Intellectual Property Regimes and Wage Inequality*

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December 2018

Abstract

We use The Patents (Amendment) Act, 2002 in India as a quasi-natural experiment to identify the causal effect of higher incentives for innovation on a firm's compensation structure. We find that stronger intellectual property (IP) protection has a sharper impact on technologically advanced firms, i.e., firms that were a-priori above the industry median in terms of technology adoption. While there is an overall increase in managers' share of compensation, this increase is about 1.6–2.2% more for high-tech firms. This difference can be attributed to a larger increase in performance pay for high-tech firms. The reform also leads to a significant reallocation of resources between firms. The high-tech firms started to produce more product varieties at higher quality and became more productive than the low-techs. Broadly, we demonstrate that stronger IP protection leads to an increase in both within-firm and between-firm wage inequality, with more robust evidence for between-firm inequality.

JEL classifications: D21, D23, L23, O1, O34

Keywords: Intellectual Property Regimes, Wage Inequality, High-tech and Low-tech firms, Managerial Compensation, Between-firm reallocation

*This paper was previously circulated as "Intellectual Property Rights and Firm Structure". This paper has significantly benefited from discussions with Samuel Asher, Pulapre Balakrishnan, Natarajan Balasubramanian, Richard Baldwin, Benjamin Balsmeier, Sanjay Banerji, Daniel Bennett, Nicolas Bloom, Guillermo Caruana, Sisir Debnath, Mercedes Delgado, Ravi Dharwadkar, Mukesh Eswaran, John Firth, Fabian Gaessler, Dietmar Harhoff, David Hsu, Olena Ivus, Ravi Jagannathan, Tarun Jain, Rajshri Jayaraman, Chad Jones, Brian Kovak, Tapas Kundu, Margaret Kyle, Anirban Mitra, Andreas Panagopoulos, Vishwanath Pingali, Ivan Png, Yi Qian, Daniel Rubinfeld, Juan-Pablo Rud, Kamal Saggi, Henry Sauermann, Jagadeesh Sivadasan, Andreas Stegmann, Neil Thompson, Andrew Toole, John Van Reenen, and Rosemarie Ziedonis as well as seminar participants at Indian Institute of Management, Calcutta; Indian Statistical Institute, Calcutta; Indian Statistical Institute, New Delhi; Institute of Management, Ahmedabad; Centre for Studies in Social Sciences, Calcutta; Indian School of Business, Hyderabad; Ashoka University; USPTO; CEMFI; Jawaharlal Nehru University; University of Birmingham; Royal Holloway University of London; ESMT Berlin; Max Planck Institute of Innovation and Competition, Munich; University of Crete; Syracuse University and conference participants at JIRICO 2016; 12th Annual Conference on Economic Growth and Development, New Delhi; 12th Annual European Policy for Intellectual Property Conference; 6th Annual Searle Center Research Roundtable on SSOs and Patents, Northwestern University; 1st World Bank-Bank of Italy conference on "Building Human Capital for 21st Century Jobs"; XXVIIth Annual Conference on Contemporary Issues in Development Economics. Chatterjee wishes to acknowledge ICICI Bank Chair in Strategic Management at IIM Ahmedabad and the National Fellow Program at Hoover Institution, Stanford University for supporting this research.

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1 Introduction

How does innovation affects wage inequality? We study how the imposition of stronger Intellectual Property Rights (IPR), brought about by a landmark legislation, the **The Patents (Amendment) Act, 2002,** affects various dimensions of the compensation structure of Indian manufacturing firms. Earlier, Indian firms could only patent new production processes, which meant that others could still produce the same product using a different process. This Act allowed firms to claim patents for new and differentiated products, thereby substantially strengthening property rights over innovation, providing stronger incentives to innovate. We study how a large cross section of Indian manufacturing firms responded to this Act in terms of changes in compensation structure. To the best of our knowledge, we believe that our work is the first to look at how a change in IPR affects wage inequality.[1]

We analyze firms' response to this exogenous change in IPR regime in two different dimensions of compensation structure: (i) relative demand for managers vis-a-vis non-managers measured as share of compensation, and (ii) extent of performance pay for managers. We find a sharp heterogeneity in firm's response to the IPR shock: the firms that were a-priori technologically advanced at the time of the reform had significantly larger increase in each of these two dimensions relative to the technologically backward firms. An important implication of our finding is that imposition of a stronger IP regime increases wage inequality between-firms.

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 implement a TRIPs-complaint IPR regime, but during this period there were several inconclusive rounds of discussion in the Indian parliament due to opposition from various sections of the political establishment (Reddy and Chandrashekaran, 2017). Eventually, in June 2002, the Indian parliament passed the second amendment to the 1970 Act known as The Patents (Amendment) Act, 2002 (Act 38 of 2002).[2] 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 under the ambit of patents and streamlined the process of patent grant. 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 (sum of R&D expenditure and technology transfer) by a large sample of Indian manufacturing firms. For an average Indian manufacturing firm, investments in technology trebled within 4 years after the imposition of the new patent law.

Our aim is to establish a causal link between innovation and wage inequality. A major contribution of our

[1] Kamal and Lovely (2013), which looks at the effect of China's WTO accession on formation of joint ventures, is the only other paper we find that comes closer to our work.

[2] 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.

work is to identify a suitable quasi-natural experiment which is a change in intellectual property rights (IPR) regime that enhances firms' future incentives to innovate. Innovation involves a whole range of activities that are intensive in managerial talent: research, conceptualization and development of new products, branding and marketing the product and so on. Innovation presents firms with more complex problems, and this raises the value of managers as problem-solvers (Garicano, 2000). On the other hand, a large body of evidence, both in management and economics, demonstrates that the compensation schemes or the type of workers a firm chooses is a crucial determinant of a firm's ability to innovate (Amabile, 1993 and 1996; Teece, 1994; Manso, 2011; Balasubramanian and Sivadasan, 2011; Azoulay et al., 2011). Therefore, under the new IPR regime, one would expect relative wages as well as demand for managers to increase across all firms.

However, the firms that had a-priori higher technological and knowledge capital had comparatively larger gains from investments in innovation either because they were more likely to win patent races or because of reduced marginal cost of additional investment. The increase in relative returns to managerial inputs would be higher in such firms, and they would would also have stronger incentives to make complementary changes in their organizational structure.[3] Thus, we expect the increase in wage inequality between managers and non-managers to be higher in technologically advanced firms. In order to see whether these hypotheses are true, we use The Patents (Amendment) Act, 2002 as the quasi-natural experiment to investigate the effects of the change in IPR regime in terms of demand for managers.

The empirical literature looking at managerial demand by firms is scarce due to limited data availability. We employ a firm-level panel dataset from the PROWESS database provided by the Centre for Monitoring of the Indian Economy (CMIE). The dataset contains direct measures of spending on several dimensions of technology adoption, namely R&D expenditure and royalty payments for technology transfer, allowing us to build a comprehensive and accurate measure of investment in technology. It also reports detailed labour compensation, divided into managerial and non-managerial, with the former divided into several management layers (Chakraborty and Raveh, 2018). In addition, the dataset provides exports, imports, capital employed and other important firm and industry characteristics. The panel format of the data enables us to have a dynamic specification in which technological investments and other firm decisions can potentially affect demand for managers.

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. We classify a firm as high-tech, if a firm's average expenditure on R&D and technology transfer between 1990-2001 as a share of GVA is greater than the median in the corresponding industry. **Table 1** compares high-tech and low-tech firms before and after the 2002 IP reform on various characteristics, such as technology adoption, managerial compensation, capital employed, trade (exports and imports) and sales. We calculate the mean share of these observable characteristics over the

[3] Aghion et al. (2017) finds that a positive export shock raises innovation more for more productive firms. We have a similar result where innovative effort is more likely to be successful for more productive firms.

gross value-added (GVA) of a firm. For an average high-tech and low-tech firm, the differences across these characteristics before the implementation of the Act were to the tune 1–30%; this increased to 30–300% after the reform.

Figure 2 plots technology adoption for our sample of Indian firms for the period 1990-2006[4] 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 does not show any such significant spike. **Figure 3** plots the average share of managerial compensation in total compensation for the high-tech and low-tech firms. We find that while there was an increasing trend in managers' share of compensation in both types of firms, the increase in the high-tech group was approximately double that of the low-tech firms. These two diagrams suggest a possible association between patent reform, technology adoption and demand for managers and paves the way to provide causal inferences.

In our analysis, we emphasize on two important questions: (a) how does imposition of stronger patent rights impact the demand for different kinds of workers (in our case managers and non-managers) differently through investments in technology?; and (b) how this change in relative demand is reflected between- and within-firms?

We investigate these questions by employing a differences-in-differences approach, treating the high-tech group of firms as the treatment group and the low-tech firms as the control group. This allows us to isolate the differential impact of the Patents Amendment Act of 2002 on the relative demand for managers for the high-tech and low-tech firms. We find a remarkably persistent statistically significant and economically meaningful positive effect of The Patents (Amendment) Act, 2002 on the relative demand for managers, both at the intensive and extensive margin. 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 1.6–2.2%. The effect is robust to various controls, specifications, estimation techniques and time-periods.

However, it is unclear from the above which type of firms is driving the result. In order to explore the finer details, we divide the firms into quintiles as well as deciles in terms of technology investments. We find two things: (a) below the median, there is no effect, and (b) entire effect of this increase in the demand for managers is driven only by firms between 60th–90th percentile (marginally big firms), with no effect on the biggest firms. Informally, we refer to this as the "snail-shaped" effect of the IP law on between-firm wage inequality. The "snail-shape" result reassures that the firms below the median (or the low-tech firms) act as the best possible control group in our main diff-in-diff specification. Additionally, we also change

[4] Our dataset runs till 2013. But, we choose to restrict our analysis upto 2006 for the following two important reasons: (a) 2008-09 financial crisis. This event may have adverse consequences on compensation across all types of workers and may alter our findings; (b) India got fully integrated to the WTO-TRIPs patent system by the end of 2005. Extending the data for longer time period after 2005 might have confunding effects of the 2002 Act and final implementation in 2005.

the definition of our high-tech and low-tech firms using a binary index of IP sensitivity based on 4-digit NAICS (North American Industrial Classification System) code in the US (based on patents, trademark or copyrights) as used by Delgado et al. (2013)[5]. Our benchmark result remains the same which tells us that the increase in wage inequality in the high-tech firms is indeed driven by the way the Act of 2002 brought the change in property rights over innovation.

The "snail-shape" also tells us that there is a competitive dimension among firms which in addition to manager-capital complementarity drives the demand for managers. To understand this, we provide a simple model in which firms with given capital stock compete for a patent. In the model, managers and capital stock are complementary inputs to innovation. Therefore, firms with very high capital stock have low incentive to hire managers as they are already ahead in competition and those with low capital stock have no incentive since they are too far behind. We show that equilibrium demand for managerial talent is non-monotonic in capital stock, and consistent with the "snail-shape" found in the data.

Our benchmark result depends on the crucial assumption that the 2002 Act estimates a causal effect of the change in the innovation policy on wage inequality. However, there could be other effects, such as globalization, IT capital, etc. that might be complementary to the policy change. To control for such events, we use a bunch of other factors, such as drop in tariffs, import competition, export market competition, skill intensity, management technology, productivity, investments in IT, labour regulation, etc. and interact with our high-tech dummy. Our estimates show that even though there are a number of complementary channels that are at work, such as skill intensity, IT capital, mangement technology, the benchmark result does not change.

Lastly, we find that the technologically advanced firms use sharper incentives to motivate managers as a result of the reform. 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.

There are at least two channels through which innovation policy affects compensation structure through technology adoption. First, stronger patent protection can lead firms to invest in exploring new avenues like product development, research activities, marketing activities for brand development, etc. (Teece, 1986, 1994). Second, existing processes are also pushed closer to the technological frontier through use of more

[5] We describe this in detail in Section 5.3.

R&D expenditure, 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. In other words, our findings suggest that stronger patent rights leads to an increase in inequality of two different kinds: (i) the technological gap between high-tech and low-tech firms increases; and (ii) both within- and between- firm wage inequality increases. Aghion et al. (2005) while investigating the relationship between competition and innovation highlights same kind of inequality, where the average technological distance between the technological-leaders and -laggards increases with competition.

The paper contributes to several strands of literature. First, we complement to the relatively new and growing literature on how different kinds of innovation activities (R&D adoption/patent filings) can induce inequality within-firms, across states, etc (Bøler, 2016; Aghion et al., 2018a; Aghion et al., 2018b; Aghion et al., 2018c; Kline et al., 2018). Aghion et al. (2018a) uses data (patent filings) on US states to show that top income inequality is (at least partly) driven by innovation. Bøler (2016) uses a R&D tax credit scheme in Norway to demonstrate 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. While our results are similar, we find that between-firm inequality plays a larger role than within-firm inequality in explaining the increase in relative demand for managers. Kline et al. (2018) analyzes how patent applications can induce inequality in worker compensation among U.S. firms. Aghion et al. (2018c) shows similar evidence for Finnish firms. We complement this literature by analyzing how wage inequality changes because of a shift in the innovation policy.

Second, we also add to the existing literature on how different kind of changes, such as technology adoption (Bresnahan et al., 2000; Galor and Moav, 2000), communication technology (Garicano, 2000, Garicano and Heaton, 2010), globalization (Guadalupe and Wulf, 2010; Caliendo and Rossi-Hansberg, 2012; Keller and Olney, 2017; Caliendo et al., 2017; Chakraborty and Raveh, 2018), etc. affects demand for managers/skilled workers and other firm organizational features. In a similar context, a significant portion of literature argues that some kind of technological adoption raises the employment shares or relative demand for skilled workers over unskilled workers (Caroli and Van Reenen, 2001) or managers over workers (Lee and Shin, 2017). However, as mentioned above all the studies establish a correlation, while we show a causal relation between innovation and relative demand for managers. In our case, this exogenous shock comes from an exogenous change in innovation policy.

Third, our finding that a change in IPR regime significantly reallocate resources across firms hint towards a capital-skill complementarity channel. It has a parallel in the literature on trade-induced skill-biased technical change (Acemoglu, 2003; Michaels et al., 2014; Autor et al., 2017), particularly in developing economies (Amiti and Cameron, 2012; Raveh and Reshef, 2016; 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) examines the impact of technology on employment and skill demand for the Indian manufacturing sector and demonstrates that adoption of new technology has increased the demand for high skilled workers. This finding is consistent with ours, as we show that higher technology adoption, due to change in innovation policy, leads to demand for more managers.

Fourth, we contribute to the debate on whether sharp incentives lead to greater innovative output. Holmstrom (1989) identifies the difficulties in motivating innovative effort. Teece (1994) and Amabile (1996) hold that sharp incentives may be inimical to innovation. Empirical work by Lerner and Wulf (2007) and Kline et al. (2017) finds that innovation is associated with long term (rather than short term) incentives. On the contrary, we uncover strong evidence that technologically-advanced firms provide sharper incentives as a result of the IPR shock. Such incentives are provided to the middle level managers (i.e., divisional heads and functional heads) who are typically responsible for new product development. [6]

Finally, the paper relates to the effect of IPR reform on innovative activities of countries, industries, firms and other industry/firm characteristics (see for example, Glass and Saggi (2002) on foreign direct investment and Ivus (2010) on high-tech exports). The effect of an IPR reform on innovation performance has been addressed at multiple levels: country (Park and Lippoldt, 2004; Chen and Puttitatun, 2005; Branstetter et al., 2006; Qian, 2007), 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. In addition, it also contributes to the literature on the effect of the specific 2002 IPR reform in India.

The paper is organized as follows. The next section lays out the details of the reform. We provide details about the data, in Section 3. The empirical strategy and exogeneity of the reform is discussed in Section 4. In Section 5, we report our results, showing the effect of higher incentives to innovation on demand for managers through higher technology adoption and how does it simultaneously affects other aspects of firm organization. We discuss the likely channels through which our effects work in Section 6. The last section concludes.

