as Divisional Managers. In effect, we consider directors to be middle management, whereas executives are the top management. There is scope for some subjective interpretation of this distinction by firms, when providing data; however, importantly it does not affect our main analysis, where we consider managers as a single aggregated group. In a later section, where this distinction is analysed, we consider different interpretative options for robustness, indicating it does not affect the key patterns observed. These features enable us to study the effect of innovation policy on firm management and organization over a relatively large period of time.

A key related issue is regarding the accuracy and consistency of the data. Starting with accuracy, CMIE mentions that it retrieves most of the compensation data from balance sheets, reported in publicly-available annual reports. To test the accuracy of our measures of interest, we compare the data reported in PROWESS to those reported in the annual reports for a random selection of firms, representing both relatively large and small ones, in the year 2011. Results appear in **Appendix B**, **Table B.1**. We compare the reported compensation of executives (Columns 1 and 2) and directors (Columns 3 and 4). In both cases we observe a strong match between the compensation data reported in PROWESS and those given in the annual reports, with correlations being higher than 0.99. In columns (5) and (6), we compare the number of reported executives in each of the sources, with the correlation being 1. These results provide some affirmation for the accuracy and reliability of the measures used.

Moving to consistency, the analysis implicitly assumes there is consistency in the definition of managers across firms. However, the said family-oriented nature of many Indian firms, and the surveys CMIE uses for smaller firms, may give rise to some subjectivity in that respect. This deserves some comment. We note that all firms included in the analysis are listed in the Mumbai Stock Exchange, and hence are subject to the same corporate governance regulations, including the said definitions; this provides a more homogenous, and regulated, environment that mitigates the given concern. This brings us to another related characteristic which is that close to 25% of firms report having no managerial compensation. These firms have no

[23] We note that this division does not proclaim that these represent the absolute number of layers in a firm. It may well be that under the middle or top groups there are further minor divisions that increase the total number of layers in a firm. The nature and scope of the data does not enable us to empirically observe these sub-layers, capping the analysis at the three, more aggregative, ones.

managerial layer, or their managerial compensation is very low.[24] Bloom et al. (2013) reports of such features in family-oriented Indian firm culture. Our data, however provides more support for the latter. In **Table B.2** of **Appendix B**, we compare some firms that report no managerial compensation to those that do in terms of some key firm level measures; the key differences are in size and technology. In particular, the firms that report having no managerial compensation produce significantly low output, are much less capital intensive, and spend less on R&D. On the other hand, family-owned firms are spread across the firms' size distribution (Bloom et al., 2013).

Next, the data set provides much variation across firms and industries in the compensation of managers compared to non-managers, which enables us to better understand how they react to IPR reform. For instance, the average share of managerial compensation in total labour compensation across 2-digit industries for the period of 1990-2006 goes from a low of approximately 1.5% to a high of around 9%, the difference across industries is also clearly observed. The variation is also seen when measuring changes (in managerial compensation) over time. Averaging annual changes over the same period, we observe that while in some industries the average annual rate of change is around 10%, in others it can get higher than 200%, hence providing quite large differences that we examine in the empirical section. Such variation will be more prominent when the data translates to the firm level.

Last, our data has a relatively wide coverage, accounting for more than 70% of the economic activity in the organized industrial sector, and 75% (95%) of corporate (excise duty) taxes collected by the Indian Government (Goldberg et al., 2010). All variables are measured in Millions of Indian Rupees (INR), deflated to 2005 using the industry-specific Wholesale Price Index,[25] and are outlined in **Appendix A**. **Table 1** presents descriptive statistics for all variables.

4 Empirical Framework

One of the important and potential spillovers from a stronger intellectual property rights regime or higher incentives to innovation is that it can induce a high-tech firm vis-à-vis low-tech one to change its internal structure accordingly to reap higher benefits. To assess whether higher incentives to innovation causally affects firm management and structure, we now

[24] Notably, compensation values of less than 100,000 INR are reported by PROWESS as zero.
[25] We thank Hunt Allcott for sharing this data with us, used in Allcott et al. (2014).

evaluate the effect of The Patents (Amendment) Act, 2002 on the share of managerial compensation in total labour compensation for manufacturing firms in India. To explore such an effect, we use a difference-in-differences approach following Branstetter et al. (2006, 2011) controlling for other firm and industry level characteristics and other simultaneous policy changes that might affect the outcome of interest. We use the following specification:

$$\left(\frac{Mcomp}{Tcomp}\right)_{it} = \alpha_i + \alpha_t + \alpha_{jt} + \beta_1(IPR_{02} \times HighTech_i) + \beta_2 IPR_{02} + \beta_3 X_{ijt} + firmcontrols_{it} + \epsilon_{it} \tag{1}$$

where, i indexes an individual firm, j the firm's industry group, and t the year. $Mcomp$ denotes the total managerial compensation, whereas $Tcomp$ is the total labour compensation of a firm. So, the dependent variable measures the share of managerial compensation in total labour compensation of a firm – our proxy for demand for managers. Our key variable of interest is IPR_{02}, the post-IPR reform dummy variable, which takes a value of 1 in the year of and years following the imposition of The Patent (Amendments) Act, 2002. In particular, IPR_{02} takes a value 1 for the years 2002-2006.

If there is any observed change in a firm's internal structure due to higher incentives in innovation as a result of a stronger IPR regime, it should be more for firms that value the innovation the most even when there are less incentives to innovate. In particular, higher incentives to innovation will motivate a firm, who value the innovation more before the reform, to change its internal structure in a certain way to reap substantial benefits from stronger patent rights than the others. To study how a change in patent regime affect firms differentially, we divide the firms into two groups based on their investments towards technology adoption before the reform. In other words, since our main variable of interest, IPR_{02}, is a time dummy, it will be difficult to distinguish between 'treatment' and 'time' effects if we do not use a 'control' group in our estimation. Firms that over the years before the reform (1990-2001) average greater than the median technology adoption (sum of R&D expenditure, royalty payment for technical knowhow, import of capital goods and expenditure towards information technology enables services) of the industry to which it belongs, are defined as 'high-tech' firms or 'treated' group in our estimation. We assign these firms a high technology use dummy, $HighTech$, equals to 1. For the rest of the firms, $HighTech$ equals 0, which serves as 'control' group in our estimations.[26] Therefore, our key variable of interest is the interaction of IPR_{02}

[26] While it is true that this is not a perfect control group that we could use in the estimations, but given the nature of the reform it is difficult to find a group of firms which is exogenous to the change in intellectual property regime. Given the circumstances, this is the best we could

and $HighTech$, $IPR_{02} \times HighTech$. This interaction term estimates the impact of a change in intellectual property rights regime on the demand for managers for a high-tech firm compared to a low-tech firm.

Therefore, our coefficient of interest is β_1. It measures the difference between high-tech and low-tech firms in terms of technology adoption and examines how this difference gets attenuated because of higher incentives to innovate. In other words, β_1 measures the between-firm inequality in terms of demand for managers because of higher incentives to innovation. In particular, it estimates the complementary effect of technology adoption and incentives to innovation on firm structure. Since we expect the share of managerial compensation of 'high-tech' firms to rise more, therefore it is the change in managerial compensation due to the IPR reform, net of general change post-2002, and net of possible permanent differences across 'low-tech' firms. On the other hand, IPR_{02} estimates the average direct effect of the intellectual property reform on the demand for managers. Alternatively, it measures for the average firm, within-firm changes in the share of managerial compensation on total labour compensation.

However, one should be careful in interpreting the basic estimates as conclusive evidence of the causal effect of IPR reform on a firm's managerial compensation, even though we argue that the reform we exploit here is sudden because of potential omitted variable bias and reverse causality. We address the former by sequentially adding various firm and industry characteristics and its interaction with the $HighTech$ dummy to our baseline specification; whereas for the latter we do some robustness checks discussed below.

X_{ijt} is a vector of firm and industry characteristics which are likely to impact a firm's managerial compensation. For example, following Chakraborty and Raveh (2016), we use both input and output tariffs at the industry-level to control for trade reforms initiated by the Indian government during the 1990s. We also control for product market competition (both for domestic and export market), labour-regulations, factories, skill-intensity, management technology, etc. at the industry-level. As for the firm-level, we control for productivity, issue of family firms, management governance, etc. Therefore, while the vector X is continuously modified, we include three basic firm-level controls ($firmcontrols$) constantly: age of a firm, amount of capital employed as a share of total gross value-added and assets. Older firms may have a more established structure and culture; so, controlling for age would take care of the

use as all other sectors are also simultaneously impacted by other reforms (e.g., trade reforms). Using any other sector, say agriculture, would have been more exogenous to the reform, but the behavioural pattern of the agricultural sector is completely different from that of services and may bias the results in a different manner.

potential differences in the flexibility of undertaking organizational reforms which can change a firm's internal structure. The second controls for capital intensity of a firm, i.e., higher capital intensity may also raise the demand for managers significantly. The last controls for firm size, given that larger firms may have greater management needs. All three are, therefore, highly correlated to the managerial compensation of a firm. α_i and α_t are time-invariant firm and year fixed effects, respectively.

While estimating the above equation, we carefully control other simultaneous reforms and channels that may affect the share of managerial compensation in a firm, such as delicensing of industries, tax incentives for R&D, The Competition Act, 2002, corporate governance reforms, etc. which could potentially affect the outcomes. To control for these unobserved policy changes, we use α_{jt}. These are primarily industry-year trends; we interact a firm's industrial classification at NIC 5-digit level (the most disaggregated level of a firm's industrial classification) with year trends to control for other policy reforms that evolved over the years and which may affect our dependent variable. We also replace the industry-year trends with industry-year fixed effects at various aggregate (industrial classification) levels, but the results do not change.

However, there were a couple of crucial changes in the realm of corporate governance reforms that took place around the implementation of The Patents (Amendment), Act, 2002 which needs mention: (i) exogenous changes in the Clause 49, in corporate governance requirements. The Clause 49 reform required firms to change the composition of their board of directors – specifically, at least 50 percent of the board had to consist of non-executive directors. It also required changes about the proportion of independent directors on a board. The reform also laid down a code of conduct for directors and senior managers, board procedures, compensation to non-executive directors, audit committee requirements, disclosure requirements and whistle blower policy regulations. The committee which suggested these changes issued its final report on January 2000, adopted by SEBI (Securities and Exchange Board of India) on February 2000 and effective for large firms on March 2001; (ii) SEBI was established in 1988 as the authority to regulate the Indian securities market under the Securities and Exchange Board of India Act, 1992 (SEBI Act).

However, SEBI's authority for carrying out its regulatory responsibilities has not always been clear and when Indian financial markets experienced massive share price rigging frauds in the early 1990s, it was realized that SEBI did not have sufficient power to carry out

investigation of the frauds. Therefore, in 2002 the SEBI (Amendment) Act, 2002 replaced the SEBI Act, 1992 to enlarge its Board of Directors and transparent functioning of the Indian capital market. All these changes can induce a large number of firms to consistently report the compensation of the managers (especially, the top managers).[27] And, our observed sharp rise in the share of managerial compensation after 2002 could potentially then be nothing but due to these auditing regulations of the corporate governance reforms. However, we do not think such is the case for a couple of reasons.

First, looking at **Figure 3** closely, it can be noticed that it is not only after 2002 that we observe a sharp rise in the share in managerial compensation, it is also during mid-1990s that we observe something similar. If it would have been only for the corporate governance reforms and nothing else, then we would have seen only a secular trend before 2002 and no spike.[28] Second, even though the reform for the Clause 49 was adopted by SEBI in 2000, it was only in late 2002 that SEBI constituted a committee to assess the adequacy of current corporate governance practices and to suggest improvements. Based on the recommendations of this committee, SEBI issued a modified Clause 49 on October 2004, which came into operation on 1 January 2006.[29] The above discussion underlines that there are multiple layers of the amendment of Clause 49, so it is hard to pinpoint one structural break to argue that corporate governance reforms led to an observed increase in the managerial compensation ratio. Finally, econometrically, all these reforms will also be controlled either by the presence of year fixed effects or industry-year trends in our regressions.

4.1 Exogeneity of The Patents (Amendment) Act, 2002

A crucial issue regarding our identification strategy is to establish that the timing of the 2002 IPR reform as exogenous, at least with respect to the internal reorganization activities of the Indian manufacturing firms. It may be that the previous IPR amendment bills or acts, say the one in 1999 led the firms to start demanding for managers anticipating the implementation of a more stronger amendment act in the next few years and this influenced the managerial compensation. Also, there may be other changes that are coincident with The Patents (Amendment) Act, 2002 which drive both the changes in the reform and the measured changes in firm behaviour towards demand for managers. For example, there might be pressure by the

[27] As these amendments in Clause 49 were focused on improving the auditing of companies through the board.
[28] Chakraborty and Raveh (2016) show that the increase in the share of managerial compensation during the 1990s is due to the trade reforms undertaken by India.
[29] There is another initiative on corporate governance (with respect to Clause 49) in India in 2003 in the form of the recommendations of the Narayana Murthy Committee. This committee was set up by the SEBI under the chairmanship of Mr. Narayana Murthy, in order to review Clause 49 and to suggest measures to improve corporate governance standards.

big firms or multinationals on the Indian government to impose a stronger intellectual property rights regime to create a certain kind of monopoly power over some products, which can reap them higher benefits. While, we cannot completely rule out these alternative explanations, we can examine their plausibility more carefully. To understand, whether such are the cases or not, we run some checks in **Table 2**.

We start by checking whether the 1999 Patent Act has a proactive effect on the share of managerial compensation. In other words, does the observed effect of 2002 reform sustain, when we introduce the 1999 reform. Column (1) interacts the 1999 reform dummy, IPR_{99}, with our $HighTech$ dummy. We define IPR_{99} as a time dummy which takes a value 1 if the year is greater than or equal to 1999. Our variable of interest, $IPR_{02} \times HighTech$, is positive and significant with no effect of the $IPR_{99} \times HighTech$. In column (2), we replace our $HighTech$ dummy in the interaction term $IPR_{99} \times HighTech$ with $HighTech_{98}$. $HighTech_{98}$ takes a value 1 if the average technological adoption expenditure of a firm for the years 1990 to 1998 is greater than the average technological expenditure of the industry to which the firm belongs. We do this to understand whether a firm which was high-tech before the 1999 Act started to demand for managers as a result of the 1999 reform and the 2002 reform was nothing but an additional push. We fail to find any evidence to this effect. In column (3), we additionally interact $HighTech_{98}$ with IPR_{02} and this interaction term should not be significant. If yes, then the firms, especially the high-tech, were re-organizing their firm structure in anticipation to the 2002 reform. We find our coefficient of interest to be positive and significant, with the additional interaction terms not affecting our outcome of interest. In short, our tests to understand whether 2002 IPR reform is a mere extension of the 1999 reform and not a sudden change towards a stronger intellectual property rights regime fails.

Additionally, we run a test with detailed estimates of the timing of changes in share of managerial compensation. In particular, we use an ex-ante ex-post approach to prove that The Patents (Amendment), Act 2002 is not endogenous. In other words, the estimation examines if there were any anticipatory effects of the reform. It could be possible that some of the high-tech firms were lobbying for the implementation of a stronger IPR regime to reap higher benefits and started reorganizing the firm structure accordingly. This could have increased the share of managerial compensation of the firms before the reform and the post-2002 increase was just a mere continuation. We argue that this is not the case. We follow Branstetter et al. (2006) and adopt the following methodology. The IPR_{02} $(t-4)$ dummy is equal to one for all years that predate the 2002 patent act by four or more years and is equal to zero in other years,

and the IPR_{02} $(t+4)$ dummy is equal to one for all years at least four years after the IPR reform and zero during other years. The other reform dummies are equal to one in specific years and zero during other years. There is no dummy for the year immediately preceding the ban (i.e., year t − 1); the coefficient on the reform dummy estimates relative to that year. The results indicate that the coefficients on the dummies for years prior to The Patents (Amendment) Act, 2002 fails to show any evidence of a significant movement in the demand for managers prior to the reform when estimated relative to the preceding year. For example, the coefficient on the IPR_{02} $(t-4)$ show that the managerial compensation of a high-tech firm is negative and insignificant prior to the reform relative to the concurrent effect of the reform, which is $IPR_{02} \times HighTech$. On the other hand, the coefficient of the interaction term of IPR_{02} and $HighTech$ continues to be positive and significant; whereas, the coefficient for the years after the reform are large, positive and significant. Thus, the timing of changes is consistent with a shift in activities that follows soon after the enactment of the reform; the coefficients are positive, significant and increases over time.

Though, our estimates show that there were no precedents of the 2002 IPR reform, we ran another series of checks following Khandelwal and Topalova (2011) to test for potential lobbying effect and influence of the 1999 reform. We test whether our variable of interest is correlated with important pre-reform (pre-2002 but post-1999) industry characteristics, which might influence the 2002 reform. In other words, we test whether some industry characteristics, such as share of managerial compensation, after the 1999 reform is correlated with the interaction of high-tech dummy and reform dummy. These characteristics include share of managerial compensation (a larger share of managers may influence the industry lobbyists to put pressure on the government to adopt more stronger intellectual property rights), share of skilled workers (a highly skilled work force may also push for reforms in order to reap benefits from higher incentives to innovation) and average factory size (this captures the ability of producers to organize political pressure groups to lobby for stronger patent rights regime). All the pre-reform characteristics are measured at the year 2000. The results are presented in columns (5) – (7) in **Table 2**. The coefficients indicate no statistical correlation between the complementary effect of technology adoption and 2002 IPR dummy and any of the industry characteristics.

One possible explanation for these outcomes can be traced to Reddy and Chandrashekaran (2017). They conducted a careful study of the dilemmas involved in the implementation of the reforms towards stronger protection of patent rights, showing that there was a lot of uncertainty

involved during the debates and discussions in the parliament with regard to the implantation of a TRIPs-compliant patent regime. Finally, we investigate whether the policymakers implemented the 2002 Act in response to firms' demand for managers. If this were the case, one should expect current share of managerial compensation to predict future implementation of the IPR reform due to the clout of the high-tech firms. We regress $IPR_{02} \times HighTech$ on share of managerial compensation in $(t-2)$ period, controlling for firm and industry-year fixed effects. Column (8) presents the result from such an exercise. The correlation between future reform and current managerial compensation is indistinguishable from 0.

5 Results

5.1 Benchmark Results

Our benchmark results from estimating equation (1) for the period 1990-2006 are presented in **Table 3**. In this table, we investigate the complementary effect of technology adoption and implementation of an IPR reform on the intensive and extensive margin of the demand for managers. In other words, how does the imposition of stronger patent rights interacted with expenditure on technology adoption prior to the imposition of rights influence a firm's structure through recruitment of new managers. We look at both the number of managers (extensive margin) and value/price of managers (intensive margin). In addition, we also check the effect on average managerial compensation. In all the regressions, we control for age, age-squared, ownership and size of a firm in addition to firm, year fixed effects and either interaction of industry-year trends or industry-year fixed effects (at various aggregate levels).

We start with the extensive margin or using the total number managers[30] as our outcome of interest in columns (1) and (2). High-tech firms because of higher incentives to innovation demand more managers vis-à-vis low-tech firms. On the other hand, we do not find any direct effect of the 2002 Patent Act on the number of managers. This implies that even though there isn't any average effect of the reform on the demand for number of managers, the difference between the high-tech and low-tech firms in terms of the demand for managers went up. Our estimates point out that a high-tech firm, because of the higher incentives for innovation,

[30] PROWESS provides the names of the managers at two different management levels for each different year. We count the number of names to calculate the total number of managers for each individual firm per year. We acknowledge that there could be other kinds of managers in a firm as well, say Human Resource Managers, but our dataset only rolls out the managers which are linked to the production activities of a firm. Please note that the number of observations in the first two columns is significantly smaller than of the other columns. The reason for this is that the names of the middle managers are not very consistently reported across the years unlike the top managers. So, for only a handful number of observations, names of both the top and middle managers are reported. Alternatively, if we use only the top managers as our dependent variable, the result remains the same. However, this is not the case with the compensation for the middle managers.

employ around 6.5-7.1 percent more managers than low-tech firms at the mean. Next, we use the total compensation of the managers in columns (3) and (4) to check whether the price of the managers also behave in the same manner as their absolute number. The results remain the same. The difference in the price of the managers, due to higher incentives to innovation, between high-tech and low-tech firms went up significantly. However, in contrast to columns (1) and (2), we also find significant effect of IPR_{02} on total managerial compensation; however, the estimates are close to half of the interaction term. These estimates give us an idea that the demand for managers increased more as a result of the difference in the demand across these two different categories of firms (due to the reform) rather than the direct effect of the reform. In other words, the demand for managers are driven by between-firm inequality in its demand rather than within-firm.[31]

Next, we use the share of managerial compensation in total labour compensation of a firm, our primary outcome of interest as the dependent variable in columns (5) – (10). Our prior is that higher incentives to innovation would influence a high-tech firm (prior to the reform) more than the others to reorganize its internal structure such that it can engage in newer innovation. And, this would increase the relative demand for managers and consequently change the firm structure. In other words, stronger patent rights may shift the technology content of production of goods to the right and new production technology may require more knowledge. Since, according to Garicano (2000) managers provide knowledge to a firm, their relative demand would increase. This increase in demand for managers can also be attributed to the phenomenon of patent-races between the firms. Subsequently, this will increase the gap in the relative demand for managers between high-tech and low-tech firms. The coefficients of the interaction term, $IPR_{02} \times HighTech$, confirms our prior. $IPR_{02} \times HighTech$ is positive and highly significant. The difference, between high-tech and low-tech firms, in the relative demand for managers because of the 2002 IPR reform is resoundingly robust across different specifications.