[6] We find that such incentives are associated with higher innovative output in at least two senses: the high-tech firms introduce more product lines as well as file more patent claims due to the IPR shock.

2 Institutional Background

The pre-1990s intellectual property regime in India was governed by the The Indian Patent Act, 1970, which was aimed at preventing foreign monopolies.[7] According to the Act, only process and not product innovations were granted patents. The term for patents was fixed at 14 years (and only 5-7 years in chemicals and drugs) while the international standard was 20 years. Several areas were excluded from patents, and the government could use patented inventions to prevent scarcity. Such a system allowed domestic firms to imitate foreign products with a slightly different process, thus expropriating value from investment in product innovation made by foreign firms. The 1970 Patent Act soon started facing international resistance as discussions on free trade started getting linked to IPR (Chaudhuri, 2005).

In 1991, India ran into its much-discussed balance-of-payments (BOP) crisis and turned to International Monetary Fund (IMF) for assistance. The IMF conditioned its assistance on the implementation of a major adjustment program that included several liberalization steps and becoming a member of the World Trade Organization (WTO). In 1994, India signed the Marrakesh Agreement and agreed to be bound by TRIPs. It enabled India to get a 10-year moratorium period (1995-2005) to transition to a stronger, TRIPs-compliant IPR regime which would respect product patents (for details see Chaudhuri, 2005). This transition had several hiccups with uncertainty around the implementation of the new regime. As we explain below, the uncertainty cleared only by 2002, and this provides us the structural break that we exploit in our study.

India's initial transition started with the failed The Patents (Amendment) Ordinance, 1994 which was tabled by a weak coalition government, amending The Indian Patent Act, 1970. It allowed for a 'mailbox' provision through which firms could file product patent applications which would be reviewed on a priority basis as and when India amends its patent laws to comply with TRIPs. However, uncertainty remained about the exact time frame of this transition. Simultaneously, The Patents (Amendment) Bill, 1995 was introduced in the Parliament to enforce the ordinance.[8] As per Indian law, a bill must be passed by both houses of the parliament. While the Upper House passed it, the Indian parliament was dissolved due to ideological differences between members of the ruling coalition once the bill was in the lower house of the parliament. The Patents (Amendment) Bill, 1995 automatically lapsed leaving the uncertainty around IPR transition alive.

The United States filed a complaint against India to the Dispute Settlement Board (DSB) of the WTO

[7] The Patent Act of 1970 was partly based on the recommendations of Patent Enquiry Committee (1948-50) and the Ayyangar Committee (1957-59), which made 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).

[8] In 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.

in 1996 for failing to abide by the TRIPs.[9] India lost this case, despite an appeal, with the U.S. further bolstered by a European Community complaint. India then negotiated with the U.S. to amend its patent law by April 1999.[10] Finally, in order to honour this commitment made to the DSB, India implemented The Patents (Amendment) Act, 1999 despite civil society concerns. This amended Act had the provision for filing of applications for product patents in the areas of drugs, pharmaceuticals and agrochemicals, though the applications were only to be reviewed after 31st December, 2004.[11] However, this Act came as a compromise in what was still an uncertain environment around patent policy and was basically a post factum of the failed Patent (Amendment) Bill, 1995. It failed to encourage much innovation.

Throughout the nineties, patent policy in India was subject to a political tug-of-war. While a large section of the INC (Indian National Congress, the ruling party during the first half of the decade) had been sympathetic to liberal patent laws, there was stiff resistance from the opposition as well as parts of INC. In April 1993, a parliamentary committee tasked to study the draft proposal by Arthur Dunkel on Uruguay round of GATT documented the strong unwillingness of India to comply with TRIPs,[12] although its recommendations were rejected by the ordinance of 1994. The BJP (Bharatiya Janata Party), after coming to power in 1998, abandoned its opposition and adopted a pro-patent position. By the turn of the millennium, a majority within both the BJP and the INC favoured a more liberal patent policy.[13] By this time, a domestic constituency had also emerged in support of the patent reform. The support occurred at different levels: first, the impact of liberal ideas regarding economic reforms slowly led to a more westernized notion of IPR; second, by this time a more 'modern', professionally managed and technologically advanced segment of industry had developed in India; third, top Indian research and scientific institutes (e.g., Council of Scientific and Industrial Research, CSIR) felt that they could benefit from patents rather than publications (Ramanna; 2002; Choudhury and Khanna, 2014).[14]

Given this background, The Patents (Amendment) Act, 2002 laid the foundation and provided the necessary impetus to change the intellectual property regime in India. According to the Controller General

[9] See: World Trade Organization, Chronological list of disputes cases, available at https://www.wto.org/english/tratop_e/dispu_e/dispu_status_e.htm 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.

[10] 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.

[11] Further, the applicants could be allowed Exclusive Marketing Rights to sell or distribute these products in India, but subject to fulfilment of certain conditions.

[12] India, Rajya Sabha, Parliamentary Standing Committee on Commerce, DRAFT DUNKEL PROPOSALS at 46 (December 14, 1994)

[13] 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.

[14] 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.

of Patents, Design and Trademarks, Govt. of India, The Patents (Amendment) Act, 2002,[15] replaced the earlier patent rules implemented by the 1970 Act.[16] This legislation proposed a new definition of the term "invention", introduced product patents in all fields of technology, increased the term of patents from 14 to 20 years (complying with TRIPs), limited the scope for the government to use patented inventions. This Act really broadened the scope for the implementation of the TRIPs complying IPR regime that India was committed to adopting.[17] 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 TRIPs (see Chatterjee et al., 2015 for more details on 3(d)).

Our detailed discussion of the events suggest that there was a significant amount of uncertainty in transitioning 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 a firm's structure.. We conduct a variety of exogeneity checks (explained in detail in Section 4.1) to ensure that we address any confounding impact of potential ex-ante industry- or firm-level changes that may have influenced the 2002 IPR reform.

3 Dataset

We exploit a dataset of Indian manufacturing firms drawn from the PROWESS database, constructed by the Centre for Monitoring the Indian Economy (CMIE). The dataset has previously been used by Khandelwal and Topalova (2011), Ahsan and Mitra (2014) and Chakraborty and Raveh (2018), among others. The dataset accounts 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, and are outlined in **Appendix A** (Data). **Table 2** presents descriptive statistics for all variables.

The 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.[18] It reports direct measures on a vast array of firm-level characteristics including sales, exports, imports, R&D expenditures, technology transfer, production factors employed, gross value added, assets, ownership, and others. The dataset covers both large and small enterprises; data for the former types is collected from balance sheets, whereas that for

[15] This act came into force on 20th May, 2003

[16] http://www.ipindia.nic.in/history-of-indian-patent-system.htm

[17] 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 Patents (Amendment) Act, 2002 was enacted.

[18] 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 characteristics. Hence, all industry-level categorization made throughout the paper are based on the 2004 NIC classification.

the latter ones 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 as 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 behavior over time; specifically, the (unbalanced) sample covers 108 (4-digit NIC) manufacturing industries that belongs to 22 (2-digit NIC) larger ones,[19] over the period of 1990-2006.

Second, the feature of the data set upon which our study is based, is that it disaggregates compensation data by managers and non-managers, with a further disaggregation of compensation to wages and bonuses. Additionally, the managers are divided into two groups: directors and executives.[20] The mon-managers are defined as those who do not manage other employees. Directors are defined as managers without executive powers, as opposed to executives who do possess such responsibilities. Executives include, for instance, the CEO, CFO, and Chairman, whereas Directors may include positions such as Divisional Managers.[21] In effect, we consider directors to be middle management, whereas executives are the top management.

A key related issue is regarding the accuracy and consistency of the data. Chakraborty and Raveh (2018) compares the compensation data for 20 randomly selected firms (representing both relatively large and small ones) from PROWESS with that of those reported in the annual reports and finds that the correlation is higher than 0.99. We implicitly assume that there is consistency in the definition of managers across firms.[22]

The data set provides a large 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% (Chakraborty and Raveh, 2018). The variation is also observed 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 as high as 200%. Such variation will be more prominent when the data translates to the firm-level.

[19]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%).

[20]While there is scope for subjective interpretation of this distinction by firms, it does not affect our main analysis, where we consider the aggregate of Executives and Directors. It may well be that there are more layers in a given firm, but given the nature and scope of our study or the data we cap the analysis at three hierarchial layers.

[21]For example, a firm 'Jaipur Polyspin Ltd.', Mr. V. K Singhal has been designated as 'Manager (Production)' and Mr. S. L. Dhanuka as 'Chaiperson and Managing Director'. In case of 'Unimin India Ltd.' has Mr. M. G. Karkhanis as 'Vice-President (Marketing)', and Mr. J. B. S. Bakshi as 'Chairperson and Managing Director'. We note that the names of the managers belonging to the middle management are are more sparsely reported than those in the top management. However, this is not the case with the compensation data.

[22]There is scope for some subjective interpretation of this distinction by firms, when providing data. However, all firms included in the analysis are listed in the Mumbai Stock Exchange, and hence are subject to the same corporate governance and reporting regulations including the said definitions, which mitigates this concern to a large extent. Moreover, our results on managers as a single group do not get affected by such issues. In addition, we use firm fixed effects which will absorb this kind of unobserved heterogeneity.

4 Empirical Strategy

Higher incentives to innovation induce firms to demand for managerial skill to maximize innovation potential, and this change is more pronounced for more technologically advanced firms. To assess such effects, we use The Patents (Amendment) Act, 2002 as an instrument for innovation to analyze its effect on the share of managerial compensation in total labour compensation for manufacturing firms in India. 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 using the following specification:

$$\begin{aligned}\left(\frac{Mcomp}{Tcomp}\right)_{it} &= \alpha_i + \alpha_t + \alpha_{jt} + \beta_1(IPR_{02} \times HighTech_{i,90-01}) + \\ &\quad \beta_2 IPR_{02} + \beta_3 X_{ijt} + firmcontrols_{t-1} + \epsilon_{it}\end{aligned} \tag{1}$$

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. IPR_{02} is the post-IPR reform dummy variable, which takes a value of 1 for years on and following the imposition of The Patent (Amendments) Act, 2002. In particular, IPR_{02} takes 1 for the years 2002-2006.

An intellectual property rights reform raises the incentives to invest both in R&D and technology transfer. On the other hand, managerial skill is a strong complement to technological inputs (Garicano, 2000). Therefore, the firms that already have higher level of technology at the time of the reform, would demand more managers than those which are technologically less advanced. Acemoglu et al. (2006) argues that for countries which are closer to the technology frontier, selection of high-skilled managers becomes crucial as managerial skill is important for innovation.

To study whether such is the case at the firm-level, i.e., whether a change in patent regime affects firms' demand for managers differentially, we divide the firms into two groups based on their investment in technology adoption before the reform. Firms are defined as 'high-tech' firms or 'treated' group in our estimation if the average GVA (gross value-added) share of technology adoption (sum of R&D expenditure and royalty payment for technical know-how) for the years before the reform (1990-2001) is greater than the median of the industry to which the firms belongs. We assign these firms a high technology use dummy, $HighTech_{i,90-01}$, equals to 1. For the rest of the firms, $HighTech_{i,90-01}$ equals 0, which serves as 'control' group in our estimations.[23]

[23] While it is true that this is not a perfect control group that we could use in the estimations, 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 use as all other sectors are also simultaneously impacted by other reforms (e.g., trade reforms). Using

Therefore, our key variable of interest is the interaction term $IPR_{02} \times HighTech_{i,90-01}$ (or its coefficient β_1). It measures the differential response of the high-tech and low-tech firms due to the IPR shock in terms of demand for managers. In other words, β_1 measures between-firm inequality in terms of demand for managerial workers. On the other hand, IPR_{02} estimates the direct effect of the IPR reform on the demand for managers. Alternatively, it measures the within-firm changes in the share of managerial compensation on total labour compensation.

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 (2018), we use both input and output tariffs at the industry-level to control for trade reforms initiated by the Govt. of India during the 1990s. We also specifically control for product market competition effect (both for domestic and export market), skill-intensity, management technology, IT expenditure, labour-regulation, productivity, etc. We also include three firm-level controls ($firmcontrols$) in all our specifications: age of a firm (older firms may have a more established structure and culture; controlling for age would take care of the potential differences in the flexibility of undertaking organizational reforms), amount of capital employed as a share of total gross value-added (higher capital intensity may also raise the demand for managers significantly) and assets (larger firms may have greater management needs). We use assets and capital intensity in $(t-1)$ period. α_i and α_t are time-invariant firm and year fixed effects, respectively.

While estimating the above equation, we carefully control for other simultaneous reforms, such as delicensing of industries, tax incentives for R&D, The Competition Act, 2002, corporate governance reforms[24], etc. that may affect the share of managerial compensation in a firm. Those, if not controlled for can bias our outcomes. To control for these unobserved policy changes (or any other change in the economic environment affecting all firms), we use α_{jt} – industry-year trends. We interact a firm's industrial classification at NIC 5-digit level (most disaggregated level of industrial classification) with year trends to control for other simultaneous policy reforms that 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

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. We additionally classify our dataset following the definition of Delgado et al. (2013). The results remain the same.

[24] 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: (i) exogenous changes in the Clause 49. The Clause 49 reform required firms to change the composition of their board of directors – specifically, at least 50% of the board had to consist of independent directors; and (ii) in 2002 the Securities and Exchange Board of India (SEBI) (Amendment) Act, 2002 replaced the earlier SEBI Act, 1992 to enlarge the Board of Directors of firms 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). However, we argue that is not the case. 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 was also during mid-1990s. If it had been only for the corporate governance reforms and nothing else, then we would have seen only a secular trend before 2002 and no spike. Chakraborty and Raveh (2018) show that the increase in the share of managerial compensation during the 1990s is due to the trade reforms undertaken by India. Second, even though the reform for the Clause 49 was adopted by SEBI in 2000, it was only in late 2002, SEBI constituted a committee to assess the adequacy of current corporate governance practices, and based on the recommendations of this committee, the Clause 49 came into operation on 1 January 2006.

change.

However, one should still be careful in interpreting the basic estimates as conclusive evidence of the causal effect of the IPR reform on the differential demand for managers between high-tech and low-tech firms because of the following two reasons: (a) omitted variable bias; and (b) reverse causality. We address the former by sequentially adding various firm and industry characteristics and its interaction with the $HighTech_{i,90-01}$ dummy to our baseline specification. As for the latter, we show that the managerial compensation or any other feature that is closely associated with the demand for managers did not influence the IPR reform through a series of exogeneity checks explicitly in the following section.

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 stronger amendment act in the next few years and this influenced the differential effect on managerial compensation between high-tech and low-tech firms. Also, there may be other changes, which are coincident with The Patents (Amendment) Act, 2002 in terms of a high-tech firm's behavior towards demand for managers. For example, there might be pressure by the big firms or multinationals to the Govt. of India 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 3**.

We start by checking whether the 1999 Patent Act has a proactive effect on the share of managerial compensation. In other words, we examine if the observed effect of 2002 reform sustains, when we introduce the 1999 reform. Column (1) interacts the 1999 reform dummy, IPR_{99}, with our $HighTech_{i,90-01}$ 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, $IPR_{02} \times HighTech_{i,90-01}$, is positive and significant with no effect of the $IPR_{99} \times HighTech_{i,90-01}$. In column (2), we replace our $HighTech_{i,90-01}$ dummy in the interaction term $IPR_{99} \times HighTech_{i,90-01}$ with $HighTech_{i,90-98}$. $HighTech_{i,90-98}$ takes a value 1 if the average technological adoption expenditure of a firm for the years 1990 to 1998 is greater than the median technological expenditure of the industry to which the firm belongs. We do this to understand whether a firm, which was a high-tech before the 1999 Act, raised its demand for managers because of the 1999 reform and the 2002 reform was nothing but an additional push. We fail to find any evidence of such kind. In column (3), we additionally interact $HighTech_{i,90-98}$ with IPR_{02} in order to see if the high-tech firms were re-organizing their firm structure in anticipation to the 2002 reform. We find our coefficient of interest ($IPR_{02} \times HighTech_{i,90-01}$)

to be positive and significant, with the additional interaction term not affecting our outcome of interest. In short, our results tell us that the 2002 IPR reform is not a mere extension of the 1999 reform , but an unanticipated change towards a stronger intellectual property rights regime.