In addition to the between-firm effect, we also provide some evidence of within-firm inequality in the demand for certain kinds of workers, i.e., managers as a response to higher incentives to innovation. However, the effect fades away when we interact industry-year fixed

[31] In addition, we also explore whether the demand for non-managerial employees (both extensive and intensive margin) increase because of the difference in the demand pattern of the high-tech and low-tech firms. We acknowledge that the PROWESS dataset is not very suitable to use the number of non-managerial employees as an outcome of interest as the data is very sporadically reported and not a high percentage of firms report the total number of employees. However, we use the data just to have an exploratory idea about the effect of the 2002 IPR reform on the demand for other kind of workers (other than managers). Results are reported in **Table B.3** in **Appendix B**. The coefficients portray that both the number of non-managers and non-managerial compensation went up (columns (1) and (2)) due to the higher incentives to innovation, but the increase in the value of the non-managerial compensation is half that of the managers.

effects at the two most disaggregated level, 3-digit and 4-digit industrial classification. Like the extensive margin results, our intensive margin results also show that the increase in the demand for managers is due to the differences in the high-tech and low-tech firms. In column (10), we use the simple Average Treatment Effect (ATE). The ATE measures the difference in mean (average) outcomes between the units assigned to the treatment (high-tech firms) and control (low-tech firms) group, respectively. Since, ATE averages across gains from units, we use average treatment effect of the treated (ATT), which is the average gain from treatment for those who are treated. We utilize the previous classification of firms as high-tech and low-tech as the treatment and the control group, respectively. We estimate the following equation to calculate the gain from 'treatment' or the 2002 IPR reform:

$$\tau_{ATT} = E[Y(1) - Y(0)|W = 1]$$

where, τ_{ATT} denotes the gain received by the firms which belong to the group of high-tech. The expected gain is assumed to be in response to the randomly selected unit (firms) from the population. This is the average treatment effect of the treated. $Y(1)$ is the outcome with the treatment and $Y(0)$ is without the treatment. The binary "treatment" indicator is W, where $W = 1$ denotes "treatment, which in our case is the 2002 IPR reform. As previously, we expect the coefficient to be positive and significant, which indicates increase in the knowledge-providers for high-tech firms because of the 2002 IPR reform. Everything else being equal, high-tech firms demand more managers than low-tech firms. That is, relative to low-tech firms, high-tech firms are expected to engage in innovation more in the post-reform period. We estimate the above equation by considering a sample of all possible pairs. The coefficient of interest remains the same. Our estimates suggest that the 2002 IPR reform increases the relative demand for managers gap between high-tech and low-tech firms by 1.6-1.7 percent at the mean.[32]

Columns (11) and (12) check whether there is any variation in effect of higher incentives to innovation across different management layers, we divide the total managerial compensation into middle and top managerial and evaluate the same. At the aggregate (putting together the between-firm and within-firm effect), the change in the property rights regime increases the relative demand for middle managers more than the top managers. However, the within-firm effect of the demand for middle managers is higher than top managers (top managers having no effect), whereas the between-firm effect of the relative demand for top managers is more

[32] As expected, the effect of the 2002 IPR reform on the share of non-managerial compensation in total labour compensation is negative and significant. The coefficients are very similar. Column (3) in **Table B.3** of **Appendix B**.

than double that of the middle managers. These coefficient estimates point towards some interesting facts.

The middle managers are basically the divisional managers, who work as the head of divisions or the kind of managers who are closely linked to the production activities without any executive powers in a firm.[33] Higher incentives to innovation increases the demand for these managers most within a firm with no effect for top managers. There could be two possible explanations: (a) as a result of higher incentives to innovate or stronger patent rights, firms now decide to produce more technology-intensive goods. This strategy would increase the amount of not-so-common or non-routine problems faced by a firm in their production technology. Non-managers, who deal with common problems, when facing this new set of problems will revert to the immediate management level, which is the middle management for finding out the solutions to the non-routine problems. As Caliendo and Rossi-Hansberg (2012) argues that it is not efficient for a firm to train the existing set of non-managerial people with new skills to solve these kind of problems, the relative demand for the middle managers will increase immediately; (b) on the other hand, stronger patent rights may induce firms to engage in patent- or R&D races. This would directly increase the demand for middle managers. On the other hand, we do not find any significant effect of the 2002 IPR reform on relative demand for managers within a firm. The entire effect comes from difference in demand across high-tech and low-tech firms.

Lastly, in columns (13) and (14) we compute the average compensation of managers (total managerial compensation/managers) and explore the required effect. Our coefficient of interest is positive and significant. We do the same for the non-managers in column (4) of **Table B.3**. Unlike the case of managers, we do not find any effect of the interaction between technology adoption and change in property rights regime on the average non-managerial compensation. Combining all the results, it points out to the fact that the 2002 IPR reform did increase a manager's internal worth to the organization and her average value in the market more for the high-tech firms than the low-tech firms, whereas the same reform did not create any demand for non-managerial worker's job. Vashisht (2017) show that adoption of new technology has increased the demand for high-skilled workers at the cost of intermediary skills, leading to the polarization of manufacturing jobs in India. This suggests that technology has reduced the

[33] These types of managers also include marketing managers.

routine task content of manufacturing jobs in India. All these results point to a quality upgrading mechanism which we elaborate next.

The difference in the effect in the demand for managers or in the share of managerial compensation between high-tech and low-tech firms because of the 2002 IPR reform brings us to a key question: what is the underlying mechanism? Stronger patents provide higher incentives to a firm to carry out higher innovation expenditure as there are significantly higher gains from innovation. In other words, India's IPR reform gave firms a chance to establish temporary monopoly rights over the new products they produce. This will induce a firm to implement newer strategies to produce such type of goods on which they would be able to file patents. And, this kind of change in operations, due to higher incentives for innovation, by a firm would require managerial skill on one hand to devise new strategies to participate in the patent-races and to adopt more technological expenditure to produce goods which have higher technological content. These kinds of new activities will create a demand for managerial skill, more so for firms which are closer to the technological frontier. Realizing that the main effect is driven by the focused IPR reform, it implies that a quality upgrading of the goods has taken place, but at a cost of the increase in the technological gap between these two set (high-tech and low-tech) of firms.

To see if this is the case descriptively, we plot average patent claims by Indian firms with the Indian patent office, divided into high-tech and low-tech firms in **Figure 5**.[34] The diagram clearly points out that even though the pattern of patent claims of these two kinds of firms were similar before 2002, they were quite different after. Average patent claims for a high-tech Indian manufacturing firm increased after the 2002 IPR reform, whereas it is not the same for a low-tech firm, given that it decreased for the categories of firms before the reform. We also plot import of capital goods in **Figure 6**. Looking at the import of capital goods will give an idea about the technological complexity of the products produced by these firms. The plot points out the difference in the adoption of technologically intensive inputs between high-tech and low-tech firms. In case of high-tech firms, it was decreasing for about three years before the reform, but took sharp turn in the post-2002 period. Combining these two sides of the

[34] Firm level patent filings data comes from the EKASWA database assembled by the Patent Facilitating Centre (PFC) of the Department of Science and Technology, Govt. of India. EKASWA contains all domestic patents published between January 1994 and early 2011. Due to the absence of a unique identifier shared by the firm level and patent data, the main problem in matching these two datasets consists in matching assignee in the patents to firm names. To match assignee names to firm names, we rely on a complete firm-by-firm manual matching and extensive checking of the (un) matched data. We focus completely on the domestic private firms leaving aside the foreign firms. Our merge rate is quite good. After restricting the sample to private, Indian patent applications, we are able to match 73.76 percent of these patents to CMIE firms. The not-so-good news is that the final sample has 631 CMIE firms (605 with non-missing sales data) over 13 years (1994 to 2006). So, it's not a very large sample.

innovation function, we argue that higher incentives to innovation have polarised demand towards certain type of workers, which are managers, both between- and within-firms.

Our results draw theoretical foundations from Acemoglu et al. (2003) and Aghion et al. (2005). The former in a theoretical model design a world where firms can engage in two activities: adopting existing technologies and developing innovations themselves. In such a case, the authors argue that managerial skill is relatively unimportant for the former case, but is critically important to successful innovation. As a result, when the returns from imitation are lower, such as in our case, it becomes important to choose the right managers. Thus, the firms which are closer to technological frontier would be hiring more managers because of an IPR reform. On the other hand, Aghion et al. (2005) concluded that competition increases the distance between technological-leaders and -laggards as competition increase the profits from innovating, and thereby encourage R&D investments aimed at "escaping competition". Applying this to our case, we argue that an IPR reform leads to patent or R&D races among firms to innovate new products such that the firm can establish certain kind of monopoly power by which they can escape from competition and this leads to recruitment of managers with specialized skills.

Our benchmark results are also remarkably similar to Branstetter et al. (2006), though they use a different context and dataset. Using detailed firm-level data on technology transfer within US multinational firms, the paper examines how IPR reforms undertaken by 16 countries over the period 1982-1999 have led to increase in royalty payments for technology transferred to affiliates. However, this increase (along with increase in R&D expenditure and levels of foreign patent applications) are concentrated among the firms which were high-tech prior to the reform, since they were expected to value IPR reform most. In our case, the firms which were high-tech prior to the reform demand more managers as a result of an IPR reform. In essence, our results highlight certain kind of intermediate effect before firms start to do more innovation as a result of an IPR reform.

5.2 Disaggregating Compensation into Wages and Incentives

Our analysis so far indicated that the 2002 IPR reform increases the relative demand for managers in the high-tech firms more than that of low-tech firms. With these results, we also provide suggestive evidence that points at an IPR reform-triggered quality upgrading

mechanism. To understand the channel better, we now divide the compensation into wages and incentives by two different management layers. Results appear in **Table 4**.

The former is the pre-determined salary received by the employees, whereas the latter is incentive-based payment, often being linked to performance. Incentives can be further divided into these four different parts: (a) benefits or perquisites; (b) bonuses and commission; (c) contribution to provident fund; and (d) contribution to pension. Columns (1) and (4) examine the ratio of total managerial wages to total wages and total managerial incentives to total incentives, similar to our outcome of interest in Equation (1). In particular, we use ($Mwages/Twages$) and ($Mincentives/Tincentives$) as the dependent variable in columns (1) and (4), respectively. The coefficient of $IPR_{02} \times HighTech$ in column (1) is negative, but not significant. It points out that the increase in the share of compensation of managers between firms, due to incentives to innovation, did not happen due to increase in wages. However, it is not the case within firms. The direct effect of the reform dummy, IPR_{02}, on the share of managerial wages is positive and highly significant. On the other hand, column (4) portrays the exact opposite results: differences between firms in terms of demand for managers is due to the difference in incentives, but there is no within-firm effect. This result bolsters our benchmark result further. Incentives to innovation creates demand for new managers and firms which value the reform more give higher incentives to managers to innovate and this drives the wedge between the high-tech and low-tech firms. Our result of the increase in managerial compensation being driven through increase in incentives as a result of an external shock is similar to the current literature on trade liberalization and managerial compensation (Cunat and Guadalupe, 2009; Chakraborty and Raveh, 2016).

Columns (2) and (3) examine the response of the ratio of managerial wages for middle and top managers, respectively. We do not find any, either between- and within-firm, effect on the middle managers wage. But, we find that the within-firm increase in the share of managerial wages is driven solely by the increase in the wages of the top managers. On other hand, columns (5) and (6) do the same for incentives. Increase in incentives, both across- and within-firm, happen only for middle managers, with weak within-firm negative effect for top managers. Increase in the compensation of managers through the increase in the incentives of the middle managers further highlights our argument. The middle managers are the ones who are basically linked with production, R&D, marketing and other activities of the products produced by a firm. When a firm, or the top management, decides to produce a new product, they hire new managers, give them higher incentives to (i) innovate, and (ii) to establish a monopoly right

over the product. Patent rights push a firm towards more innovation, which leads to certain kind of competition to establish some monopoly rights over a product. Connecting the results on the incentive-based payments to the previous ones, it becomes imperative that firms' division of profits is managers-biased, but not towards top management. This becomes all the more relevant in our case to show that the managerial pay increases only through market channels and not non-market channels. In other words, exogenous shock, in terms of an IPR reform, did not raise managerial incentives in poor-governance settings, in line with the hypothesis of executive's rent capture opportunities (Olney and Keller, 2017).