Additionally, we run a placebo 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 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 $IPR_{02} \times HighTech_{i,90-01}$. The coefficient of the interaction term of IPR_{02} and $HighTech_{i,90-01}$ 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 the enactment of the reform; the coefficients are positive, significant and increases over time.

We ran some further checks following Khandelwal and Topalova (2011) to test for potential lobbying effect and influence of the 1999 reform. In particular, we test whether the interaction of high-tech dummy and reform dummy is correlated with important pre-reform (pre-2002 but post-1999) industry characteristics, which may have influenced the 2002 reform. These characteristics include share of managerial compensation (a larger share of managers may influence the industry lobbyists to put pressure on the Govt. 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 2000-01. These results are presented in columns (5) – (7) in **Table 3**. 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 conduct 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 implementation 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 influence of the high-tech firms. We regress $IPR_{02} \times HighTech_{i,90-01}$ 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

In this section, we report our empirical findings on the effect of the IP reform of 2002 on the organization of Indian firms. We describe our results under two heads: managerial compensation and incentive provision.

5.1 Managerial Compensation

We present our benchmark results from estimating equation (1) in **Table 4**. We use managerial share of total compensation as a measure of demand for managerial skill in the intensive margin, for the period 1990-2006 as our outcome of interest. We provide different specifications by varying the fixed effects (firm, year, industry-year and so on) as well as the level of aggregation while always controlling for the age (including a quadratic term), ownership and size of a firm.

We find that in each of these specifications, the coefficient of the interaction term $IPR_{02} \times HighTech_{i,90-01}$ is positive, highly significant and roughly similar across specifications (1.6% – 1.7%). On the other hand, the coefficient of the variable IPR_{02} is positive and significant for the initial specifications, but becomes insignificant once we allow for industry fixed effects at sufficiently disaggregated levels. In other words, the increase in the demand for managers in the intensive margin is due to both within-firm effect as well the differences in the high-tech and low-tech firms, but the latter effect is stronger.

In column (5), we additionally interact the $HighTech_{i,90-01}$ dummy with year dummies to control for the pre-trends that may influence our results using the following regression equation:

$$\begin{aligned}\left(\frac{Mcomp}{Tcomp}\right)_{it} &= \alpha_i + \alpha_t + \alpha_{jt} + \beta_1(IPR_{02} \times HighTech_{i,90-01}) + \beta_2 IPR_{02} + \\ &\quad \alpha_t \times HighTech_{i,90-01} + firmcontrols_{t-1} + \epsilon_{it} \qquad (2)\end{aligned}$$

The coefficient of the interaction term is still positive and significant; but, smaller than the coefficient of IPR_{02}. This points out that when controlling for pre-trends, the within-firm wage inequality is higher than the between-firm, which is opposite to that of our finding in column (4). **Figure 4** plots coefficients (β_1s) from equation (2) for our main firm outcome variable, share of managerial compensation. The estimated coefficients illustrate that, the difference between the high-tech and low-tech firms in terms of share of managerial compensation is not significantly different from zero before the patent reform of 2002 (except for the years 1995 and 1996)[25]. The share of managerial compensation rises differentially for high-tech firms after 2002. In particular, it took a sharp rise in the year following the implementation of the IPR reform and increased further thereafter.

In column (6), we use simple Average Treatment Effect of the Treated (ATT), which measures the difference in mean (average) outcomes between the units assigned to the treatment (high-tech firms) and control (low-tech firms) group, respectively. Our estimates suggest that the 2002 IPR reform increases the relative demand for managers gap between high-tech and low-tech firms by 1.7% at the mean, which is the same as the estimate from our OLS regressions.

We also use total number of managers[26], absolute managerial compensation, and average managerial compensation as dependent variables in **Table 14** of **Appendix B**. Our coefficient of interest continues to be positive and significant across all dimensions of the demand for managers. Columns (1) and (2) perform the same analysis for demand for managers in the extensive margin by treating the total number of managers as the outcome variable. We see that while the IPR reform has had no within-firm effect on the extensive margin but the between-firm effect is positive and significant. In particular, our results show that at the extensive margin, the reform caused the high-tech firms to employ 6.3% - 6.9% more managers than the low-tech firms at the mean. Columns (3) – (4) substitutes total managers by absolute managerial compensation. As the coefficients demonstrate, substitution of dependent variable does not change our benchmark finding. While the extensive margin considers the effect of IPR on "quantity" of managers employed, columns (5) and (6) looks at the average "price" of managers. We now treat the average compensation of managers, obtained by dividing the total compensation with the number of managers, as dependent variable in a firm. The estimates tell us that both the within- and between-firm effect are positive and significant.

In **Table 15** of **Appendix B**, we perform a set of similar exercises for non-managerial employees.[27] We

[25] Chakraborty and Raveh (2018) shows that drop in input tariffs, as a result of the trade reforms in India during the 1990s, significantly increased the demand for managers. The result is acute for firms importing capital goods and raw materials.

[26] PROWESS provides names of the managers at the top and middle management level. We count the names to calculate the number of managers in a firm across different years. We note that the names of the managers belonging to the middle management are not as consistently reported as top management. So, when we match the data (with the number of managers across both management levels and compensation), the number of observations drop significantly. However, that is not the case with only the top management. If we use only the top management data, then the number of observations rise significantly and our result continues to hold.

[27] We note that PROWESS provides very limited data (only for about 250 firms) on the total number of employees. We do not claim that using data for such a small number of firms can be generalized, but it gives an idea of what happened on the non-managerial side of the firms.

find that, in terms of non-managerial share of total compensation, the within-firm effect is positive while the between-firm effect is negative. Moreover, while there is no significant effect of IPR on average compensation, there is a positive effect on employment both through the within-firm and between-firm channels.

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 its average value in the market more for the high-tech firms than the low-tech. On the other hand, while the same reform led to an increase in non-managerial employment, their share of compensation went down since their average wages remained virtually unchanged across the economy. In a somewhat similar context, Vashisht (2017) finds 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. These results may suggest that technology has reduced the routine task content of manufacturing jobs in India.[28]

Although our results consistently show that a significant change in innovation regime increases the difference between the high-tech and low-tech firms in terms of demand for managerial workers, but cannot seem to answer two important questions: (a) is the control group unaffected by treatment? (b) which type of firms are actually driving the results?

To answer these two questions and better understand how relative demand for managers change with technology adoption, we carry out some additional estimations by dividing the firms into quintiles and declies in **Table 5**. Columns (1) – (3) use quintile regressions. A firm belongs to 1st quintile if the average GVA share of technology adoption of a firm falls below 20th percentile of the corresponding industry of the firm on and/or before 2001, so on for others. Our estimates clearly show that the change in the IPR regime in 2002 does not affect the firms for the first two quintiles in any way, with some weak effect for 3rd quintile of firms. The firms that are most strongly affected belong to the top two quintiles, which are basically the firms above the median (like our previous results). The quintile results vividly confirms a cut-off below the median based on the technology adoption expenditure of the firms.

To establish it more clearly, we now divide the firms into deciles in columns (4) – (6). A firm belongs to 1st decile if the average GVA share of technology adoption of a firm falls below 10th percentile of the corresponding industry of the firm on and/or before 2001, so on for others. The decile estimates corroborate our previous finding (firms above the median are relatively more affected) with two additional features: (i) choice of our control group is sound. IPR change does not at all affect the low-tech firms, i.e., there is no effect for firms below the median. (ii) the effect increases as a firm's technology adoption increases, but till 9th decile. It vanishes again for the top decile or the biggest of the firms. In other words, the change in the IPR law or competition for innovation induces the marginally big firms or firms belonging from 60th–90th percentile to invest more in technology adoption and therefore demand more managers. To put it differently,

[28] Garicano (2000) argues that managerial skill is important for non-routine tasks in the production processes.

our coefficients point towards a certain 'snail-shaped' effect of the change in the IP law – zero effect till 5th decile (which is the median), then there is significant effect, where the effect rises as we go up the size distribution, and then it vanishes again for the 10th decile. Our results are surprisingly similar to the findings of Bustos (2011) although we use a different context and dataset. The paper shows that the impact of a regional free trade agreement, MERCOSUR, on the technology upgrading is highest in the upper-middle range (3rd quartile of firms of the firm-size distribution) of the Argentinean firms.

Figure 5 shows such a shape. It plots the average of the coefficient estimates for each of the decile. The graph shows that the 2002 IPR reform did not induce any more than proportionate increase in the demand between managerial and other type of workers for firms below the median, whereas it is not the case for firms above the median. The effect increases with the decile, becomes the highest in case of 9th decile (for firms between 80th-90th decile) and again falls to zero. We now explain our finding using a theoretical framework.

5.1.1 Theoretical Model

In this section we provide a simple theoretical explanation of the observed heterogeneity or the "snail-shaped" pattern in the relative demand for managers. The complementarity between managerial input and technology is driven through a bucket of interrelated factors, e.g., knowledge spillovers, scale/size effetcs and so on. However, if demand for managers were driven only by the internal dynamics of a firm, then one would expect that firms with larger technological stock would also hire more managers. We posit that competitive forces shape the incentive to hire managers leading to the snail shape that we observe in the data.

In a patent race, the largest firms (in terms of technological stock) have a lower incentive to invest in managerial talent since they are already ahead in competition. Similarly, the smallest firms have very low incentive to invest as they stand very little chance to outcompete the firms that are already ahead. Thus, it turns out that the marginally big firms have the strongest incentive to invest in managerial talent to boost their chances of winning patents. We provide a simple model in which firms with given capital stock compete for a patent and innovation output has the complementarity property: marginal productivity of managers (as measured by likelihood of winning the patent) is increasing in capital stock. We show that equilibrium demand for managerial talent is non-monotonic, and consistent with the snail-shape found in the data.

There is a set of firms numbered 1 through n, with $n \geq 2$. We will denote the set of all firms by N. We think of k_j as technological capital for firm j, and this can be interpreted as the level of knowledge or R&D investment, depending on the context. In our empirical set-up this assumption plays an important role in identifying our baseline effects, by creating our treated group of high-techs and control group of low-techs. The firms are indexed in the order of their capital stock, i.e., $k_1 > k_2 > ... > k_n > 0$. Firm j employs $m_j \geq 0$ units of managerial time at a cost of $w > 0$ per unit, and m_j is the only choice variable in the model. Managers innovate using the available capital, and the payoff from innovation is governed by a contest. The payoff function embeds two basic assumptions: (i) managerial time and technological capital are complements, and (ii) innovation is a competitive process and a firm's payoff from innovation depends on the other firms' level of innovation.

We think of firms engaging in a race for a patent of value $v > w$, and each firm j wins the patent with probability $\frac{m_j k_j^\alpha}{\sum_{i=1}^n m_i k_i^\alpha}$, where $\alpha \in (0, 1]$ is the degree of complementarity between the two inputs. Another interpretation of this payoff function is that the total value to innovation in the industry is v, and each firm j obtains a share $m_j k_j^\alpha$ of the total pie.

Thus, the profit function of firm j is

$$\pi_j(m_1, m_2, ...m_n) = \frac{m_j k_j^\alpha}{\sum_{i=1}^n m_i k_i^\alpha} v - m_j w,$$

In Nash equilibrium, each firm j chooses $m_j \geq 0$ to maximize π_j given the other firms' choices.

We have

$$\frac{\partial \pi_j}{\partial m_j} = \frac{k_j^\alpha}{\left(\sum_{i=1}^n m_i k_i^\alpha\right)^2} \left[\sum_{i=1}^n m_i k_i^\alpha - m_j k_j^\alpha\right] v - w \tag{3}$$

Notice that m_j appears only in the denominator of the expression for $\frac{\partial \pi_j}{\partial m_j}$. This implies that the Nash equilibrium is given by the first order conditions

$$\frac{\partial \pi_j}{\partial m_j} \leq 0 \text{ and } m_j \frac{\partial \pi_j}{\partial m_j} = 0 \text{ for all } j.$$

In other words, some firms will have $m_j = 0$ while, the others will have $m_j > 0$ given by $\frac{\partial \pi_j}{\partial m_j} = 0$. For any action profile $(m_1, ...m_n)$, denote the firms with $m_j = 0$ as the **inactive** firms and those with $m_j > 0$ as the **active** firms. Before solving the game with the non-negativity constraint (the "original" game), it is instructive to solve the same game without the nonnegativity constraint on m_j (the "unconstrained" game).

The first order condition for the unconstrained game is simply $\frac{\partial \pi_j}{\partial m_j} = 0$. In this game, denoting $\sum_{i=1}^n m_i k_i^\alpha = x$, we can write

$$x - m_j k_j^\alpha = \left(\frac{w}{v}\right) \frac{x^2}{k_j^\alpha} \tag{4}$$

Adding over all $j = 1, 2, ..n$, in (4) we get

$$nx - x = \left(\frac{w}{v}\right) x^2 \left[\sum_{i=1}^n \frac{1}{k_i^\alpha}\right] \Rightarrow x = \frac{n-1}{\sum_{i=1}^n \frac{1}{k_i^\alpha}} \left(\frac{v}{w}\right) \tag{5}$$

With a little algebra, we can solve for this unconstrained game. In equilibrium, for $j = 1, 2, ..n$,

$$m_j^N = \left(\frac{v}{w}\right)\left(\frac{n-1}{k_j^\alpha\left(\sum_{i=1}^n \frac{1}{k_i^\alpha}\right)}\right)\left(1 - \frac{n-1}{k_j^\alpha\left(\sum_{i=1}^n \frac{1}{k_i^\alpha}\right)}\right)$$

Denoting $c_j = \frac{1}{k_j^\alpha}$ as an inverse measure of a firm's capital stock, we have the unique Nash equilibrium of the unconstrained game in terms of a normalized value of c_j :

$$m_j^N = \left(\frac{v}{w}\right)\left(\frac{c_j}{\frac{1}{n-1}\sum_{i=1}^n c_i}\right)\left(1 - \frac{c_j}{\frac{1}{n-1}\sum_{i=1}^n c_i}\right) \tag{6}$$

(6) denotes the equilibrium of an unconstrained game. Now, we derive the solution to the constrained game through several steps. The first step is to see that the choice of the active firms in any equilibrium of the constrained game is as if the inactive firms are excluded from play, and the game is unconstrained. In the unconstrained game where only a subset $S \subseteq N$ of firms are playing, we denote the equilibrium action of firm $j \in S$ in such a game by m_j^S.

Lemma 1 *Suppose the set of active firms in an equilibrium of the original game is A. The equilibrium choice of firm $j \in A$ is given by $m_j^* = m_j^A$.*

Proof. Fixing an equilibrium (and thus the set A), we can rewrite (3) as

$$\frac{\partial \pi_j}{\partial m_j} = \frac{k_j^\alpha\left[\sum_{i\in A, i\neq j} m_i k_i^\alpha\right]}{\left(\sum_{i\in A} m_i k_i^\alpha\right)^2} v - w \tag{7}$$

If $j \in A$, we have $m_j > 0$, implying $\frac{\partial \pi_j}{\partial m_j} = 0$. This is also the equilibrium condition for the unconstrained game for the set A of firms. ■

We have already solved for the unconstrained game in (6). All that remains to be done now is identify the set of active firms in the original game. The following result says that firms with large enough capital stock are the active ones.

Lemma 2 *For $j \geq 2$, if firm j is active in equilibrium, then firm $j-1$ must be active too.*

Proof. In Appendix C ■

By the above Lemma, there must be some cut-off T such the set of active firms is given by $j \leq T$. All that remains to be done is to identify T.

Before describing the formal result, we provide some intuition. Think of the equilibrium in the unconstrained game between a subset S of firms, where $S = \{1, 2, ...t\}$. The non-negativity constraint binds when $\frac{c_j}{\frac{1}{t-1}\sum_{i=1}^t c_i} > 1$ for some $j \leq t$. When $t = 2$, we have $m_1^S = m_2^S = \frac{c_1 c_2}{c_1 + c_2} > 0$, i.e., the non-negativity constraint does not bind. As t grows, i.e., we add progressively smaller firms to S, eventually m_t^S becomes negative, i.e., $\frac{1}{t-1}\sum_{i=1}^{t} c_i < c_t$. The cut-off T is given by the largest value of t such that $m_t^S > 0$. Now we formally develop this idea.

Define, for $t = 2, 3...n$,

$$K_t = \frac{1}{t-1}\sum_{i=1}^{t} c_i - c_t$$

We can write

$$\begin{aligned} K_{t+1} &= \frac{1}{t}\sum_{i=1}^{t+1} c_i - c_{t+1} \\ &= \frac{t-1}{t}\left[\frac{1}{t-1}\sum_{i=1}^{t} c_i - c_{t+1}\right] \\ &= \frac{t-1}{t}\left[K_t + (c_t - c_{t+1})\right] \end{aligned}$$

Since $c_t < c_{t+1}$, $K_{t+1} < 0$ if $K_t \leq 0$. We also know that $K_2 = c_1 > 0$. Define $T = \max\{t : K_t > 0\}$.

The following proposition establishes that in the Nash equilibrium, the set of firms $A = \{1, 2, ..T\}$ are active.

Proposition 1 *There is a unique Nash equilibrium of the game given by the following*

$$m_j^* = \begin{cases} \left(\frac{v}{w}\right)\left(\frac{c_j}{\frac{1}{T-1}\sum_{i=1}^{T} c_i}\right)\left(1 - \frac{c_j}{\frac{1}{T-1}\sum_{i=1}^{T} c_i}\right) & \text{for } j = 1, 2, ...T \\ 0 & \text{for } j = T+1, ...n \end{cases}$$

In other words, the set of active firms is $A = \{1, 2, ...T\}$; and we have $m_j^* = m_j^A$ for $j \in A$ and $m_j^* = 0$ for $j \notin A$.

We provide the proof in the appendix.

The two important features of this equilibrium are : (1) firms smaller than a threshold do not employ managers for innovation, and (2) the demand for managers among the active firms at first increases and then decreases in capital stock.

The first feature has already been discussed. To see the single-peakedness, denote $\frac{c_j}{\frac{1}{T-1}\sum_{i=1}^{T} c_i}$ by d_j^T for $j = 1, 2, ...T$. Now, $m_j^* = \frac{v}{w} d_j^T (1 - d_j^T)$. Since c_j is increasing in j, so is d_j. Therefore, m_j reaches maximum at $j^* = \arg\min_{j'} \left| d_j^T - \frac{1}{2} \right|$. Typically this maximum will be an interior maximum in the set of active firms.

We cannot directly observe m_j^* in our data. Our natural experiment, i.e., stronger IP protection, can be interpreted as an increase in the value v of a patent. Straightforwardly, $\frac{dm_j^*}{dv} = \frac{m_j^*}{v}$. Thus, the change in managerial employment due to a stronger IP regime (which is closer to what we observe in the data) also follows the same snail-shaped pattern as m_j^*.

5.2 Disaggregating Compensation into Wages and Incentives

Our empirical and theoretical exposition so far indicates that the positive impact of the 2002 IPR reform on the relative demand for managers is driven only by firms above the median, but below the top percentiles. The change in patent law has virtually no effect for the low-tech firms. In this sub-section, we now examine the components of the managerial compensation to better understand the sources of the change.

There is considerable debate in the literature about the role of performance incentives in motivating innovation. Holmstrom (1989), Teece (1994) and Amabile (1996) indicate that short-term performance incentives may not be conducive to generating effort towards innovative activities. Lerner and Wulf (2007) and Kline et al. (2017) point out the value of long term incentives for innovation. We, however, find an increase in incentive share of pay especially for high tech firms.

We disaggregate the compensation into wages and incentives and present the results in **Table 6**. We define as incentive pay, a part of compensation reported, as the following heads: (a) benefits or perquisites; (b) bonuses and commission; (c) contribution to provident fund; and (d) contribution to pension, whereas wages are considered to be the pre-determined component of the total compensation salary received by the employees. Column (1) examines managers' share of total wage, $Mwages/Twages$; and column (2) uses managers' share of total incentive pay, $Mincentives/Tincentives$, as the outcome of interest in Equation (1).

Notice first that the coefficient of the interaction term in column (1) is negative and weakly significant, and the same in column (2) is positive and highly significant. Therefore, differences between high-tech and low-tech firms in terms of demand for managers is only due to the difference in share of incentives. On the other hand, the within-firm effect is positive for managers' share of wages but insignificant for managers' share of incentives. This result is consistent with empirical findings elsewhere that a positive external shock (e.g., trade liberalization) brings about an increase in managerial compensation through an increase in incentive pay (Cunat and Guadalupe, 2009; Chakraborty and Raveh, 2018). Our result that incentive driven increase is concentrated in high-tech firms is also reminiscent of the conclusion in Acemoglu et al. (2006) that firms closer to the technological frontier provide sharper incentives to their managers.

Figures 6 and **7** plot the coefficients of the difference between high-tech and low-tech firms for managerial wages and incentives, respectively. Both the figures imitates our empirical finding. In case of wages (**Figure 6**), the coefficient drops after the reform, hinting that the difference between the managerial and non-managerial wages reduces after the 2002 patent reform. Whereas, in case of incentives (**Figure 7),** it was the opposite. The difference started increasing the year after the implementation of the reform and it became distinctly different from 0.

We have also checked the results for wages and incentives (of all managers) as a share of total compensation. The results do not change. **Table 15** (**Appendix B**) reports our additional findings.

5.3 Disaggregating Industries Based on Intellectual Property (IP) Classification

Until now, we divide our sample of firms based on their technological knowledge within an industry. We now change our intra- to inter-industry classification based on the IP intensity of industries at the 4-digit level as developed by Delgado et al. (2013a). We use two approaches – high-IP products and high-IP clusters. We start with the former.

The high-IP product list is primarily based on 4-digit NAICS (North American Industrial Classification System) code with above average IP intensity in the US (based on patents, trademark or copyrights).[29] To define the high-IP group of products, Delgado et al. (2013a) matches the NAICS industries to the Comtrade product categories at SITC, Rev. 3 (Standard International Trade Classification, Revision 3). We use the International Standard Industrial Classification (ISIC) Rev. 4 to match to the National Industrial Classification (NIC) of India.[30] Using this classification, we could match about 50-55% of the industries. Our 'treated' group is now the high-IP intensity industries, which takes a value 1 through out the entire time period of our study. On the other hand, the 'control' group is the low-IP intensity products, which takes a value 0. The identification of the low-IP products is also based on the same classification as the ESA-USPTO Report described. Our conjecture is that due to the implementation of the IP-law in 2002, the patentable intensity of the high-IP products would increase multi-fold, so demand for managerial skill would increase more than proportionately in those industries than low-IP intensity industries. Our variable of interest, $IPR_{02} \times HighIP_j$ would capture the relative differences across these two set of industries, where the classification is based on IP intensity of industry j ($HighIP_j$).

Delgado et al. (2013) argues that the classification of the high-IP products/groups are very broad and based on somewhat coarse mapping. Therefore, to further embellish the analysis, particular sub-categories of high-IP products (e.g., biopharmaceuticals or ICT) is defined. To define subsets of the high-IP product group, a clustering approach is used to create groups (called 'clusters') in such a way that objects in the same cluster are more similar to each other than to those in other groups. In this case, the objects are narrowly defined industries or traded products (NAICS or SITC). The cluster approach allows more refined mapping of related traded products into meaningful groups of high-IP intensity. To do so, they use the industry cluster data from the U.S. Cluster Mapping Project (USCMP; Porter (2003)).[31] Industry clusters are groups of industries related by knowledge, skills, inputs, demand and other linkages in a region (Porter, 2003). The main method in the USCMP of creating these groups is the correlation of employment between industries across regions within the U.S. For example, the computer hardware and software industries are in the same Information and Communication Technology cluster because employment in each industry is

[29] ESA-USPTO Report, U.S. Department of Commerce, 2012

[30] Rijesh (2010) also uses UN classification system to match SITC Rev.3 with 2004 NIC 4-digit industries. In addition to the UN system, we also use this classification to duly classify the product categories into high-IP and low-IP products.

[31] Additional information on the USCMP can be accessed at http://www.clustermapping.us/.

strongly co-located.[32] They use the USCMP to assess which clusters have high-patent intensity in the U.S. and then define the high-IP clusters. The (mutually exclusive) clusters with the highest IP intensity are biopharmaceuticals, medical devices, analytical instruments, chemicals, ICT and production technology (PT). We use the same concordance tables as defined above to do match the high-IP clusters with the Indian industrial classification. Our matching percentage increases to around 70-75%.

Results are presented in **Table 7**. Columns (1) – (3) present our estimates from high-IP group classification, whereas columns (4) – (6) do the high-IP cluster analysis. Columns (1) and (4) use interaction of industry fixed effects and time trends, columns (2) and (5) in addition controls for the interaction of $HighIP_j$ and time trends, and columns (3) and (6) change the defintion of IPR_{02}. In these two columns, it 1 for the year 2002, 2 for 2003, 3 for 2004, and so on. We use it in an increasing order to measure the increasing intensity of the 2002 IPR reform over the years. Our coefficient of interest, $IPR_{02} \times HighIP_j$, across all these different methods remain positive and significant. The estimates show that the 2002 IPR reform led to around 0.1-1.3% difference in the price of managers between low-IP and high-IP intensity groups at the mean.

5.4 Between-firm Responses

Having established that our main result is now robust across different set of classifications, we now aim to understand how does this particular change in IP law leads to (a) reallocation of productive factors between firms (high-tech and low-tech)? and (b) responses (between-firm) in terms of product variety, product quality and productivity. We present our results in **Table 8**.

Columns (1) – (3) show significant evidence of between-firm reallocation of productive factors in terms of capital employed, R&D expenditure and transfer of technology. Garicano (2000) explicitly shows that changes in production technology is significantly associated with changes in organizational design, especially in terms of demand for managers. We find similar kind of results in case of Indian manufacturing firms – demand for managers rises as firms adopt increased use of these three factors as a result of the change in patent law.[33] These reallocation of productive factors across firms also point towards a capital-skill complementarity channel that may be at work.

Next, we estimate the effect of change in the IP law on product scope of firms. The implementation of product patent filings should have a positive effect on the number of product varieties produced, especially for the high-tech firms. For such, we use the number of products produced by a firm in a year as the dependent variable. We aggregate the number of products produced by each individual firm in one year to

[32] Delgado et al. (2013b) show that these cluster definitions capture many types of inter-industry linkages discussed in the economies of agglomeration literature. Other clustering and network studies at firm-level focus on specific linkages, such as the technology and market proximity (Bloom et al., 2012). In this case, the goal is to capture meaningful groups of industries (and products) that are highly related among themselves in various dimensions (technology, skills, input-output).

[33] A couple of recent survey papers (Williams, 2017 and Sampat, 2018) show how patent laws significantly affect research investments.

define the product scope of a firm. In other words, we aggregate firm-product-year-level data to firm-year-level. Column (4) shows that the change in the IP law increases the number of products produced by the high-tech firms by about 7.3%.

We now utilize our firm-product-year-level data to explore the effect of stronger patent laws on product quality in column (5). We use unit price as an indicator for quality (Medina, 2017). Our estimate shows that changes in IP law lead to significant increase in the relative difference in product quality between high-tech and low-tech firms. Lastly, in column (6) we explore whether and how changes in patent law affects firm-level productivity. We estimate productivity using Levinshon-Petrin methodology (2003). We find significant improvements in relative productivity. At the mean, productivity for the high-tech firms increased by around 4% more than the low-tech firms. Overall, changes in the patent law induces what we call a quality-upgrading mechanism. High-tech firms now became more productive, produce more products at a higher quality.[34]

5.5 Firm Characteristics

We now examine additional heterogeneity in **Table 9** using various firm characteristics to identify the set of firms, which drive the main result(s). We start by dividing the sample into exporters and non-exporters in columns (1) and (2). The coefficients show that the differential response in the demand for managers is significant for both exporters and non-exporters, with the effect significantly higher for the latter group of firms. Interestingly, on the other hand, the within-firm effect is higher for exporters. We believe that this result is due to the fact that to begin with, exporting firms as a group are much more similar in terms of technological expenditure than non-exporting firms.

Next, we divide firms by ownership – domestic and foreign in columns (3) and (4). The interaction effect of $IPR_{02} \times HighTech_{i,90-01}$ is significant for both domestic and foreign firms, with the effect slightly higher for foreign firms. In terms of within-firm effect, we find a similar effect (in terms of magnitude) for domestic firms and no effect for foreign firms. Lastly, in columns (5) and (6) we follow Nouroz (2001) and use the input-output classifications to categorize firms by the end use of their products. The division is made into two groups – intermediate (intermediates, basic and capital) and final (consumer durables and non-durables) goods. The interaction effect is significant for both classes of firms. Overall, our findings show that an IPR shock has an economy-wide effect in comparison to trade or other marcoeconomic shocks, where the effect is limited to only a few sections of firms such as exporters (Caliendo and Rossi-Hansberg, 2012).

[34] We also look at the effects on sales (divided into domestic and exports) of firms. Revenues from both domestic and exports increases for high-tech firms. However, the increase in total sales is significantly driven by domestic sales.

5.6 Sensitivity Analysis

We check for the robustness of our results by using several controls, alternative techniques, sample and time period in **Tables 10, 11**, **12** and **13**.

5.6.1 Complementary Effects

This section controls for all other possible channels that can simultaneously affect the managerial compensation of a firm. While some of these channels do have significant effects, our primary result remains true and significant in every case establishing the fact that IPR reforms indeed contribute to a higher relative demand for managers for high-tech firms.

Trade Shocks: We start by controlling for all possible trade channels that can concurrently affect managerial compensation and present the results in **Table 10**. Recent research by Caliendo and Rossi-Hansberg (2012) points out that trade significantly affects organizational structure of firms through increase in demand for managers (Cunat and Guadalupe, 2009; Chakraborty and Raveh, 2018). Chakraborty and Raveh (2018) uses the trade liberalization exercise adopted by India during the 1990s to examine its effect on the demand for managers and show that drop in input and not output tariffs significantly explains the rise in the share of managerial compensation for Indian manufacturing firms. We use the same indicators and interact them with $HighTech$ in columns (1), (2) and (3). Our results indicate that both input and output tariffs significantly increased the difference in the demand for managers across high-tech and low-tech firms. However, we do not find any statistically significant effect when we use them jointly.

Cunat and Guadalupe (2009) and Guadalupe and Wulf (2010) show that import competition and product market competition significantly affects managerial or executive compensation. We use Chinese competition as a proxy for import competition.[35] We use the following indicator for Chinese import competition in column (4) to measure such effect. PROWESS does not give any information regarding the trade destinations of the firms. To overcome such a shortcoming, we match the firm-level data from PROWESS with the trade-destination based product level UN-COMTRADE dataset at NIC 2004 4-digit level. To establish causality between import competition and managerial compensation, we follow Chakraborty and Henry (2018) and use China's entry to the WTO on December 11th, 2001 as a quasi-natural experiment, together with the differential competitive pressures faced by Indian firms due to this trade shock, as our identification strategy. We use the following index:

$$AvgM01_j^{China} = \sum\nolimits_{1992-2001}[\frac{imports_{jt}^{China}}{imports_{jt}^{Total}}]$$

$$= \sum\nolimits_{1992-2001}[\frac{imports\ from\ China\ for\ the\ years\ 1992-2001\ for\ the\ industrial\ category\ j}{imports\ from\ World\ for\ the\ years\ 1992-2001\ for\ the\ industrial\ category\ j}]$$

[35] 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%.