5.3 Testing for Other Possible Channels

Table 5 checks for all other possible channels that can concurrently affect managerial compensation. We start with one of the most important factors, the effect of trade reform. India underwent a major trade liberalization program in the 1990s and Chakraborty and Raveh (2016) show that drop in input and not output tariffs significantly explains the rise in the share of managerial compensation for Indian manufacturing firms in the 1990s. We use the same indicators in this case, but interacted with $HighTech$ in column (1). We do not find any effect of trade reform playing any role for the difference in the rise in the share of managerial compensation between high-tech and low-tech firms. Our primary result continues to be true and significant.

Cunat and Guadalupe (2009) and Guadalupe and Wulf (2010) show that import competition and product market competition significantly affects managerial or executive compensation. Column (2) uses Chinese imports as a share of total imports of India as an indicator for domestic import competition. India's imports from China increased from around 1% in 1992 to 17% in 2006; the increase in the share is especially sharp between 2001 and 2006, from 5.5% to 17%. This can significantly induce managerial compensation. We use trade data from WITS and match it at NIC 2004 4-digit level to create a measure of competition (in the domestic market) from China at the industry-time level. It is defined as the share of imports from China in total imports (MC_{CH}^{IN}). We interact this share with our $HighTech$ dummy to to explore whether the increase in managerial compensation of the high-tech firms is due to product market competition effect. We do not find this to be true. The interaction term is positive but

not significant.[35] As the coefficient demonstrates, our variable of interest continues to positive and significant. Caliendo et al. (2017) argue that participation in export market significantly increases executive compensation. In column (3), we use the share of India's exports in total exports to the US to see whether export market competition has positively affected the demand for managers. We find negative effect of the interaction term with weak significance. Participation in the export market closes the gap between high-tech and low-tech firms in terms of demand for managers. However, our main variable of interest is significant and positive.

Next, in column (4) we test for the potential correlation between relative demand for managers and skilled labour. We measure the latter using the 3-digit industry level ratio of non-production workers to all employees in an industry, obtained from Ghosh (2014) (1990-2000), and the Indian **Annual Survey of Industries** (ASI 2001-2006). This is the standard skill-intensity measure used in the literature. Our outcome variable of interest and skill intensity do not appear to have significant correlation. The main result continues to hold, suggesting that it is not driven by increases in the demand for skill. Column (5) uses management technology and its interaction with $HighTech$ dummy as an additional control. A firm belonging to an industry which has higher quality of management technology may demand for managers. We use data on management technology from the World Management Survey. It is given for a single year, which is 2004 across all the NIC 2004 2-digit industries. Our estimates point out that management technology of an industry is positively and significantly correlated with the demand for managers, but this is a complementary additional effect with our main variable of interest still positive and significant. Establishment of new factories may create a demand for new managers as local knowledge is important (Bloom et al., 2010). Therefore, we add an additional related measure: the number of factories and plants at the industry-level, derived from ASI. The inclusion of this additional control does little to change our benchmark finding. IPR reform continues to significantly increase the demand for managers, higher in case of high-tech firms. Bloom et al. (2013) points out that better managed firms in India have higher productivity. To address this, we control for productivity by following Ahsan (2013) using Levinshon and Petrin (2003) methodology. Result is presented in column (7). As the results demonstrate, higher productive firms demand more managers, but our coefficient of interest is stable in sign, magnitude and significance.

[35] We also check our results by looking at Chinese competition in one of India's important export market, the U.S. We use the Chinese share of imports by the U.S. to check whether competition from China in India's one of the most important trade destinations lead to such changes in the share of managerial compensation of firms. We do not find any such evidence.

Another related concern is about labour market institutions in India. On average, the labour market is rigid in India and there may be cross-regional variation in labour market rigidity in India. Bloom and Van Reenen (2010) show that labour market institutions affect quality of management practices and demand for managers. It could be true that increase in demand for managers and rising income of managers concentrate in high-tech firms that happen to be in Indian states with less severe labour market regulations. Accordingly, we use the postcodes for each firm to locate its state/region and then interact the state-year fixed effects to control for the variation in labour regulations across different states in India in column (8). Our baseline result does not change.[36]

Next, is the issue of family firms in India as highlighted by Bloom et al. (2013). Family firms may use their control over the Board of Directors to appoint their family members in several of the managerial positions within the firm and this could increase the managerial compensation. If this is the case, then our results are nothing but a spurious correlation between the IPR reform and demand for managers. Though, PROWESS does not give any direct indicator of ownership regarding family firms, it does give the percentage of shares held by Indian individuals and Hindu undivided families. We follow Patnaik (2017) and use this indicator for family ownership of manufacturing firms in India. However, this indicator starts only from 2007 onward. So, we use the proportion of shares for 2007 to classify a firm as family-owned and assumed that it was the same for the period 1990-2006. This is quite a restrictive assumption, but given the limitations of the dataset that we use, this is the best that can be done. In column (9), we interact family-ownership indicator with $IPR_{02} \times HighTech$ and see whether family firms influence any increase in the share of managerial compensation or not. We do not get any such evidence.

[36] Besley and Burgess (2004) divides all the major Indian states based on the amendments done by each state on the Industrial Disputes Act (IDA) into three categories: pro-worker, neutral or pro-employer. We interact the index from Besley and Burgess with our variable of interest, $IPR_{02} \times HighTech$, and ran our regression. The estimate does not change. A recent OECD study on state-level labour reforms in India uses a survey to identify the areas in which states have made specific changes to the implementation and administration of labour laws. In particular, the survey scores progress in 21 states in introducing changes in recent years to not only regulations dealing with labour issues, but also the relevant administrative processes and enforcement machinery. The regulations covered by the state specific survey goes well beyond the IDA and include the Factories Act, the Trade Union Act, and Contract Labour Act among others. Within each major regulatory area, a number of issues is considered. Scores are given based on whether or not a given state has introduced changes. A higher score is given for changes that are deemed to be pro-employer. The OECD study aggregates the responses on each individual item across the various regulatory and administrative areas into an index that reflects the extent to which procedural changes have reduced transaction costs vis-à-vis labour issues. The reduction in transaction costs can come about for different reasons including reductions in the scope of regulations, removing ambiguities in their application, and simplifying compliance procedures. Based on the values of the index, we divide the states that are the concern of this paper into three equal groups of five. States with a flexible labour related regime include: Andhra Pradesh, Gujarat, Haryana, Rajasthan, and Uttar Pradesh. States with an inflexible labour related regime include: Assam, Bihar, Kerala, Maharashtra, and West Bengal. The remaining are treated as having a neutral stance. We also use the OECD (2007) indicator to replace the Besley and Burgess (2004); our baseline result still does not alter.

Lastly, we follow Olney and Keller (2017) to investigate whether the difference between the demand for managers in case of high-tech and low-tech firms, as a result of stronger patent rights, is due to poor governance settings. In other words, is the difference in the relative demand for managers due to exogenous shock received by the firms in the form of the higher incentives to innovation or due to other non-market channels. This could happen due to poor governance settings due to lack of corporate governance reforms. Previously, we argue that the year fixed effects or industry-year fixed effects will control for the different corporate governance reforms that has been undertaken by the manufacturing sector in India, but now we use a specific indicator to explicitly control for such issues. We use the number of independent directors in the Board of Directors in a firm as an indicator for poor governance settings. The higher the number of independent directors within a firm, the better or higher will be the transparency or auditing of a firm in terms of its payments. The corporate governance reforms only initiated from 2001 onwards and it started to get implemented from 2003-04 with 2006 being the latest year. Our dataset runs from 1990 to 2006 and since a majority of the firms started reporting the composition of Board of Directors from 2003-04 onward, matching the number of independent directors with our main dataset drops around 90 percent of the observations. However, we use the number of independent directors of a firm and its interaction with $IPR_{02} \times HighTech$ in column (10). None of the regressors are significant, including our main variable of interest; but the sign of the coefficient does not change.

5.4 Robustness Checks

We check for the robustness of our benchmark results by using alternate methods and sample in **Table 6**. We start by reducing the time period from 1990-2006 to 1990-2005 or reducing it by one year. The year 2005 is a crucial year in terms of India's IPR reform, where India finally complied with the TRIPs agreement and it could influence the outcome of interest. Reducing the time period does not affect our benchmark finding. The estimates confirm that the IPR reform of 2002 continues to have significantly contributed to the differences in the demand for managers between high-tech and low-tech firms. Column (2) aggregates our dependent variable and $HighTech$ to the industry-level, where $HighTech_i$ changes to $HighTech_j$, where j denotes any industry. An industry is labelled as $HighTech$ if its average technological expenditure for the period 1990-2001 is greater than the average technological or innovation expenditure of the whole of manufacturing sector. Our motivation is to check whether there is

any change in the results obtained so far if we change the level of aggregation. Our benchmark result is robust to this kind of aggregation.

Column (3) runs a placebo test. We drop all firms except for the pharmaceutical sector from the sample. The reason to do this are twofold: (i) the pharmaceutical firms are argued to be the early adopters of technology as compared to other manufacturing; and (ii) one of the provisions of the 2002 IPR reform is that it extends the purview of the patent policy to other manufacturing sectors; it was already existing for pharmaceutical sector. Given these primitives, we should not expect any effect of this IPR change on the pharmaceutical firms. The estimate shows our hypothesis to be true. Big firms pay fat compensation to their managers and this can influence the overall results. To correct for such bias, we drop firms which are greater than 90th percentile of the total assets of the industry to which the firm belongs in column (4). The baseline coefficient does not change.

Columns (5) and (6) uses fractional logit and Poisson Pseudo-Maximum Likelihood (PPML) using Silva and Tenreyro (2006), to deal with the problem of zeros. Since, our dependent variable is a ratio, therefore including zeros when estimating with OLS may produce biased estimates. We understand that dealing with zeroes is a huge issue and we use these two methods to control for such issues. Both the methods estimate the coefficients in terms of percentage changes and the dependent variable does not need to follow a Poisson distribution or be integer-valued (it can be continuous). We estimate the standard errors using Eicker-White robust covariance matrix estimator. As the point estimates demonstrate, the 2002 IPR reform induces significant increase in the relative share of managerial compensation.

5.5 Firm Characteristics

Having identified the effect, and tested for other competing channels, let us now examine the issue by dividing the dataset according to various firm characteristics. We do this to identify which set of firms drive the main result. **Table 7** presents the results. We start by dividing the sample of firms into exporters and non-exporters. The coefficients of $IPR_{02} \times HighTech$ and its interaction with exporter and non-exporter dummy in column (1) show us that the entire effect is driven by the exporting firms. In case of non-exporting firms, interestingly the effect is opposite. This gives support to the idea that exporting and non-exporting firms behave differently to certain exogenous shock and exporting firms tend to innovate more than the non-exporters. Next, we divide firms by ownership – domestic and foreign. Results appear in

column (2). The interaction effect of $IPR_{02} \times HighTech$ with the respective ownership dummies is significant for both domestic and foreign firms, with the effect double in case of the foreign firms. In other words, incentives to innovate are higher for foreign than domestic high-tech firms.

Lastly, we turn to test firms by end use. We follow Nouroz (2001) and use the input-output classifications to categorize firms by the end use of their products. The division is thus made to five groups: consumer non-durables, intermediates, basic, capital, and consumer durables. However, we combine consumer durables and non-durables into final goods and intermediates, basic and capital goods into intermediate goods category and interact each of these two dummies with our variable of interest in column (3). The coefficients show us that that the main result is a feature of firms that belong to both final and intermediate goods category. This indicates that the incentives to innovation have led the firms to produce or innovate more of final goods than intermediate goods.