Thus, we define $AvgM01_j^{China}$ as a measure of Chinese competition that an industry faces because of the unilateral liberalization policies pursued by China; it is a 10-year average of the share of imports by industry j for the period 1992-2001. We interact this measure with WTO_t. WTO_t is a year dummy variable intended to capture the effect of China's entry into the WTO. It takes a value of 1 for the years following the signing of the WTO agreement by China. Therefore, WTO_t equals 1 for the years 2002-2006. So, our variable of interest, $AvgM01_j^{China} \times WTO_t = DComp_{IN}^{China}$, provides a measure of the amount of competition faced by Indian firms as a result of China becoming a member of the WTO. The interaction term $DComp_{IN}^{China}$ provides a clear and exogenous measure of import competition from China and represents a difference-in-differences approach to measure the effect of Chinese import competition on the product variety of Indian manufacturing firms. In order to measure the differential effect of the Chinese import competition on the managerial compensation, we interact $DComp_{IN}^{China}$ with our $HighTech_{i,90-01}$ dummy. We fail to find any statistically significant effect of domestic competition from Chinese imports.[36]

Caliendo et al. (2017) argues that participation in export market significantly increases executive compensation. In column (5), we use the share of Chinese imports in total imports of the US to see whether export market competition, $FComp_{IN}^{China}$, has positively affected the demand for managers. We find negative effect of the interaction term with weak significance. Higher participation in the export market closes the gap between high-tech and low-tech firms in terms of demand for managers.

Other Possible Channels: We follow Chakraborty and Raveh (2018) and test for other industry- and firm-level channels in **Table 11**. We start by testing 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 ASI (2001-2006). The main result continues to hold, suggesting that it is not driven only by increases in the demand for skill. However, our outcome variable of interest and skill intensity appears to be significantly correlated. This suggests that capital-skill complementarity might also be a channel through which demand for managers increased because of higher technology adoption due to the IPR reform.

Column (2) uses management technology and its interaction with $HighTech_{i,90-01}$ dummy as an additional control. We use data on management technology from 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 use an additional related measure: the number of factories and plants

[36] We also use an alternate measure of Chinese import competition. We use lagged value of the share of imports from China at 2004 NIC 4-digit level weighted by sales share of those industries. We continue to find no effect of Chinese import competition.

at the industry-level, derived from ASI. The inclusion of this additional control does little to change our benchmark finding.

Bloom et al. (2013) points out that better managed firms in India have higher productivity. To address this, we control for productivity using Levinshon and Petrin (2003) methodology in column (4). As the results demonstrate, more productive firms demand more managers, but our coefficient of primary interest is stable is sign, magnitude and significance.

One can argue that the sudden expansion in Information Technology enabled services (ITES) in early 2000s can explain some of the increased relative demand for managers in the high-tech firms that we ascribe to IP reforms. In order to control for this, we use expenditure incurred by firms towards in-house information technology and consultancy fees for technological upgradation in column (5). We find consultancy fees for technology upgradation to be significantly correlated with the share of managerial compensation. However, the sign and significance of our main channel does not go away.

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. We construct an indicator for family ownership by considering the proportion of shares held by Hindu undivided families from 2007 (which is the first year for which PROWESS reports such data) and assuming that such proportion remained constant over the period 1990-2006. In column (6), we interact the family-ownership indicator with $IPR_{02} \times HighTech_{i,90-01}$ and see whether family firms influence any increase in the share of managerial compensation or not. We do not get any such evidence.

Olney and Keller (2017) suggest that the increase in managerial compensation during a trade shock may be explained by the fact that the top management gets to decide its own pay. In order to check if our results can be explained by the lack of good corporate governance, we use the number of independent directors in the Board of a firm as an indicator of quality of governance. Since most firms started reporting the composition of their boards from 2003-2004 onwards, matching the number of independent directors with our main dataset running from 1990 till 2006 drops around 90 percent of the observations. In column (7) we report the results from this control. None of the regressors are significant, including our main variable of interest; but the sign of the coefficient does not change.

Lastly, following Bloom and Van Reenen (2010), we control for cross-regional variation in labour market rigidity in India in order to check if the sharper response of high-tech firms to IP reforms appears due to a possible concentration of high-tech firms with more flexible labour market regulations. Accordingly, we use the postcode 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.[37]

[37] 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

5.6.2 Trend-Break Analysis

Following Burgess and Pande (2005), we estimate a trend break model to control for the differential time trends that may affect our outcome variable(s) using the following specification

$$\begin{aligned}\left(\frac{Mcomp}{Tcomp}\right)_{it} &= \alpha_i + \alpha_t + \alpha_{jt} + \beta_1[HighTech_{i,90-01} \times (t - 2001)] + \beta_2[HighTech_{i,90-01} \times (2002 - 2006)] \\ &+\beta_3[IPR_{02} \times (t - 2001)] + \beta_4[IPR_{02} \times (2002 - 2006)] + firmcontrols_{t-1} + \epsilon_{it}\end{aligned} \tag{8}$$

Here, $(t - 2001)$ is a linear time trend and captures the differential pre-trend and post-trends of the 2002 patent reform, whereas $(2002 - 2006)$ is fixed time trend of the 2002 patent Act. These terms enter the regression interacted with our $HighTech_{i,90-01}$ and IPR_{02} dummy. The time trends have a switch in 2002 because of the implementation of the Patent Amendment Act (2002). If the patent reform of 2002 has significantly influenced the demand for managers, we expect the interaction terms of the $[2002 - 2006]$ trend with $HighTech_{i,90-01}$ and IPR_{02} dummy to be significantly different from the pre-trend interactions. Results are reported in **Table 12**. We test for this using share of managerial compensation (columns (1) – (2)), total number of managers (column (3)), and average managerial compensation (column (4)) as the dependent variables, respectively.

Our coefficients show that the post-trends are significantly different from pre-trends. For example, the effect of 2002 IPR reform on the share of managerial compensation for the high-tech firms, $HighTech_{i,90-01} \times (2002 - 2006)$, is five times higher than pre-trend. In case of number of managers or the extensive margin, we do not see any effect of pre-trends. Lastly, in case of average managerial compensation, the result continues to be the same – the post-trends are significantly different from pre-trends.

5.6.3 Other Robustness Checks

In **Table 13**, we start by changing the time period under consideration from 1990-2006 to 1990-2005. The reason for doing so is that 2005 is a crucial year when India finally complied with the TRIPs agreement and this could influence the outcome of interest. Reducing the time period does not affect our benchmark finding – the complementarity effect of IPR reform of 2002 and technology adoption continues to significantly explain the difference in the demand for managers between high-tech and low-tech firms. Column (2) aggregates our

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. 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. We also use the OECD (2007) indicator to replace the Besley and Burgess (2004); our baseline result still does not alter.

dependent variable ($Mcomp/Tcomp$) and $HighTech_{i,90-01}$ to the industry-level (formally, $HighTech_{i,90-01}$ is replaced by $HighTech_{j,90-01}$, where j denotes an industry). An industry is categorized as $HighTech_{i,90-01}$ if its average technological expenditure for the period 1990-2001 is greater than the median technological or innovation expenditure of the whole of manufacturing sector. The motivation to do this is to check whether the differential effect holds between these different types of industries as well. The results suggest that the 2002 IPR reform also led to larger increase in demand for managers in high-tech industries. In other words, our benchmark result is robust to this kind of aggregation.

Column (3) runs a placebo test. We drop all firms except for those in the pharmaceutical sector from the sample. The reason to do this are twofold: (i) the pharmaceutical firms are known to be the early adopters of technology as compared to other manufacturing sectors; and (ii) unlike other sectors, product patents were already allowed for the pharmaceutical sector prior to 2002. Given these primitives, we should not expect any effect of the reform of 2002 on the pharmaceutical firms. The estimate shows our hypothesis to be true.

Big firms pay disproportionately larger compensation to their managers and this can also influence the overall results (Autor et al., 2017). 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.

Since our dependent variable is a ratio, estimating zero-valued variables with OLS may produce biased estimates. So, we use fractional logit and Poisson Pseudo-Maximum Likelihood (PPML) (Silva and Tenreyro, 2006) in columns (5) and (6) to control for such. 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).[38] As the point estimates demonstrate, the 2002 IPR reform continues to induce significant increase in the relative share of managerial compensation.

6 Discussion of Results

We find that the change in intellectual property rights regime in India, as encapsulated in the Patent (Amendment) Act, 2002, had the following effects. The IP reform led to an increase in managers' compensation as a share of total labour compensation as well as the employment share of managers. This increase in the relative value of managers is significantly more for firms that were technologically advanced before the reform. Additionally, there is also a within-firm shift in the demand for managers, but the between-firm effect is more consistently significant across specifications. This increase in relative demand is driven by the demand both for top and middle managers.

Disaggregating the total managerial compensation into wages and incentives, we see that it is the share of incentives rather than wages that explains the difference between high- tech and low-tech firms. The rise

[38] We estimate the standard errors using Eicker-White robust covariance matrix estimator.

in incentives is stronger for the middle management than for the top management. Looking at firm-size distribution, we find that all these effects are driven particularly by the marginally big firms. In other words, IPR induces only the firms above the median but below the 90th percentile to adopt more technology and therefore demand for managers. On the other hand, the IPR change does not affect firms below the median.

We also find that the 2002 IPR reform led to between-firm reallocation of productive factors (in terms of capital employed, technology adoption). High-tech firms, as a result of the change in the IP law, started to produce more product varieties at higher quality and became more productive. These results give possible hint towards a quality-upgrading mechanism.

Lastly, these effects hold across exporters and non-exporters, domestic and foreign firms as well as firms producing final or intermediate goods. We now try to reconcile these findings with the related literature and seek to find the channels through which an IPR reform may raise the demand for managers and thereby contribute to wage inequality.

Acemoglu and coauthors, in a series of papers (Acemoglu et al., 2006; Acemoglu et al., 2007) hold that managerial skill is more valuable to firms closer to the technological frontier, and in particular for firms engaged more in innovation than imitation. The IPR reform in India increased the relative value of product innovation over process imitation by introducing monopoly rights over new products. As a result, there was an economywide increase in demand for managers. In addition, since technology intensity is complementary to managerial skills at the intensive margin, we find that the increase in relative demand for managers is stronger for more firms between 60th and 90th percentile.

While we measure technological intensity by R&D expenditure and technology transfers, there is a clutch of other complementary factors associated with technological advancement (e.g., ICT, management technology, expenditure in physical capital etc.). There is a large literature examining the correlation between these factors with innovation expenditure, organization design and demand for skilled labour (Bresnahan et al., 2002; Burstein et al., 2016; Caroli and Van Reenen, 2001; Guadalupe et al., 2014). We find that each of these has an independent effect on the increase in relative demand for managers, which is thus consistent with the large literature on capital-skill complementarity. However, even after controlling for these factors, we find that technology intensity of inputs has a statistically significant effect on share of managerial compensation for high-tech firms.

Our results are consistent with the idea of a firm as a problem solving entity enunciated in Garicano (2000). The production process essentially involves workers solving a flow of problems. Unsolved problems travel up the organizational layers, and a manager's role is to attend to the exceptional problems occurring within his/her span of control. The organizational hierarchy is designed to optimize managers' time and maximize problem solving efficiency.

The IPR reform increases the value of new products, and as the firm undertakes more new product development the complexity of the problems faced by the firm increases significantly. Since the production workers (non-managers) are faced with more challenging or exceptional problems, the role of the manager becomes more valuable to the firm. This explains the increase in the demand for managers relative to production workers consequent to the IPR reform. Our results, especially the between-firm increase in demand for managers is consistent with the idea of IPR reforms inducing patent-races (Branstetter et al., 2006). While product patents increased the gains from product innovation, the firms that were already technologically advanced had a deeper stock of technical knowledge, skills and resources and therefore were at an advantage in such races. Therefore, the expected gains from new product development increased more for firms already ahead in the race. We find significant evidence of such conjectures, when we look at product varieties and quality of products.

Our data shows a sharp rise in performance pay especially for high-tech firms while the larger literature provides at best mixed support for short term incentives as a way of motivating innovation (Teece, 1994; Amabile, 1996; Lerner and Wulf, 2007; Kline at al., 2017). On the other hand, similar increase in incentives have been reported due to trade shocks or increased market competition (Cunat and Guadalupe, 2009; Keller and Olney, 2017). We hypothesize that the new IPR regime suddenly created a climate of competition among firms in the race to capture monopoly rights. In this environment, the increase in performance pay was possibly a measure adopted by firms in order to motivate managers to not only engage in innovation but to innovate fast enough to be able to win the patent race.

Our result on product varieties and product quality validate this idea of managers being incentivized for patent races. There was a sharp increase in the number of new products introduced and product quality by high-tech firms. On the other hand, the shift in compensation structure towards incentives was sharper for middle managers who were typically the divisional heads. Notice that it is these middle level managers, i.e., heads of product divisions and managers of functions like R&D, production, marketing, strategy etc. that drive the entire process of conceptualizing and bringing a new product to the market. We believe that the main effect of IPR on firm structure was a sharp increase in the employment and compensation of middle managers in high-tech firms, and sharper provision of incentive to these managers in order to reduce the time to market for new products.

Our findings inform us on the debate on whether management practices can be improved through incentives or information (Bloom et al., 2017). In this debate, one side thinks of management practices as the optimal design for the particular environment while the other side considers quality of management as any other technological input which can be increased through appropriate measures. While we do not observe changes in management practices, we find that sharper incentives indeed improve R&D output. In this sense, our results provide support for the idea of managerial input as any other factor of production.

We close this section with a comment comparing the IPR shock with a trade shock. Some of our results like increased demand for managers, higher between-firm wage inequality, sharper incentives, etc. have also been observed elsewhere due to increased competitiveness because of trade shocks. However, while a trade shock typically affects those industries that are engaged in export or import, we find that a change in property rights over innovation affects virtually all sectors of the economy. It is this pervasiveness of impact that underlines the importance of intellectual property as a lever of policy and driver of welfare.

7 Conclusion

We investigate the effect of an IPR reform on wage structure and whether this effect will be different for high-tech vis-à-vis low-tech firms. We argue that stronger patent rights due to an IPR reform will induce a high-tech firm to innovate more, creating higher demand for managers. This is driven by the complementarity between managerial skill, technology adoption and innovation. 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 1.6–2.2%, with the effect driven by only the 3rd quartile of firms. This effect is robust to various controls, specifications, estimation techniques and time periods. Our results provide suggestive evidence for a quality upgrading mechanism through capital-skill complementarity.

Our results are also indicative of the kind of changes a developing economy like India goes through with increasing formalization and integration with the global economy. Associated with the upgradation of quality in the technologically advanced firms, we find evidence of increasing wage inequality in two dimensions: between managers and non-managers as well as between high-tech and low-tech firms. Such wage polarization appears to be an important economic trade-off associated with globalization of developing economies.

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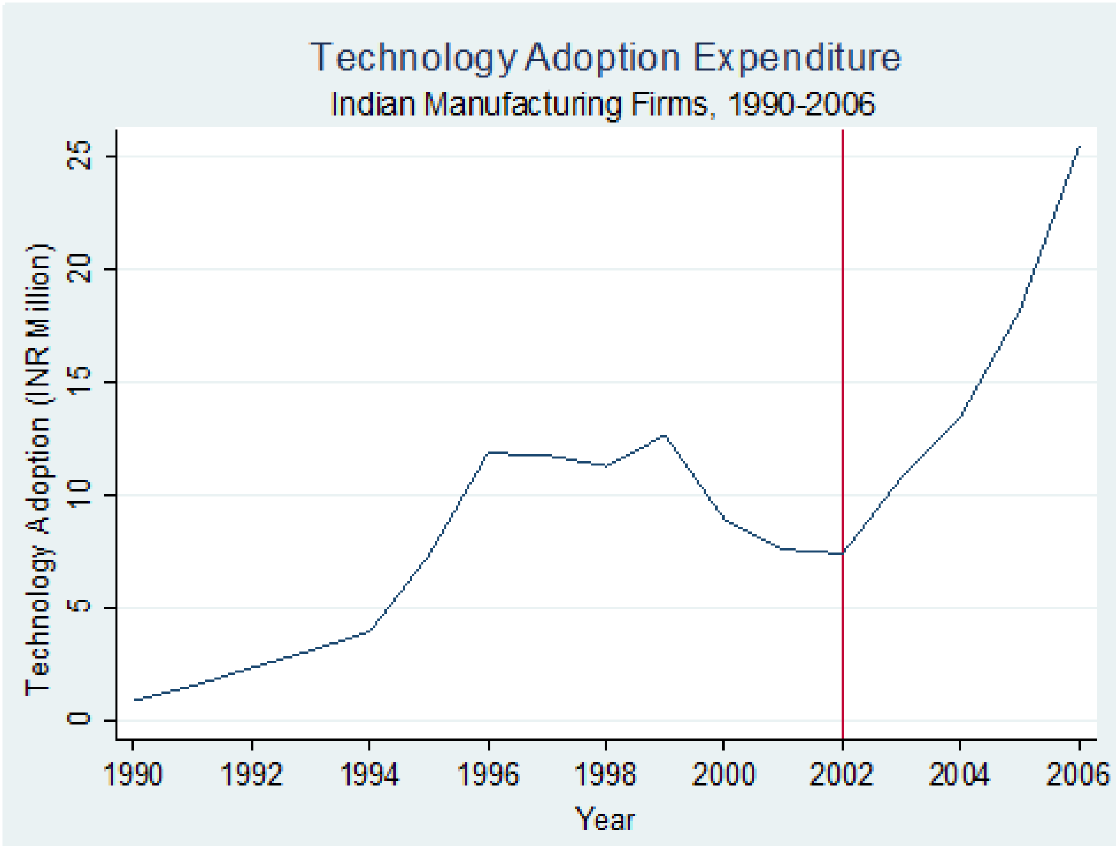

Figure 1: Technology Adoption: Indian Manufacturing Firms, 1990-2006
Notes: Figure presents the average technology adoption (sum of R&D expenditure and Technology Transfer) for manufacturing firms in India, 1990-2006

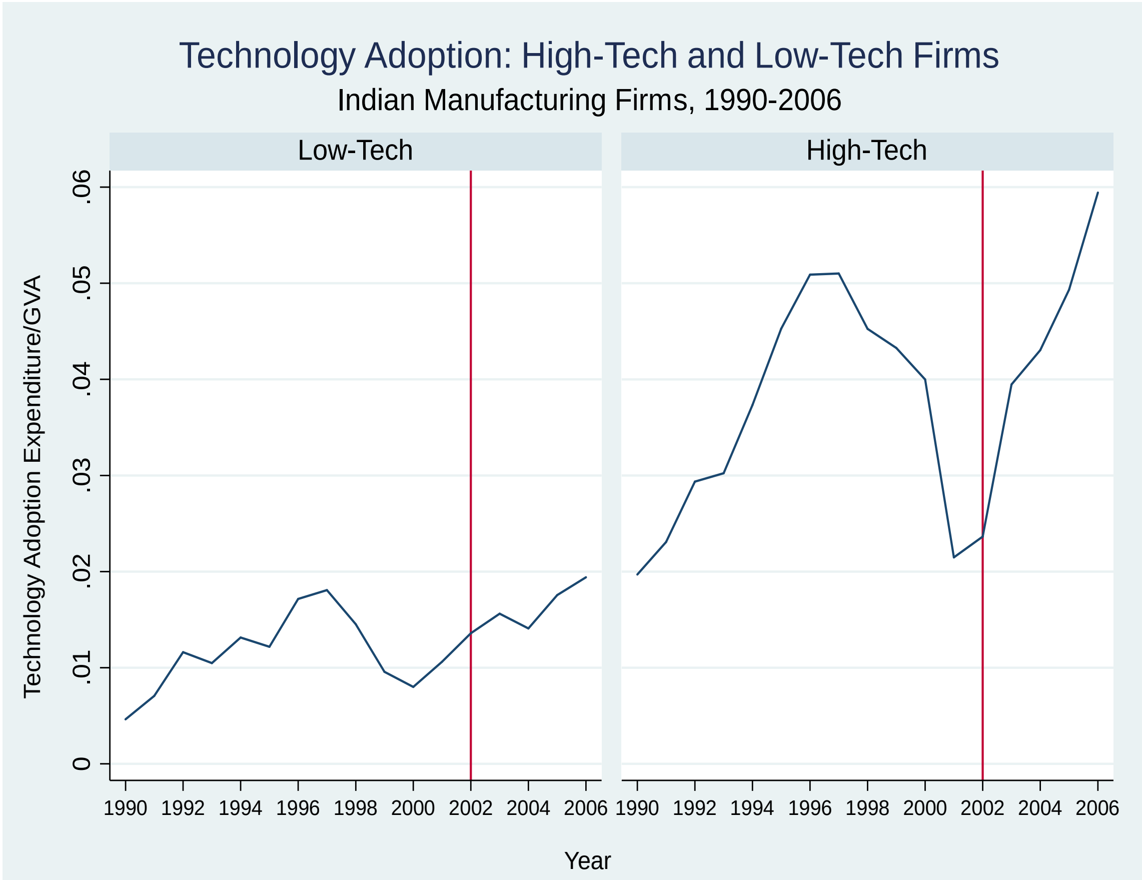

Figure 2: Technology Adoption: High-Tech and Low-Tech Firms, 1990-2006

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

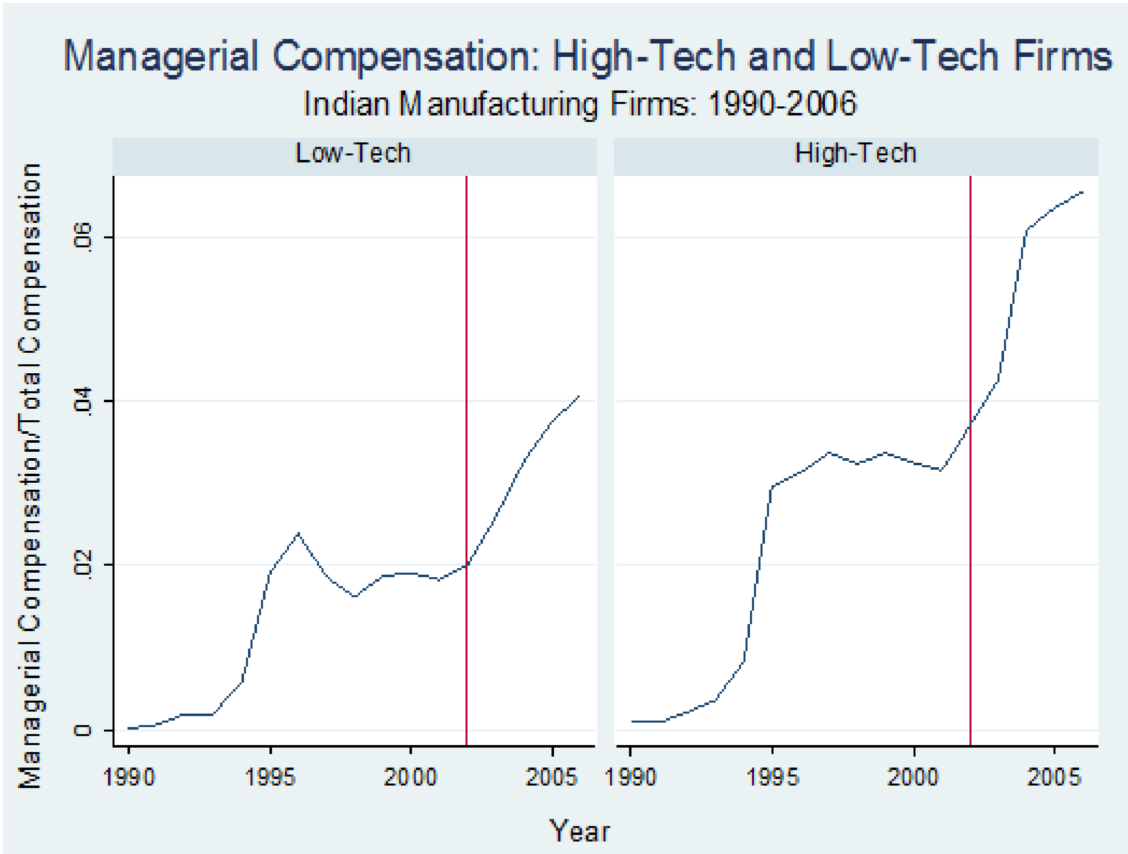

Figure 3: Managerial Compensation: High-Tech and Low-Tech Firms, 1990-2006

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

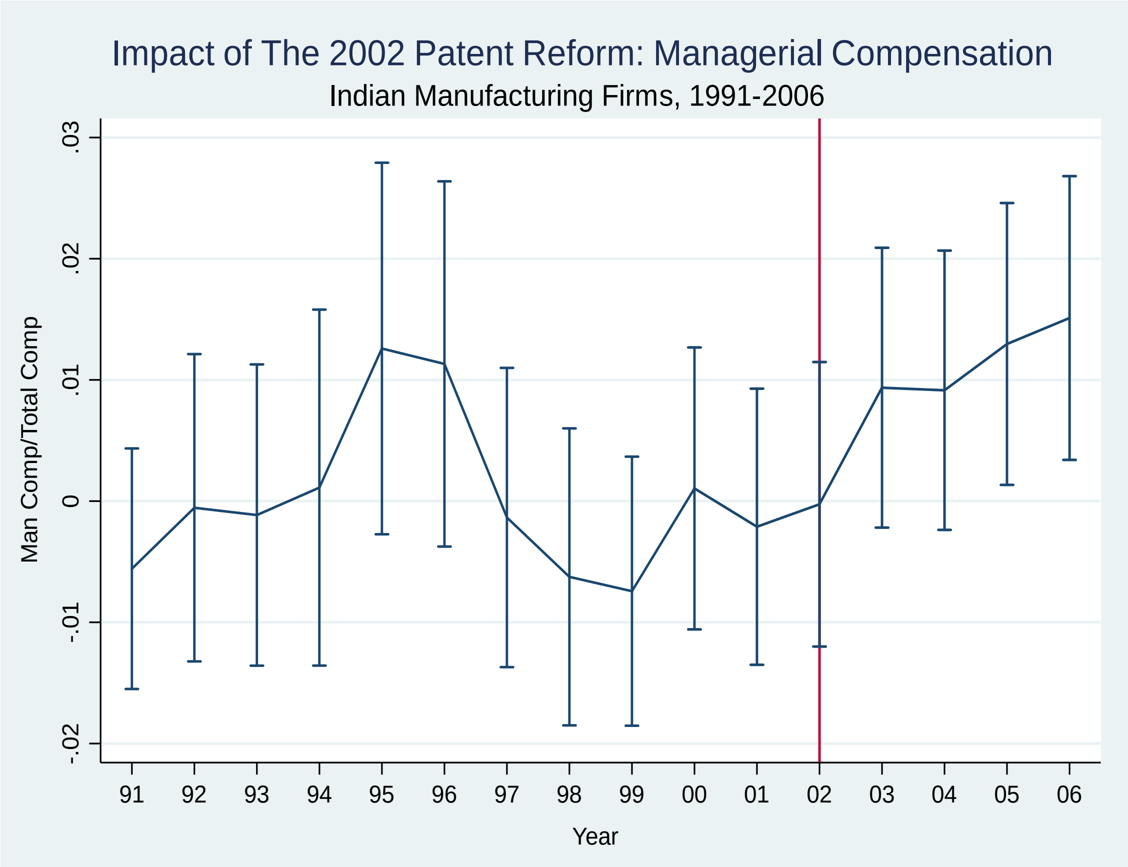

Figure 4: Impact of 2002 IPR reform: Managerial Compensation, 1991-2006

Notes: Figure presents the response of the difference in the share of managerial compensation in total labour compensation for high-tech and low-tech firms in our sample for the period 1991-2006. 95% confidence intervals are shown.

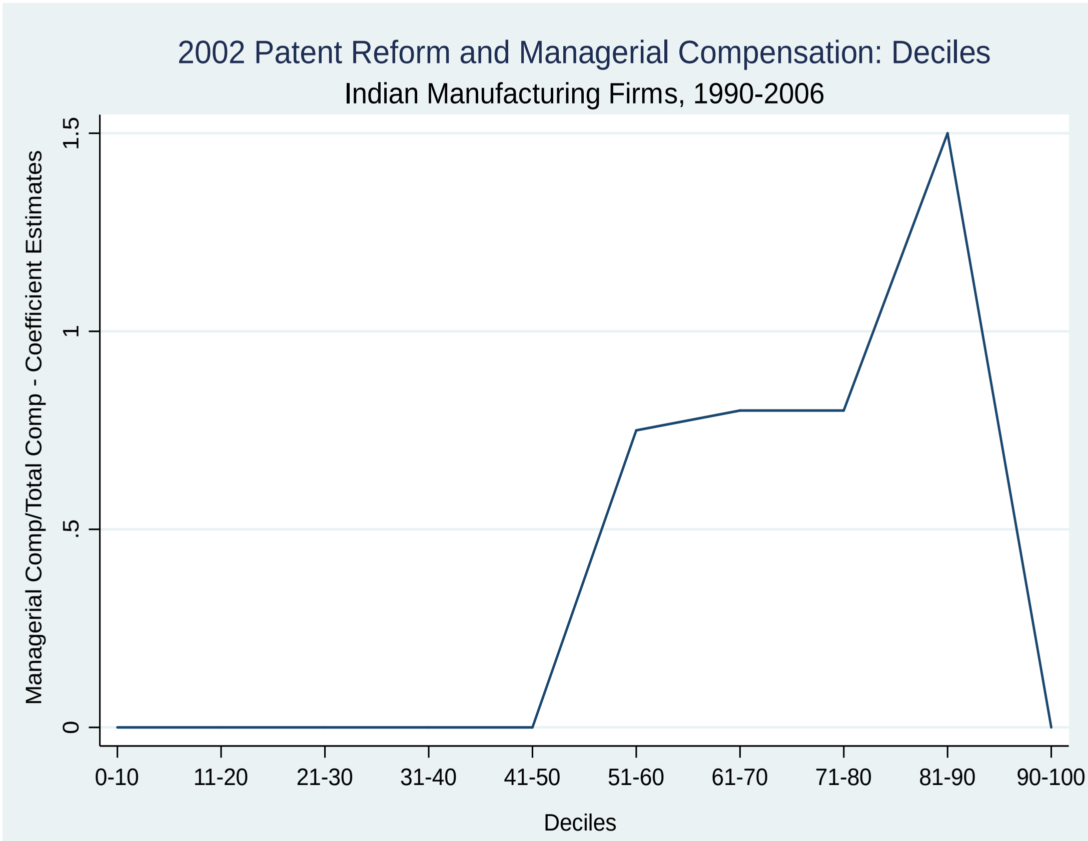

Figure 5: 2002 IPR reform and Managerial Compensation, Dividing Firms into Deciles
Notes: Figure presents the response of the difference in the share of managerial compensation in total labour compensation for firms within each decile in our sample for the period 1990-2006.