5.6 Organizational Design

Teece (1994) points out that adoption of new technologies by a firm leads to implementation of new organizational forms. In a similar context, Little (1985, p.14) also highlights that "our work among innovative companies indicates that the management decision on how to organize for innovation is critical". We build on our benchmark results that higher incentives to innovation leads to increase in demand for managers, more for high-tech firms to understand how the 2002 IPR reform affects the internal design between these two categories of firms. We build on the results from **Table 3**, where our estimates suggest that IPR reform of 2002 significantly increases the relative demand for managers recruited in a firm, which is a high-tech firm. We understand that recruitment of new managers in a firm can change its internal design, realizing this we hereafter examine the various aspects of the organizational structure of a firm. Results of the effect of IPR reform on the organizational design of a firm appear in **Table 8**.

An organization can change either horizontally or vertically. A horizontal expansion refers to the addition of new divisions with similar managerial and non-managerial layering, whereas a vertical expansion refers to the addition of vertical hierarchical layers, following the definition of Garicano (2000), such as extra managerial roles between the CEO and the non-managerial workers. We start by considering the former. Ideally, we should use the number of

divisions within a firm as a direct measure for horizontal dimension of a firm. Since, this is not available in our data, we measure this indirectly through the number of new varieties produced. Assuming that different products require distinct same-level divisions, we use this proxy for horizontal size. Columns (1) and (2) report the results. We find significant effect of the $IPR_{02} \times HighTech$ on the number of new varieties produced. This result highlights two aspects: higher incentives to innovation (i) forces a high-tech firm to expand horizontally significantly more than a low-tech, and (ii) influences a high-tech firm to produce more new varieties than its counterpart.

Next, we study vertical change. To understand the vertical expansion of a firm, we construct a dummy that measures the number of layers in the organization. As was described earlier, the data enables us to consider three types of workers: non-managers, directors, and executives (the latter two representing the aggregated managerial layer). Since executives are managers with executive powers, and hence make the top management of a firm, we consider it as being the highest layer. Thus, this dummy is assigned a number between 1 and 3. PROWESS provides the names of the directors and the executive directors of the firms for each year. We count the number of directors and executive directors for each firm and assign the dummy 1 if the number of managers at each level is greater than zero. Unlike the names or the number of managers, PROWESS provides number for total employees very sporadically (as highlighted before). We therefore use the non-managerial compensation data to indicate the non-managerial layer; but we use only the ones which have positive values (assuming that a firm cannot have any non-managers). In addition, we also assumed that a firm will always have a managerial level. So, the dummy for vertical layers will always take two; 3 is assigned when where there are all the three layers present. With this, we plan to test whether there is an additional management layer between the high-tech and the low-tech firms that has been implemented because of the 2002 IPR reform.[37]

Columns (3) and (4) considers the effect of the 2002 IPR reform on the vertical dimension of a firm. Our coefficient of interest points out that the imposition of patent rights significantly enhances its vertical layers. In other words, the 2002 IPR reform significantly increases the differences in hierarchical structure between high-tech and low-tech firms. Combining this with the previous result, it says that the IPR reform is expanding a firm both horizontally and vertically, much like a tree. Realizing this, we carry out an exercise in columns (5) and (6) to

[37] As mentioned, due to data limitations we treat each level as one aggregate layer, yet this does not preclude having further sub-layers within the managerial ones, which our data does not capture.

see which dimension (horizontal or vertical) of a firm is significantly correlated with the demand for managers. This will give us an idea about how a high-tech firm is choosing its strategies to reorganize because of higher incentives to innovation. To carry out such an exercise, we employ a horse-race specification between the two and interact the indicator for horizontal dimension (the number of new varieties produced) and vertical layers (number of hierarchies) with $IPR_{02} \times HighTech$. Our conditional correlates point out that the increase in the demand for managers are due to the adding of new products by a firm rather than adding a vertical layer. This result suggests that higher incentives to innovation, results in a firm to innovate new products for which new divisions are being created and subsequently demand for managers increased.

6 Conclusion

This study is one of the first such that links the literature on innovation economics with organizational economics, employing stronger patent reform as an instrument for incentives to innovation to demonstrate the causal effect of the former on the latter. We investigate whether there is any effect of an IPR reform on the organizational dynamics of firms or firm structure. And, in doing so, we argue that the effect will be different for high-tech vis-à-vis low-tech firms (as in classified before the reform). We argue that stronger patent rights due to an IPR reform will induce a high-tech firm to innovate more and this will create the demand for managers as innovation will give rise to a new set of non-routine problems. Since, managerial skill is important to solve new set of problems, firms will demand more managers; more in case of high-tech than low-tech firms, and this will eventually lead to a change in the organizational design.

We test this argument by utilizing a quasi-natural experiment from India in terms of utilizing a IPR reform implemented in 2002; the reform changed the IPR regime in India from process to product patents with other important characteristics. We find a remarkably robust, persistent and economically meaningful positive effect of the 2002 IPR reform on the relative demand for managers; with the difference in the effect between high-tech and low-tech firms being significant and positive. In other words, the 2002 IPR reform led to an increase in demand more for managers, higher in case of high-tech firms. Our benchmark estimations indicate that the 2002 IPR reform led to an increase in the share of managerial compensation of an average high-tech firm as compared to low-tech firm by 1.6.-1.7%. This effect is robust to various controls, specifications, estimation techniques and time periods. In addition, we identify the

subset of firms that drive the result are exporters, both domestic and foreign and belong to both consumer non-durable and intermediate goods industries. Next, we find that higher incentives to innovation increases the within-firm wage gap but between top managers and the other employees, whereas it increases both within- and across-firm incentives gap for middle managers. Lastly, we find that change in intellectual property rights regime expands a firm both horizontally and vertically, but it is the horizontal dimension of a firm which creates the demand for managers.

Put together, these results provide suggestive evidence for a quality upgrading mechanism. Imposition of patent rights induces high-tech firms (compared to low-techs) to innovate more or use new technologies in their production function and this increases the demand for managers. In doing so, patent rights also increase the gap between high-tech and low-tech firms in terms of adoption of new technologies driving in the end both between- and within-firm wage inequality between managers and others both at the extensive and intensive margin.

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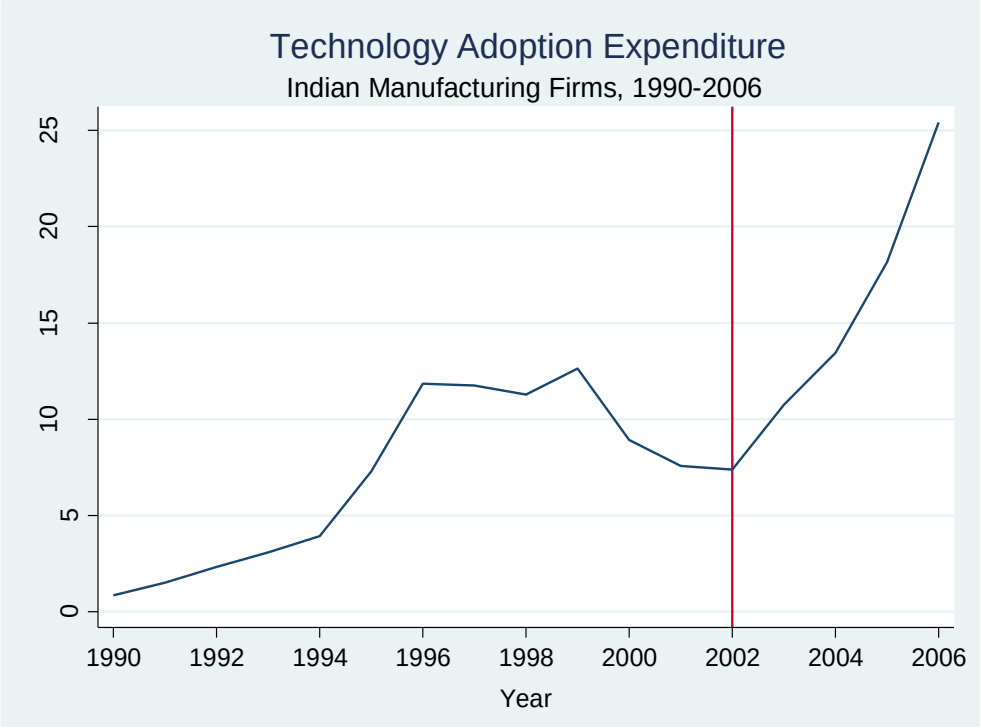

Figure 1: Technology Adoption Expenditure: Indian Manufacturing Firms, 1990-2006

Notes: Figure presents the average technology adoption (sum of R&D expenditure, Technology Transfer, Import of Capital Goods and ITES expenditure) for manufacturing firms in India, 1990-2006

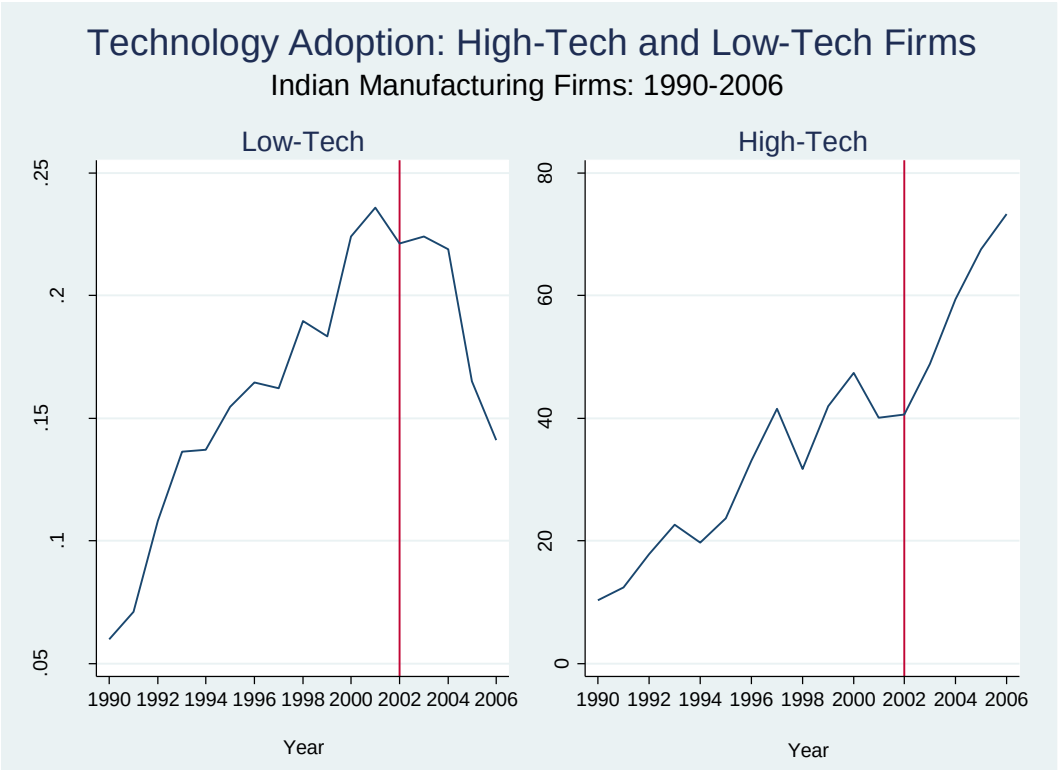

Figure 2: Technology Adoption: High-Tech and Low-Tech Firms, 1990-2006

Notes: Figure presents the average technology adoption (sum of R&D expenditure, Technology Transfer, Import of Capital Goods and ITES expenditure) for manufacturing firms in India, 1990-2006

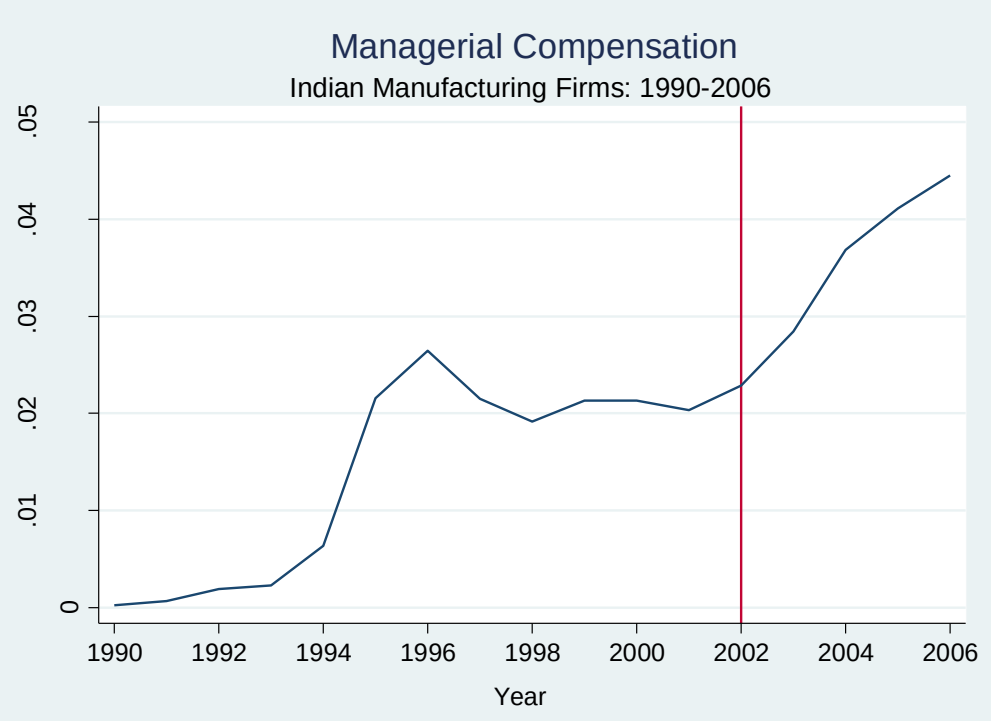

Figure 3: Managerial Compensation: Indian Manufacturing Firms, 1990-2006

Notes: Figure presents the average share of managerial expenditure in total labour compensation for manufacturing firms in India, 1990-2006

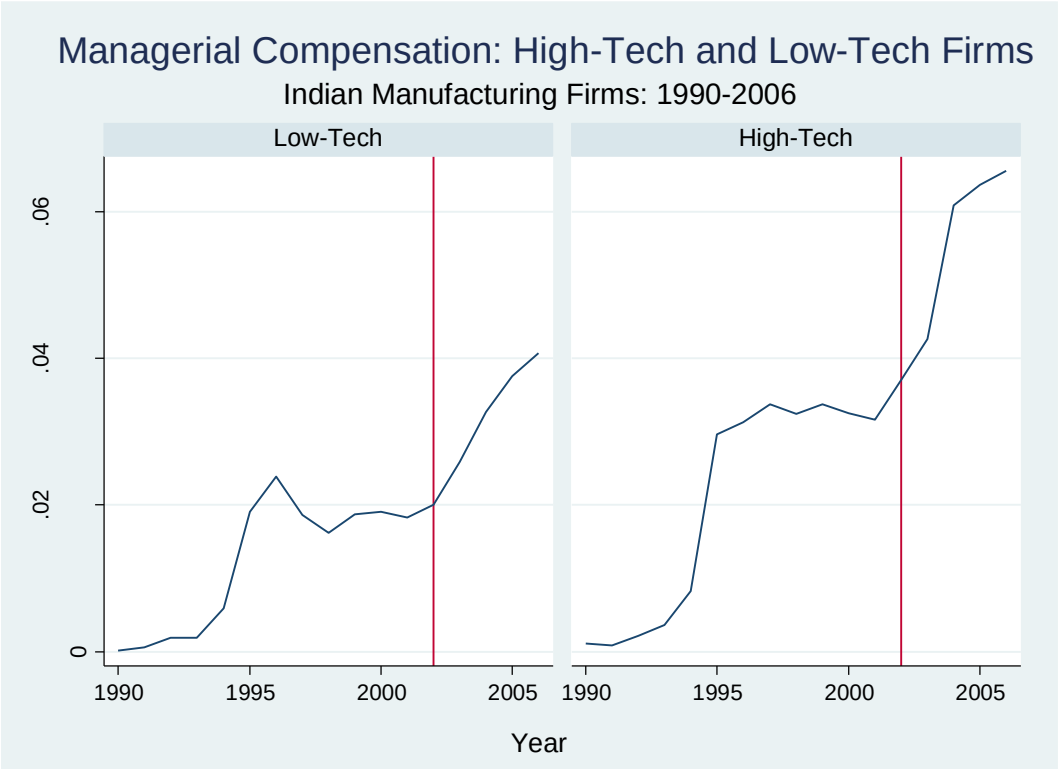

Figure 4: Managerial Compensation: High-Tech and Low-Tech Firms, 1990-2006

Notes: Figure presents the average share of managerial expenditure in total labour compensation for manufacturing firms in India, 1990-2006

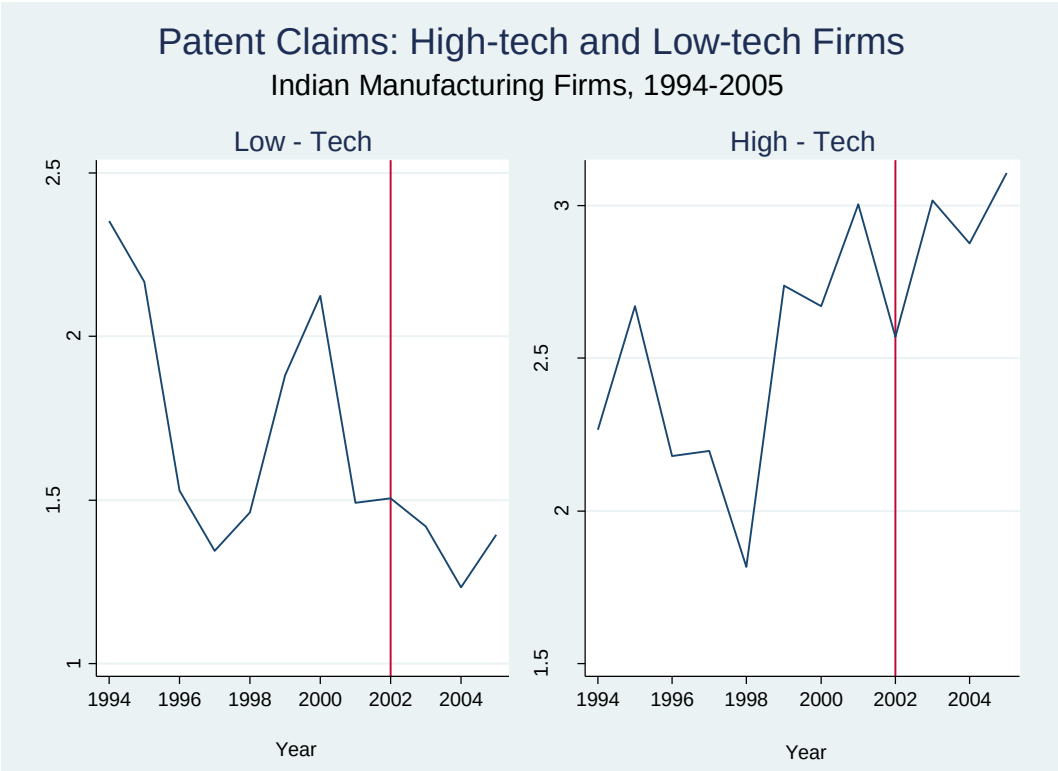

Figure 5: Patent Claims: High-Tech and Low-Tech Firms, 1990-2006

Notes: Figure presents the average patent claims filed with the Indian Patent Office for manufacturing firms in India, 1990-2006

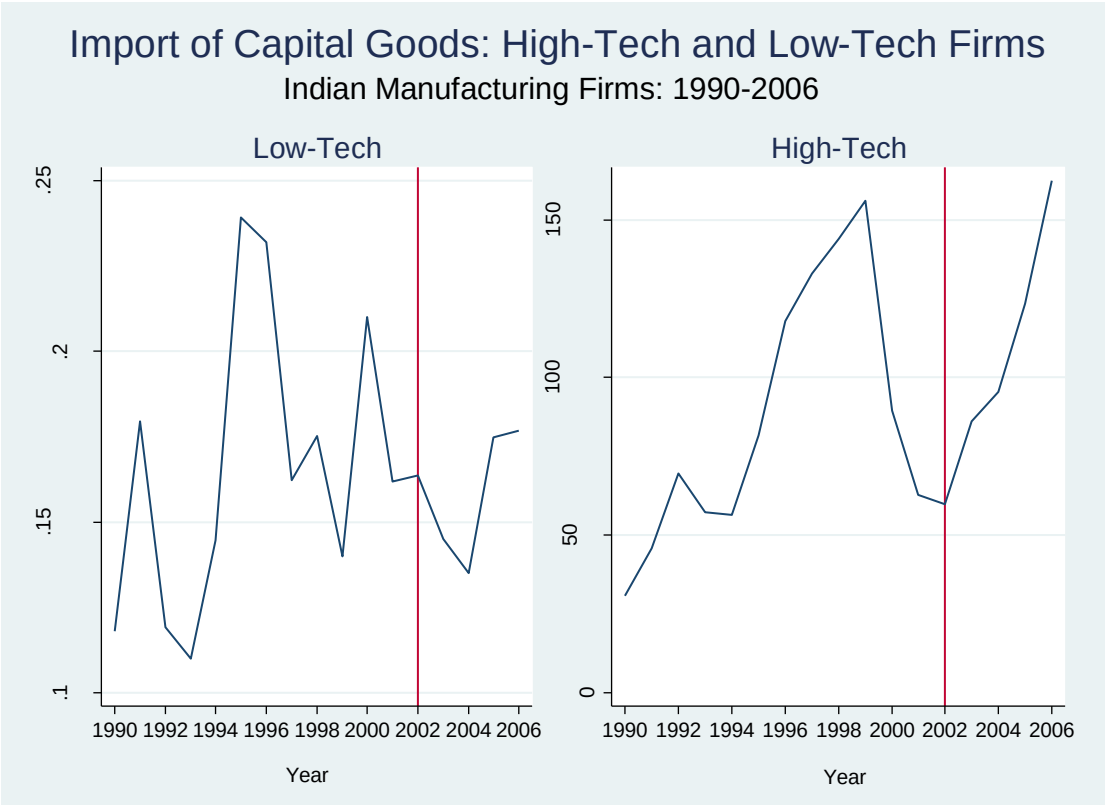

Figure 6: Import of Capital Goods: High-Tech and Low-Tech firms, 1990-2006

Notes: Figure presents the average import of capital goods for manufacturing firms in India, 1990-2006