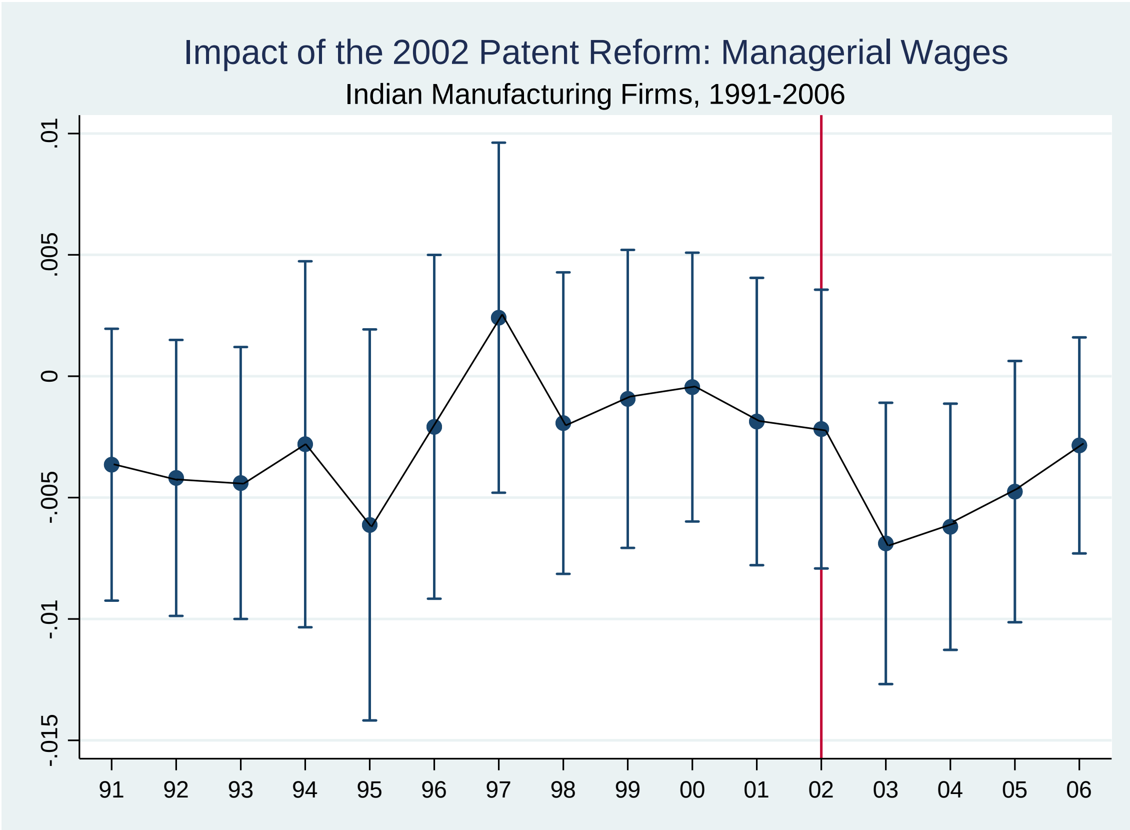

Figure 6: Impact of 2002 IPR reform: Managerial Wages, 1991-2006

Notes: Figure presents the response of the difference in the share of managerial wages in total labour wages for high-tech and low-tech firms in our sample for the period 1991-2006. 95% confidence intervals are shown.

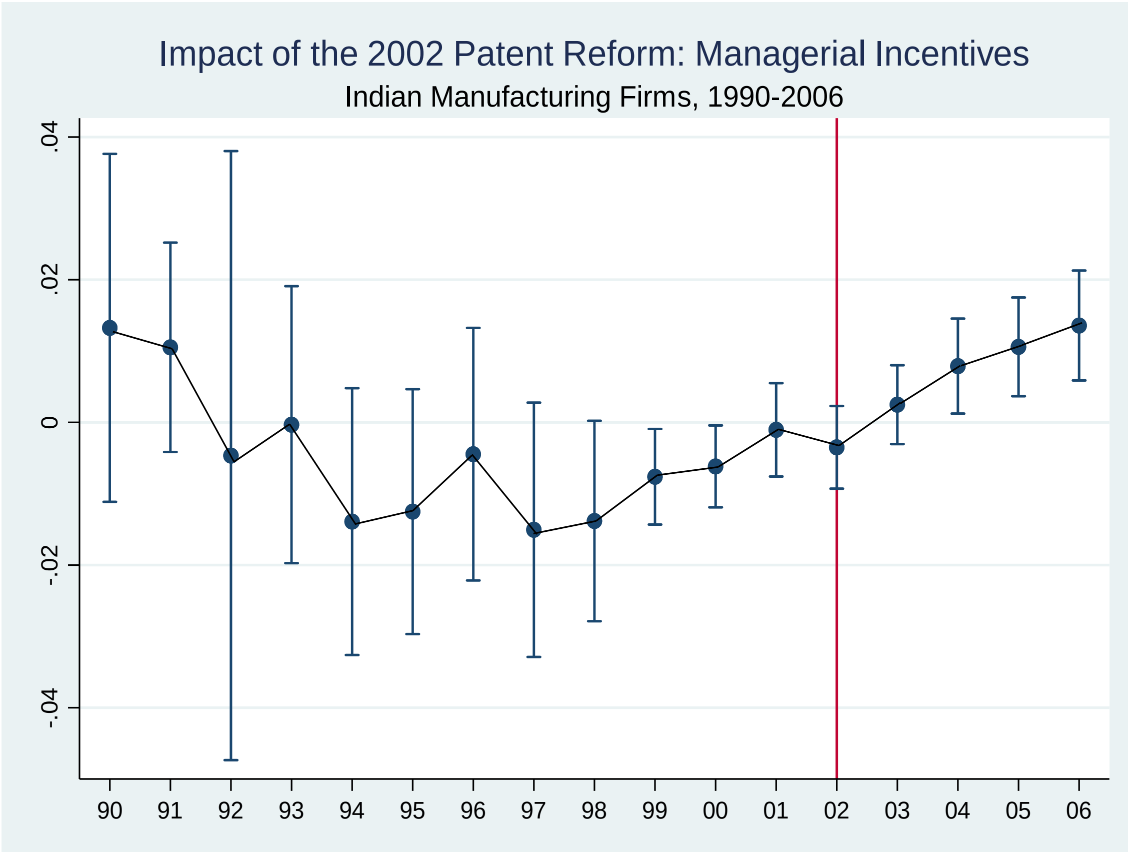

Figure 7: Impact of 2002 IPR reform: Managerial Incentives, 1990-2006

Notes: Figure presents the response of the difference in the share of managerial wages in total labour wages for high-tech and low-tech firms in our sample for the period 1990-2006. 95% confidence intervals are shown.

Table 1: Comparison of High-tech and Low-tech firms

	Pre-ReformPeriod (1990-2001)		Post-ReformPeriod (2002-2006)	
	Low-tech	High-tech	Low-tech	High-tech
Technology Adoption/GVA	0.0031	0.0456	0.0039	0.1673
Managerial Comp/Total Comp	0.0122	0.0187	0.0219	0.0537
Capital/GVA	2.7466	2.8870	2.9477	3.9560
Imports/GVA	0.2853	0.3950	0.3042	1.3872
Exports/GVA	0.2787	0.2832	0.3930	0.5119
Sales/GVA	2.7450	2.8528	3.2992	4.5127

Notes: Annual data at the firm-level, covering the period of 1990-2006. Numbers represent average values over the period mentioned. 'Technology Adoption' is defined as the sum of Research and Development Expenditure and Royalty Payments for Technical Knowhow (Technology Transfer). 'Managerial Compensation/Total Compensation' is the share of managerial compensation in total labour compensation. 'Capital' is the amount of capital employed by each firm. 'Imports' is total imports of a firm. Total imports is the sum of import of raw materials, capital goods, finished goods and store and spares. 'Exports' is total exports of a firm. 'Sales' is total sales (exports plus domestic sales). 'GVA' is the gross value-added of a firm. It is defined as total sales minus total expenditure on raw materials.

Table 2: Descriptive Statistics

	Mean	Median	Std. Dev.	Min	Max
Panel A: Organizational Variables - Dependent Variables					
Managerial Comp/Total Comp	0.09	0.05	0.13	$8.90e-06$	1
Managerial Compensation	6.51	1	343.94	0.1	66315.1
Number of Managers	1.82	2	0.85	1	9
Non-Managerial Compensation	99.67	14.8	675.13	0.1	52189.1
Managerial Wages	7.97	1.2	477.26	0.1	57590.5
Non-Managerial Wages	97.72	14.2	630.49	0.1	39720.6
Managerial Bonuses	3.49	0.3	19.43	0.1	8724.6
Non-Managerial Bonuses	21.95	3.5	147.55	0.1	9089.5
Product Varieties	4.49	3	4.44	1	86
Productivity	0.52	0.37	0.52	0.02	5.52
Panel B: Firm/Industry-level Determinants - Explanatory Variables					
Capital Employed	1049.62	128.1	10599.64	2	891409
Technology Adoption/GVA	0.03	0	5.69	0	2163
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
$(ChM/TotalM)_{India}$	10.68	4.47	13.77	0.005	93.66
$(ChM/TotalM)_{US}$	14.22	12.03	11.68	0.007	100
Skill Intensity	0.26	0.25	0.07	0.04	0.71
Management Technology	2.41	2.48	0.60	0	3.17
Factories	3920.77	3315	3037.77	15	14486
IT Expenditure	0.07	0	5.24	0	999.7
Consultancy Fees	8.13	0	217.53	0	46822.8

Notes: Annual data at the firm-level, covering the period of 1990-2006. Monetary values are in real INR Millions. ‘Managerial Comp/Total Comp’ is the share of managerial compensation in total labour compensation. ‘Managerial Compensation’ is the total managerial compensation. ’Number of Managers’ is the total number of managers (middle plus top) in a firm. ’Non-Managerial Compensation’ is the total non-managerial compensation. ’Managerial Wages’, ’Non-Managerial Wages’, ’Managerial Bonuses’ and ’Non-Managerial Bonuses’ is the total managerial wages, total non-managerial wages, managerial bonuses and non-managerial bonuses. ‘Layers’ is the number of vertical or hierarchial layers.’Product Scope’ is the number of products manufactured by a firm in a single year. ‘Capital Employed’ is the amount of capital employed by a firm. ‘Technology Adoption/GVA’ is defined as the share of the sum of Research and Development Expenditure and Royalty Payments for Technical Knowhow (Technology Transfer) in gross value-added of a firm. ‘Assets’ is the total assets of a firm. ‘Tariffs (input and output)’ are at the 3-digit NIC 2004. ‘$(ChM/TotalM)_{India}$’ is the share of Chinese imports in total imports of India. ‘$(InM/TotalM)_{US}$’ is the share of Indian imports in total imports of the US. ’Skill Intensity’ is the ratio of non-production workers to total employees at the 3-digit NIC 2004. ’Management Technology’ is a measure of management quality score obtained from Bloom and Van Reenen (2010) at 2-digit NIC 2004. ‘Factories’ is the number of factories at 3-digit NIC 2004. ‘Productivity’ is a firm-level measure, estimated following the Levinsohn and Petrin (2003) methodology. ’IT Fees’ is the amount of within-firm expenditure towards information technology services. ’Consultancy Fees’ is the amount of expenditure incurred by a firm towards information technology services, but from external sources.

Table 3: Endogeneity of The Patents (Amendment), Act, 2002

					Pre-Reform Characteristics			
	Managerial Compensation/ Total Compensation				ManComp/ TComp	Skilled Workers	Factory Size	$IPR_{02}\times$ $HighTech$
	1999 Reform			Ex-ante Ex-post				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IPR_{02}	0.030^{***} (0.005)	0.027^{***} (0.004)	0.028^{***} (0.004)	0.006^{*} (0.003)				
IPR_{99}	-0.005 (0.007)	-0.002 (0.007)	-0.001 (0.008)					
$IPR_{02}\times HighTech_{i,90-01}$	0.005^{**} (0.003)	0.007^{**} (0.002)	0.006^{*} (0.007)	0.006^{***} (0.007)	-0.0001 (0.002)	0.0001 (0.002)	-0.001 (0.008)	
$IPR_{99}\times HighTech_{i,90-01}$	0.001 (0.002)							
$IPR_{99}\times HighTech_{i,90-98}$		-0.006^{*} (0.003)	-0.006^{*} (0.003)					
$IPR_{02}\times HighTech_{i,90-98}$			0.001 (0.003)					
$IPR_{02}(t-4)\times HighTech_{i,90-01}$				-0.009 (0.007)				
$IPR_{02}(t-3)\times HighTech_{i,90-01}$				0.005 (0.005)				
$IPR_{02}(t-2)\times HighTech_{i,90-01}$				0.001 (0.003)				
$IPR_{02}(t+1)\times HighTech_{i,90-01}$				0.011^{***} (0.003)				
$IPR_{02}(t+2)\times HighTech_{i,90-01}$				0.016^{***} (0.004)				
$IPR_{02}(t+3)\times HighTech_{i,90-01}$				0.021^{***} (0.005)				
$IPR_{02}(t+4)\times HighTech_{i,90-01}$				0.024^{***} (0.006)				
$(\text{Mcomp/Tcomp})_{t-2}$								0.005 (0.012)
$(\text{CapEmployed})_{t-1}$	0.005^{***} (0.002)	0.006^{***} (0.001)	0.005^{***} (0.002)	0.005^{***} (0.002)	0.005^{***} (0.001)	0.005^{***} (0.002)	0.005^{***} (0.001)	0.017^{***} (0.005)
Firm Controls_{t-1}	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	62,677	62,677	62,677	62,677	56,086	56,081	56,081	56,086
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 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 '$IPR_{02}\times HighTech_{i,90-01}$' as the dependent variable. IPR_{02} is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding 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. '$HighTech_{i,90-98}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 1998, is greater than the median of the corresponding industry (to which the firm belongs). '$(\text{Mcomp/Tcomp})_{t-2}$' 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. Firm controls include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 4: Intellectual Property Regimes and Wage Inequality: Benchmark Results

	Managerial Compensation/Total Compensation					
						ATT
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.013*** (0.004)	0.016*** (0.005)	0.008 (0.009)	−0.016 (0.010)	0.015*** (0.004)	Yes
$IPR_{02} \times HighTech_{i,90-01}$	0.016*** (0.002)	0.017*** (0.002)	0.017*** (0.002)	0.017*** (0.002)	0.010*** (0.003)	0.017^a (0.002)
$(\text{CapEmployed})_{t-1}$	0.004** (0.002)	0.005*** (0.002)	0.005*** (0.002)	0.005*** (0.002)	0.004** (0.002)	Yes
$HighTech_{i,90-01}\times$ Year FE	No	No	No	No	Yes	No
Firm Controls_{t-1}	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.49	0.49	0.49	0.50	0.49	n/a
N	57,461	57,461	57,461	57,461	57,461	68,016
Firm FE	Yes	Yes	Yes	Yes	Yes	No
Year FE	Yes	No	No	No	No	No
Industry FE (5-digit)*Year Trend	Yes	No	No	No	Yes	Yes
Industry FE (2-digit)*Year FE	No	Yes	No	No	No	No
Industry FE (3-digit)*Year FE	No	No	Yes	No	No	No
Industry FE (4-digit)*Year FE	No	No	No	Yes	No	No

Notes: Columns (1) – (6), (7) and (8) use share of managerial compensation in total compensation, share of managerial compensation for middle managers and top managers as the dependent variable, respectively. 'IPR_{02}' is a dummy variable, which takes a value 1 if year $\geq$ 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Capital Employed' is the total amount of capital used by a firm. Firm controls include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 5: Intellectual Property Regimes and Wage Inequality: Dividing Firms into Quintiles and Deciles - Checking for the Control Group