	Mean	Median	Std. Dev.	Min	Max
Panel A: Organizational Variables - Dependent Variables					
Managerial Compensation /Total Compensation	0.02	0.003	0.08	0	1
Layers	1.61	2	0.62	1	3
Product Scope	4.49	3	4.45	1	86
Managers' Compensation	1.31	0.2	169.65	0	66315.1
Non-Managers' Compensation	95.53	14.4	631.83	0	47619.5
Managers' Wages	0.63	0.04	147.11	0	57590.5
Non-Managers' Wages	93.73	13.6	624.18	0	39720.6
Managers' Bonuses	0.12	0	3.55	0	8724.6
Non-Managers' Bonuses	4.61	0	66.26	0	9053.9
Panel B: Firm/Industry-level Determinants - Explanatory Variables					
Capital Employed	1049.62	128.1	10599.64	2	891409
Assets	1540.61	192.4	15736.8	1.4	1200000
Input Tariffs	69.95	46.95	49.17	17.34	202.02
Output Tariffs	72.71	49.29	56.72	14.5	298.07
Skill Intensity	0.26	0.25	0.07	0.04	0.71
Productivity	0.84	0.58	2.19	0.02	4.96
Factories	3920.77	3315	3037.77	15	14486

Notes: Annual data at the firm level, covering the period of 1990-2006. Monetary values are in real INR Millions. 'Managerial Compensation/Total Compensation' is the share of managerial compensation in total labour compensation. 'Product Scope' is the number of products manufactured by a firm in a single year. 'Layers' is the number of vertical layers. Compensation is the sum of wages and bonuses. Regarding managers, it is the sum of Executives (top management) and Directors (middle management), whereas for Non-managers, it is all the other employees. 'Top Managers' is the number of executive managers. 'Capital Employed' is the amount of capital employed by a firm. 'Assets' is the total assets of a firm. 'Tariffs (input and output)' are at the 4-digit NIC 2004. 'Skill Intensity' is the ratio of non-production workers to total employees at the 3-digit NIC 2004. 'Productivity' is a firm level measure, estimated following the Levinsohn and Petrin (2003) methodology. 'Factories' is the number of factories at 3-digit NIC 2004.

Table 1: Summary Statistics

					Pre-Reform Characteristics			
	Managerial Compensation/ Total Compensation				Managerial Compensation/ Total Compensation	Share of Skilled Workers	Average Factory Size	$IPR_{02} \times Hightech$
	1999 Patent Reform			Endogeneity of 2002 Reform				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IPR_{02}	0.030***	0.027***	0.028***	0.006*				
	(0.005)	(0.004)	(0.004)	(0.003)				
IPR_{99}	–0.005	–0.002	–0.001					
	(0.007)	(0.007)	(0.008)					
$IPR_{02} \times HighTech$	0.005**	0.007***	0.006***	0.006***	–0.0001	0.0001	–0.001	
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.008)	
$IPR_{99} \times HighTech$	0.001							
	(0.002)							
$IPR_{99} \times HighTech_{98}$		–0.006*	–0.006*					
		(0.003)	(0.003)					
$IPR_{02} \times HighTech_{98}$			0.001					
			(0.003)					
$(Mcomp/Tcomp)_{t-2}$								0.005
								(0.012)
$Capital\ Employed_{t-1}$	0.005***	0.006***	0.005***	0.005***	0.005***	0.005***	0.005***	0.017***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.005)
$IPR_{02}\ (t-4)$				–0.009				
				(0.007)				
$IPR_{02}\ (t-3)$				0.005				
				(0.005)				
$IPR_{02}\ (t-2)$				0.001				
				(0.003)				
$IPR_{02}\ (t+1)$				0.011***				
				(0.003)				
$IPR_{02}\ (t+2)$				0.016***				
				(0.004)				
$IPR_{02}\ (t+3)$				0.021***				
				(0.005)				
$IPR_{02}\ (t+4)$				0.024***				
				(0.006)				
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.50	0.50	0.50	0.50	0.41	0.95	0.95	0.48
N	62677	62677	62677	62677	56086	56081	56081	56086
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE(2-digit)*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1) – (4) use share of managerial compensation in total compensation as the dependent variable. Columns (5), (6) and (7) uses the share of managerial compensation, share of skilled workers and average factor size at period $(t-2)$ and column (8) uses '$IPR_{02} \times HighTech$' as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. 'IPR_{99}' is a dummy variable, which takes a value 1 if year is greater than equal to 1999. '$HighTech_{98}$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 1998, is greater than the median of the industry, to which the firm belongs. '$(Mcomp/Tcomp)_{t-2}$' is the share of managerial compensation at $(t-2)$ period. '$IPR_{02}\ (t-4)$' is a dummy which is equal to 1 for all years that predate the reform by 4 or more years and is equal to 0 in all other years. '$IPR_{02}\ (t+4)$' dummy is equal to 1 for all years at least four years after reform and 0 during other years. The other reform dummies are equal to 1 in specific years relative to reform and 0 during other years. There is no dummy for the year immediately prior to the reform (i.e., year $t-1$); the coefficients on the reform dummies provide estimates relative to that year. . '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. All the regressions include the individual terms of the double interaction terms. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 2: Endogeneity of The Patents (Amendment), Act, 2002

	Total No. of Managers		Managerial Compensation		Managerial Compensation/Total Compensation								Average Managerial Compensation	
										ATT	Middle Managers	Top Managers		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
IPR_{02}	0.104	–0.046	0.319***	0.371***	0.019***	0.013***	0.016***	0.008	–0.016	Yes	0.011***	0.0003	0.431***	0.596***
	(0.078)	(0.129)	(0.039)	(0.043)	(0.003)	(0.004)	(0.005)	(0.009)	(0.010)		(0.002)	(0.005)	(0.121)	(0.162)
$IPR_{02} \times HighTech$	0.069**	0.063**	0.714***	0.712***	0.017***	0.016**	0.017***	0.017***	0.017***	0.017***	0.005***	0.012***	0.460***	0.457***
	(0.030)	(0.032)	(0.023)	(0.023)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.001)	(0.002)	(0.051)	(0.051)
$Capital\ Employed_{t-1}$	0.090**	0.084**	0.088***	0.073***	0.004**	0.004**	0.005***	0.005***	0.005***	Yes	0.002***	0.003	0.122**	0.096*
	(0.039)	(0.041)	(0.012)	(0.011)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)		(0.001)	(0.002)	(0.056)	(0.051)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.58	0.61	0.74	0.74	0.49	0.49	0.49	0.49	0.50	n/a	0.35	0.47	0.78	0.80
N	5935	5935	57461	57461	57461	57461	57461	57461	57461	68016	42084	42084	5935	5935
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Year FE	No	No	No	No	Yes	No	No	No	No	No	Yes	Yes	No	No
Industry FE(5-digit)*Year Trend	Yes	No	Yes	No	No	Yes	No	No	No	Yes	Yes	No	Yes	No
Industry FE (2-digit)*Year FE	No	Yes	No	Yes	No	No	Yes	No	No	No	No	Yes	No	Yes
Industry FE(3-digit)*Year FE	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No
Industry FE(4-digit)*Year FE	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No

Notes: Columns (1) – (3), (4) – (5), (6) – (11) and (12) – (13) use total number of managers, total mangerial compensation, share of managerial compensation in total compensation and average managerial compensation as the dependent variable, respectively. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 3: Intellectual Property Regimes and Firm Organization: Benchmark Results

	Managerial Wages /Total Wages			Managerial Incentives /Total Incentives		
	All Managers	Middle Managers	Top Managers	All Managers	Middle Managers	Top Managers
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.017***	–0.003	0.020***	–0.009	0.025**	–0.034*
	(0.006)	(0.004)	(0.004)	(0.023)	(0.011)	(0.020)
$IPR_{02} \times HighTech$	–0.002	–0.001	–0.003***	0.014**	0.007***	0.007
	(0.002)	(0.001)	(0.001)	(0.006)	(0.002)	(0.006)
$Capital\ Employed_{t-1}$	0.004**	0.002*	0.002	0.006	0.004**	0.002
	(0.002)	(0.001)	(0.002)	(0.005)	(0.002)	(0.004)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.61	0.51	0.67	0.77	0.50	0.80
N	22769	22769	22769	24259	24259	24259
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE(5-digit)*Year Trend	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1) – (3) and (4) – (6) use total managerial wages and ratio of managerial to total wages and ratio of managerial incentives to total incentives of a firm as the dependent variable, respectively. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 4: Intellectual Property Regimes and Firm Organization: Disaggregating the Compensation – Wage and Incentive Component

	Managerial Compensation/Total Compensation									
	Trade Reform	Domestic Market Competition	Export Market Competition	Skill Intensity	Manag Tech	Factories	TFP	Labour Regulation	Family Firm	Insider Board
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IPR_{02}	0.013***	0.015***	0.015***	0.015***	0.015***	0.015***	0.012**	0.024**	0.009**	0.003
	(0.004)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)	(0.006)	(0.011)	(0.004)	(0.028)
$IPR_{02} \times HighTech$	0.010***	0.015***	0.022***	0.007***	0.007***	0.007***	0.007***	0.016***	0.016***	0.003
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)
$Input\ Tariffs_{t-1} \times HighTech$	–0.003									
	(0.008)									
$Output\ Tariffs_{t-1} \times HighTech$	0.006									
	(0.008)									
$MC_{CH}^{IN} \times HighTech$		0.0002								
		(0.0002)								
$EX_{US}^{IN} \times HighTech$			–0.0004*							
			(0.0002)							
$Skill\ Intensity_{t-1} \times HighTech$				0.010***						
				(0.002)						
$MangTech_{t-1} \times HighTech$					0.016***					
					(0.003)					
$Factories_{t-1} \times HighTech$						0.002***				
						(0.0002)				
$TFP_{t-1} \times HighTech$							0.009**			
							(0.004)			
$IPR_{02} \times HighTech \times FamFirm_i$									–0.0003	
									(0.0002)	
$IPR_{02} \times HighTech \times NonIndDire_i$										–0.006
										(0.007)
$Capital\ Employed_{t-1}$	0.004**	0.004**	0.005**	0.004**	0.004**	0.004**	0.007***	0.004**	0.004**	0.008
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.008)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.49	0.49	0.49	0.49	0.49	0.49	0.70	0.51	0.51	0.87
N	57461	52014	56971	57456	56210	57456	26264	52391	52391	4834
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE(5-digit)*Year Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State FE*Year FE	No	No	No	No	No	No	No	Yes	No	No

Notes: Columns (1) – (10) use share of managerial compensation in total compensation as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. '$Input\ Tariffs_{t-1}$' and '$Output\ Tariffs_{t-1}$' are input and output tariffs at 2004 NIC (National Industrial Classification) 4-digit level, respectively. 'MC_{CH}^{IN}' is the index of Chinese import competition. 'EX_{US}^{IN}' is an index of export market competition. '$Skill\ Intensity$' is defined as the ratio of non-production workers to total employees. This is at 3-digit level NIC 2004. '$MangTech$' is an index of Management Quality at 2004 NIC 2-digit level. It has been sourced from Bloom and Van Reenen (2010). '$Factories$' is the number of factories at 3-digit level NIC 2004. 'TFP' is total factor productivity at firm level estimated using Levinshon and Petrin (2003). '$FamFirm_i$' is an indicator for family firm constructed based on the percentage of shares held by the Hindu undivided-family as promoters in 2007. '$NonIndDire_i$' is the number of non-independent directors within the Board of Directors of a firm. It is a indicator for poor governance settings. '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. All the regressions include the individual terms of the double interaction terms. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 5: Intellectual Property Regimes and Firm Organization: Testing for Other Competing Channels

	Managerial Compensation/Total Compensation					
	Time Period: 1990-2005	Industry -level	Only Pharma	Drop Firms > 90th Perecentile	Fractional Logit	PPML
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.043***	–0.028	0.004	0.039***	3.378***	–0.264***
	(0.009)	(0.018)	(0.005)`	(0.009)	(0.840)	(0.029)
$IPR_{02} \times HighTech$	0.005**	0.007**	0.006	0.006***	0.126***	0.083***
	(0.002)	(0.003)	(0.006)	(0.002)	(0.029)	(0.027)
$Capital\ Employed_{t-1}$	0.005***	0.001	0.005		0.540***	0.563***
	(0.002)	(0.003)	(0.006)		(0.040)	(0.035)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.50	0.60	0.50	0.50	NA	0.04
N	57339	1742	8880	62674	62677	62677
Firm FE	Yes	No	Yes	Yes	Yes	No
Industry FE	No	Yes	No	No	No	No
Industry FE(5-digit)*Year Trend	No	Yes	Yes	No	No	Yes
Industry FE(2-digit)*Year FE	Yes	No	No	Yes	Yes	No

Notes: Columns (1) – (6) use share of managerial compensation in total compensation as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. All the regressions include the individual terms of the double interaction terms. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 6: Intellectual Property Regimes and Firm Organization: Robustness Checks

	Managerial Compensation/ Total Compensation		
	Export Orientation	Ownership	End Use
	(1)	(2)	(3)
$IPR_{02} \times HighTech \times Exporter$	0.006***		
	(0.002)		
$IPR_{02} \times HighTech \times Non - Exporter$	–0.020**		
	(0.008)		
$IPR_{02} \times HighTech \times Domestic$		0.007**	
		(0.003)	
$IPR_{02} \times HighTech \times Foreign$		0.014**	
		(0.006)	
$IPR_{02} \times HighTech \times Intermediate$			0.006*
			(0.004)
$IPR_{02} \times HighTech \times Final$			0.009***
			(0.003)
$Capital\ Employed_{t-1}$	0.004**	0.005***	0.005**
	(0.002)	(0.002)	(0.002)
Firm Controls	Yes	Yes	Yes
R-Square	0.49	0.49	0.49
N	57461	57461	57461
Firm FE	Yes	Yes	Yes
Industry FE (2-digit)*Year FE	Yes	Yes	Yes

Notes: Columns (1) – (3) use share of managerial compensation in total compensation as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 7: Intellectual Property Regimes and Firm Organization: Firm and Industry Characteristics

	Organizational Design					
	Horizontal Expansion		Vertical Expansion			
	Product Scope		Management Layers		Managerial Compensation/ Total Compensation	
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	–0.048	0.194**	0.079***	0.100***		
	(0.033)	(0.088)	(0.014)	(0.024)		
$IPR_{02} \times HighTech$	0.073***	0.065***	0.157***	0.160***		
	(0.017)	(0.016)	(0.007)	(0.007)		
$IPR_{02} \times HighTech \times Layers$					–0.009	–0.008
					(0.009)	(0.009)
$IPR_{02} \times HighTech \times Productscope$					0.007***	0.007***
					(0.002)	(0.002)
$Capital\ Employed_{t-1}$	0.036***	0.034***	0.039***	0.035***	0.002	0.003*
	(0.012)	(0.011)	(0.007)	(0.007)	(0.002)	(0.002)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.72	0.72	0.50	0.50	0.52	0.53
N	57461	56985	57461	57461	57461	57461
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	Yes	No	Yes	No
Industry FE (5-digit)*Year Trend	Yes	No	Yes	No	Yes	No
Industry FE (2-digit)*Year FE	No	Yes	No	Yes	No	Yes

Notes: Columns (1) – (2) use natural logarithm of new product varieties produced. Columns (3) – (4) exploit number of management layers of a firm as the dependent variable. Columns (5) – (6) use share of managerial compensation in total compensation as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 8: Intellectual Property Regimes and Firm Organization: Organizational Design

Appendix

Appendix A Data

We use an annual-based panel of Indian firms that covers up to 8,000+ firms, across 108 industries within the manufacturing sector, over the period of 1990-2006 (with the exception of specific cases, where specified so). Unless otherwise specified, variables are based on data from the PROWESS database of the Centre for Monitoring Indian Economy (CMIE). All monetary-based variables measured in millions of Rupees, deflated to 2005 using the industry-specific Wholesale Price Index (derived from Allcott et al., 2014). All industry level cases are based on the 2004 National Industrial Classification (NIC).

Variable definitions

1. **Managerial compensation/Total compensation**: Share of managerial compensation in total labour compensation; compensation defined as the sum of all salaries, and additional bonuses.
2. **Total Managers**: Total number of managers in a firm. This is a sum of total number of managers at the top and middle management level.
3. **Average Managerial Compensation**: Total managerial compensation divided by total number of managers.
4. **Managerial wage/Total wage**: Share of managerial wage in total wage of a firm.
5. **Managerial incentives/Total incentives**: Share of incentives or bonuses in total incentives of a firm. Incentives is a sum of bonuses or perquisites, commission, contribution to pension, contribution to provident fund.
6. $\boldsymbol{HighTech}$: It takes a value 1 if the average of R&D expenditure, royalty payments for technical knowhow (technology transfer), import of capital goods, and expenditure towards information technology enabled services is greater than the median of the industry average, to which the firm belongs and zero otherwise.
7. $\boldsymbol{IPR_{02}}$: It takes a value 1 if year is greater than equal to 2002.
8. **Horizontal Expansion or Product scope**: The number of different varieties of product produced by a firm.
9. **Vertical Expansion or Management Layers**: The number of vertical layers – 1, 2 or 3. We assume a firm to have 2 layers throughout – one management layer and non-managerial layer.
10. **Capital employed**: Total amount of capital employed by a firm.
11. **Assets**: Total assets of a firm. It is an indicator of size.
12. **Age**: Age of a firm in years.
13. **Ownership**: It indicates whether a firm is domestic-owned or foreign-owned.
14. **Input/output tariffs**: Input/output tariffs at the 4-digit industry level, obtained from Ahsan and Mitra (2014) for the period of 1990-2003, with the balance collected from Chakraborty and Raveh (2016).
15. $\boldsymbol{MC_{CH}^{IN}}$: Share of Chinese imports in total imports of India. It is a measure of import competition.

16. $\boldsymbol{EX_{US}^{IN}}$: Share of India's exports to the US. It is a measure of export market competition.
17. **Skill intensity**: The 3-digit industry level ratio of non-production workers to all employees, obtained from the Indian Annual Survey of Industries (2001-2006) and from Ghosh (2014) (1990-2000).
18. **Management technology**: The 4-digit industry level management quality score in 2004, obtained from Bloom and Van Reenen (2010); the score is between 1 and 5, with 5 denoting the highest quality.
19. **Factories**: The 3-digit industry level number of factories/plants.
20. **Productivity**: Total Factor Productivity (TFP) at the firm-level is computed using the Levinsohn and Petrin (2003) methodology.
21. **Exporter/Non-Exporter**: It takes a value 1 if a firm's export earning is greater than zero and 0 otherwise.
22. **Intermediate/Final goods**: These goods are classified according to the I-O table by end-use. The intermediate goods category includes intermediates, capital and basic goods, whereas the final goods category includes consumer durable and consumer non-durable.

Appendix B

Firm Name	Executive Remuneration		Director's Remuneration		Number of Executives	
	PROWESS	Annual Report	PROWESS	Annual Report	PROWESS	Annual Report
	(1)	(2)	(3)	(4)	(5)	(6)
Tecpro Systems	199.4	199.4	0.4	0.4	2	2
Jain Irrigation Systems	249.5	249	5.5	5.5	4	4
Bharat Forge	210.9	201.9	12.2	9.4	1	1
Crompton Greaves	208.6	120	95	94.9	3	3
Shree Cement	208	207.9	7.3	6.7	2	2
Bajaj Auto	216.4	216.4	9.8	9.3	3	3
Piramal Enterprises	239.4	239.5	11	11.2	1	1
Lupin	250.3	244.1	14	14.1	2	2
Apollo Tyres	246.7	246.7	10.8	10.8	2	2
Dr. Reddy's Laboratories	281.7	281.8	21	22	3	3
J S W Steel	295.1	280.4	9.8	10.1	4	4
Divi's Laboratories	309.1	315.7	0.8	0.8	1	1
Hindalco Industries	313.1	313.1	140.5	140.5	2	2
Cadial Healthcare	350	350	5	4.7	2	2
Reliance Industries	406.7	406.7	18.6	18.9	1	1
Grasim Industries	499.8	499.8	110.9	110.9	1	1
Jindal Steel and Power	789.3	789.9	0.6	0.6	4	4
Hero Motocorp	1032.4	1032.4	7	7.2	3	3

Notes: Columns (1) – (4) present comparisons of compensation figures reported in PROWESS and Annual reports for randomly selected 20 firms in 2011.Figures are in Millions of Rupees. In case of executives and directors, the correlation between the two is 0.99. Columns (5) and (6) compares the number of executives reported in PROWESS and Annual reports for randomly selected 20 firms in 2011. The correlation between the two is 1.

Table B.1: Comparison of Compensation and Number of Executives – PROWESS and Annual Reports

	Mean	Median	Std. Deviation	Min	Max
Panel A: Firms with Reported Managers' Compensation					
Innovation intensity	0.11	0.02	12.78	0	2163
Capital Employed/GVA	8.23	1.74	142.78	0	16789
Panel B: Firms with no Reported Managers' Compensation					
Innovation intensity	0.003	0	0.27	0	89.85
Capital Employed/GVA	2.17	0	43.67	0	7227

Notes: Panel A (B) covers firms that reported positive (zero) managerial compensation. 'Innovation intensity' is the GVA share of R&D expenditure and royalty payments for technical knowhow. 'GVA' is gross value added, defined as total sales minus total raw material expenditure. 'Capital Employed' is the amount of capital employed. For further information on variables see data Appendix.

Table B.2: Firms with Managerial Compensation vs. Firms without Managerial Compensation

	Total Number of Non-Managers	Non-Managerial Compensation	Non-Managerial Compensation /Total Compensation	Average Non-Managerial Compensation	Non-Managerial Wage	Non-Managerial Incentives	Average Non-Managerial Wage	Average Non-Managerial Incentive
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	
IPR_{02}	0.487***	–0.109	0.065***	0.152	0.481***	–0.117	0.177*	0.011
	(0.101)	(0.087)	(0.021)	(0.099)	(0.066)	(0.092)	(0.093)	(0.030)
$IPR_{02} \times HighTech$	1.040***	0.314***	–0.019***	0.032	1.413***	0.127***	0.027	–0.003
	(0.097)	(0.016)	(0.003)	(0.025)	(0.038)	(0.021)	(0.019)	(0.004)
$Capital\ Employed_{t-1}$	0.020	0.105***	–0.011**	0.005	0.126***	0.118***	0.003	0.003
	(0.028)	(0.017)	(0.005)	(0199)	(0.028)	(0.035)	(0.017)	(0.006)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.54	0.94	0.62	0.82	0.75	0.66	0.85	0.85
N	42084	57461	57461	2082	57461	23170	2082	2082
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE(5-digit)*Year Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech$' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer, Import of Capital Goods and ITES before the year 2001, is greater than the median of the industry, to which the firm belongs. '$Capital\ Employed$' is the total amount of capital used by a firm at $t-1$ period. Firm controls include age, age squared of a firm and assets of a firm. We use 'Assets' as the size indicator. It is also used at $t-1$ period. Both 'Capital Employed' and 'Assets' are expressed in their natural logarithmic form. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table B.3: Intellectual Property Regimes and Firm Organization: Non-Managerial Dimension