	Managerial Compensation/Total Compensation					
	Quintile			Decile		
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.016*** (0.005)	0.018*** (0.006)	0.022*** (0.004)	0.015*** (0.005)	0.018*** (0.006)	0.016*** (0.005)
$IPR_{02} \times Qtile_1$	0.004 (0.006)	0.005 (0.006)	0.003 (0.007)			
$IPR_{02} \times Qtile_2$	0.002 (0.005)	0.003 (0.004)	0.001 (0.005)			
$IPR_{02} \times Qtile_3$	0.006 (0.004)	0.007* (0.004)	0.007* (0.004)			
$IPR_{02} \times Qtile_4$	0.006* (0.004)	0.007** (0.004)	0.007** (0.004)			
$IPR_{02} \times Qtile_5$	0.010** (0.005)	0.012** (0.005)	0.011** (0.005)			
$IPR_{02} \times Decile_1$				0.010 (0.007)	0.011 (0.008)	0.005 (0.010)
$IPR_{02} \times Decile_2$				0.008 (0.006)	0.009 (0.006)	0.004 (0.007)
$IPR_{02} \times Decile_3$				0.002 (0.008)	0.002 (0.007)	0.003 (0.008)
$IPR_{02} \times Decile_4$				0.009 (0.008)	0.010 (0.008)	0.0002 (0.007)
$IPR_{02} \times Decile_5$				0.007 (0.006)	0.008 (0.006)	0.011 (0.008)
$IPR_{02} \times Decile_6$				0.007* (0.004)	0.008* (0.004)	0.007* (0.004)
$IPR_{02} \times Decile_7$				0.008* (0.005)	0.008* (0.005)	0.008* (0.005)
$IPR_{02} \times Decile_8$				0.008* (0.004)	0.009* (0.006)	0.007* (0.004)
$IPR_{02} \times Decile_9$				0.014** (0.007)	0.016** (0.008)	0.014** (0.007)
$IPR_{02} \times Decile_{10}$				0.007 (0.007)	0.009 (0.007)	0.007 (0.007)
$Qtile_i(Decile_i)\times$ Year FE	No	No	Yes	No	No	Yes
Firm Controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.48	0.48	0.48	0.50	0.50	0.50
N	57,461	56,981	57,461	52,391	51,795	52,391
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE (5-digit)*Year Trend	Yes	No	Yes	Yes	No	Yes
Industry FE (2-digit)*Year FE	No	Yes	No	No	Yes	No

Notes: Columns (1) – (6) use share of managerial compensation in total labour compensation. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$Qtile$' (quintile) or '$Decile$' (decile) are dummy variables. For example, in case of $Qtile_1$, it takes a value 1 if a firm's average GVA share of technology adoption expenditure (R&D Expenditure + Technology Transfer) on or before the year 2001 falls wihtin the 0-20th percentile of the corresponding industry's technology adoption and so on. Similarly, in case of decile. If a firm's average GVA share of technology adoption expenditure on or before the year 2001 falls within 0-10th percentile of the corresponding industry's technology adoption expenditure, $Decile_1$ takes a value 1 and so on. 'Firm Controls' include age, age squared of a firm, capital employed and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used at $t-1$ period and 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 6: Intellectual Property Regimes and Wage Inequality: Disaggregating the Compensation - Wages and Incentives

	Managerial Wages/ Total Wages	Managerial Incentives/ Total Incentives
	(1)	(2)
IPR_{02}	0.019^{***} (0.006)	-0.013 (0.023)
$IPR_{02} \times HighTech_{i,90-01}$	-0.008^{**} (0.004)	0.032^{**} (0.013)
$(\text{CapEmployed})_{t-1}$	0.004^{*} (0.002)	0.006 (0.005)
Firm Controls_{t-1}	Yes	Yes
R-Square	0.62	0.78
N	57,461	57,461
Firm FE	Yes	Yes
Year FE	Yes	Yes
Industry FE (5-digit)*Year Trend	Yes	Yes

Notes: Columns (1) and (2) use ratio of managerial wages 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. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Capital Employed' is the total amount of capital used by a firm. Firm controls include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 Wage Inequality: Categorizing Industries into High- and Low-IP intensive Industries

	Managerial Compensation/Total Compensation					
	High-IP Group			High-IP Clusters		
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.032*** (0.007)	0.033*** (0.009)	−0.001 (0.002)	0.024*** (0.003)	0.023*** (0.004)	0.001 (0.001)
$IPR_{02} \times HighIP_j$	0.012** (0.005)	0.013* (0.007)	0.003** (0.001)	0.005* (0.003)	0.010** (0.005)	0.001* (0.000)
$HighIP_j \times$ Year FE	No	Yes	No	No	Yes	No
Firm Controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.61	0.61	0.61	0.59	0.59	0.59
N	22, 119	22, 119	22, 119	31, 726	31, 726	31, 726
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) – (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 $\geq$ 2002 in columns (1) - (2) and (4) - (5). In columns (3) and (6), 'IPR_{02}' takes 1 for year 2002, 2 for 2003, 3 for 2004 and so on. We use it in an increasing oder to measure the intensity of the 2002 IPR reform over the years. '$HighIP_j$' is a dummy variable which takes a value 1 if an industry is classified into 'High-IP product' or 'High-IP cluster' in columns (1) - (3) and (4) - (6), respectively. We use this classification from Delgado et al. (2013). 'Firm Controls' include age, age squared of a firm, size (assets) of a firm and capital employed by a firm. Both 'Capital Employed' and 'Assets' at used at $t-1$ period and 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 Wage Inequality: Between-Firm Responses

	Factors of Production			Product Variety	Product Quality	Productivity
	Capital Expenditure	R&D Expenditure	Technology Transfer			
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.172*** (0.033)	−0.093 (0.082)	−0.113 (0.142)	−0.048 (0.033)	−0.605 (0.545)	−0.023 (0.016)
$IPR_{02} \times HighTech_{i,90-01}$	0.250*** (0.014)	0.643*** (0.029)	0.217*** (0.027)	0.073*** (0.017)	0.401*** (0.094)	0.040*** (0.006)
Firm Controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.95	0.74	0.67	0.72	0.36	0.61
N	57,632	62,805	62,804	57,461	253,162	62,805
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: The dependent variable in columns (1), (2) and (3) is the natural logarithm of capital expendiure, R&D expenditure and Expenditure on Technology Transfer. Columns (4), (5), and (6) use product variety, product quality and total productivity of a firm. We measure total productivity using Levinshon and Petrin (2003) methodology. 'IPR_{02}' is a dummy variable, which takes a value 1 if year $\geq$ 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Firm Controls' include age of a firm, age squared, size (assets), and capital employed (except for column (1)) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and in their natural logarithmic form. Numbers in the parenthesis are clustered standard errors at the firm-level. Intercepts are not reported.*,**,*** denotes 10%, 5% and 1% level of significance.

Table 9: Intellectual Property Regimes and Wage Inequality: Firm Characteristics

	Managerial Compensation/Total Compensation					
	Export Orientation		Ownership		End Use	
	Exporters	Non Expoters	Domestic	Foreign	Intermediate Goods	Final Goods
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.023*** (0.005)	0.017* (0.009)	0.013*** (0.005)	0.007 (0.011)	0.008 (0.005)	0.016* (0.009)
$IPR_{02} \times HighTech_{i,90-01}$	0.004** (0.002)	0.015*** (0.005)	0.016*** (0.002)	0.022*** (0.005)	0.016*** (0.003)	0.017*** (0.003)
$(\text{CapEmployed})_{t-1}$	0.005*** (0.002)	0.006** (0.002)	0.004** (0.002)	0.004 (0.003)	0.003 (0.003)	0.005** (0.002)
Firm Controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.69	0.54	0.50	0.50	0.46	0.50
N	31,640	26,001	49,641	7,820	25,903	31,558
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) – (6) use share of managerial compensation in total labour compensation as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Capital Employed' is the total amount of capital used by a firm. Firm controls include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 10: Intellectual Property Regimes and Wage Inequality: Controlling for Different types of Trade Shocks

	Managerial Compensation/Total Compensation				
	India's Trade Liberalization Program			Domestic Market Competition - China	Export Market Competition - US
	(1)	(2)	(3)	(4)	(5)
IPR_{02}	0.013*** (0.005)	0.014*** (0.004)	0.013*** (0.005)	0.015*** (0.005)	0.015*** (0.005)
$IPR_{02} \times HighTech_{i,90-01}$	0.010*** (0.002)	0.010*** (0.002)	0.011*** (0.002)	0.015*** (0.002)	0.022*** (0.003)
$HighTech_{i,90-01} \times InpTariff_{t-1}$	0.003*** (0.001)		−0.006 (0.008)		
$HighTech_{i,90-01} \times OutTariff_{t-1}$		0.003*** (0.001)	0.009 (0.008)		
$InpTariff_{t-1}$	−0.004* (0.002)		−0.004** (0.002)		
$OutTariff_{t-1}$		−0.002 (0.002)	−0.0002 (0.001)		
$DComp_{IN}^{China} \times HighTech_{i,90-01}$				0.0002 (0.0002)	
$FComp_{IN}^{China} \times HighTech_{i,90-01}$					−0.004* (0.002)
$(\text{CapEmployed})_{t-1}$	0.005** (0.002)	0.005*** (0.002)	0.005*** (0.002)	0.004*** (0.002)	0.005** (0.002)
Firm Controls_{t-1}	Yes	Yes	Yes	Yes	Yes
R-Square	0.50	0.50	0.50	0.49	0.49
N	52,391	52,391	52,391	52,014	56,971
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE (5-digit)*Year Trend	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1) – (5) use share of managerial compensation in total compensation and average managerial compensation as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. "$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). '$InpTariff_{t-1}$' and '$OutTariff_{t-1}$' are input and output tariffs at 2004 NIC (National Industrial Classification) 4-digit level, respectively. '$DComp_{IN}^{China}$' is the measure of Chinese import competition faced by Indian firms in the domestic market. '$FComp_{IN}^{China}$' is the measure of export market competition faced by Indian firms in an export destination (US). 'Capital Employed' is the total amount of capital used by a firm. Firm controls include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 11: Intellectual Property Regimes and Wage Inequality: Controlling for Other Possible Channels

	Managerial Compensation/Total Compensation							
	Skill Intensity	Management Technology	Factories	Total Factor Productivity	IT and Consul Fees	Family Firm	Insider Board	Labour Regulation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IPR_{02}	0.015*** (0.004)	0.015*** (0.004)	0.015*** (0.004)	0.012** (0.006)	0.015*** (0.004)	0.009** (0.004)	0.003 (0.028)	0.024** (0.011)
$IPR_{02} \times HighTech_{i,90-01}$	0.007*** (0.002)	0.007*** (0.002)	0.007*** (0.002)	0.010*** (0.002)	0.010*** (0.002)	0.016*** (0.002)	0.003 (0.006)	0.016*** (0.002)
$HighTech_{i,90-01} \times SkIntens_{t-1}$	0.010*** (0.002)							
$HighTech_{i,90-01} \times ManTech$		0.003*** (0.001)						
$HighTech_{i,90-01} \times Factories_{t-1}$			0.016*** (0.003)					
$HighTech_{i,90-01} \times TFP_{t-1}$				0.009** (0.0004)				
$HighTech_{i,90-01} \times ITFees_{t-1}$					0.003 (0.006)			
$HighTech_{i,90-01} \times ConsFees_{t-1}$					0.005*** (0.001)			
$IPR_{02} \times HighTech_{i,90-01} \times Familyfirm_i$						−0.0003 (0.000)		
$IPR_{02} \times HighTech_{i,90-01} \times IndDir_{it}$							−0.006 (0.007)	
Firm Controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.49	0.49	0.49	0.70	0.49	0.51	0.87	0.51
N	57,456	56,210	57,456	26,264	56,084	52,391	4,834	52,391
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
State FE*Year FE	No	No	No	No	No	No	No	Yes

Notes: Columns (1) – (8) use share of managerial compensation in total compensation and average managerial compensation as the dependent variable. '$SkIntens$' is a proxy for skill intensity at the industry-level. It is defined as the share of non-production workers to total employees at the NIC 3-digit level. '$ManTech$' is an index of Management Quality at 2004 NIC 2-digit level and 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). '$ITFees$' is the expenditure by a firm towards its information technology enabled services. '$ConsFees$' is the expenditure by a firm towards its consultancy for technological upgradation or transfer. '$Familyfirm$' is an indicator for family firm constructed based on the percentage of shares held by the Hindu undivided-family as promoters in 2007. '$IndDir$' is the number of independent directors within the Board of Directors of a firm. It is an indicator for poor governance settings. 'IPR_{02}' is a dummy variable, which takes a value 1 if year $\geq$ 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Firm Controls' include age, age squared of a firm, capital employed and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used at $t-1$ period and 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 12: Intellectual Property Regimes and Wage Inequality: Trend Break Analysis

	Man Comp/ Total Comp		Total Managers	Avg Managerial Compensation
	(1)	(2)	(3)	(4)
$HighTech_{i,90-01} \times (t-2001)Trend$	0.001^{***} (0.000)	0.001^{***} (0.000)	0.005 (0.004)	0.038^{**} (0.015)
$HighTech_{i,90-01} \times (2002-2006)Trend$	0.005^{***} (0.000)	0.005^{***} (0.000)	0.020^{***} (0.005)	0.050^{***} (0.013)
$IPR_{02} \times (t-2001)Trend$	0.003 (0.002)	−0.001 (0.004)	−0.017 (0.026)	−0.014 (0.082)
$IPR_{02} \times (2002-2006)Trend$	0.006^{***} (0.001)	0.008^{**} (0.004)	0.157^{***} (0.023)	0.010 (0.047)
$(\text{CapEmployed})_{t-1}$	0.004^{**} (0.002)	0.004^{**} (0.002)	0.075^{**} (0.031)	0.168 (0.164)
Firm Controls_{t-1}	Yes	Yes	Yes	Yes
R-Square	0.49	0.49	0.52	0.81
N	57,461	57,461	10,252	4,371
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE (5-digit)*Year Trend	Yes	No	Yes	Yes
Industry FE (2-digit)*Year FE	No	Yes	No	No

Notes: Columns (1) – (2), (3), and (4) use managerial share of total compensaiton, total number of managers, and average managerial compensation as the dependent variable, respectively. 'IPR_{02}' is a dummy variable, which takes a value 1 if year $\geq$ 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). '$(t-2001)Trend$' captures the differntial pre-trend and post-trends of the 2002 Patent reform, whereas '$(2002-2006)Trend$' only captures a fixed time trend after the Patent Reform of 2002. 'Capital Employed' is the total amount of capital used by a firm. 'Firm Controls' include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 13: Intellectual Property Regimes and Wage Inequality: Other Robustness Checks

	Managerial Compensation/Total Compensation					
	Time Period: 1990-2005	Industry-Level	Only Pharma	Drop Firms > 90th Percentile	Fractional Logit	PPML
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.043*** (0.009)	−0.028 (0.018)	0.004 (0.005)	0.039*** (0.009)	3.378*** (0.840)	−0.264*** (0.029)
$IPR_{02} \times HighTech_{i,90-01}$	0.005** (0.002)	0.007** (0.003)	0.006 (0.006)	0.006*** (0.002)	0.126*** (0.029)	0.083*** (0.027)
$(\text{CapEmployed})_{t-1}$	0.005** (0.002)	0.001 (0.003)	0.005 (0.006)	0.005** (0.002)	0.540*** (0.040)	0.563*** (0.035)
Firm Controls_{t-1}	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.50	0.60	0.50	0.50	n/a	0.04
N	57,339	1,742	8,880	62,674	62,677	62,677
Firm FE	Yes	No	Yes	Yes	Yes	Yes
Industry FE	No	Yes	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE (5-digit)*TimeTrend	Yes	Yes	Yes	Yes	Yes	Yes

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 $\geq$ 2002. '$HighTech_{i,90-01}$'$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Capital Employed' is the total amount of capital used by a firm. 'Firm Controls' include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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.

Appendix

A Data

We use a yearly 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). All industry-level variables 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 wages and 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. $HighTech$: It takes a value 1 if the average of R&D expenditure and royalty payments for technical knowhow (technology transfer) is greater than the median of the industry average of the corresponding industry of the firm and zero otherwise.

7. IPR_{02}: It takes a value 1 if year is greater than equal to 2002.

8. **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 (2018).

9. $DComp_{IN}^{China}$: Share of Chinese imports in total imports of India. It is a measure of import competition that Indian firms face at the domestic market.

10. $FComp_{IN}^{China}$: Share of Chinese imports in total imports of the US. It is a measure of export market competition that Indian firms face.

11. **Skill Intensity (**$SkIntens$**)**: 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).

12. **Management Technology (**$ManTech$**)**: 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.

13. **Factories (**$Factories$**)**: The 3-digit industry level number of factories/plants.

14. **Productivity (**TFP**)**: Total Factor Productivity (TFP) at the firm-level is computed using the Levinsohn and Petrin (2003) methodology.

15. **IT Fees** ($ITFees$): All expenses paid by a firm towards information technology.

16. **Consultancy Fees** ($ConsFees$): All expenses paid by a firm towards technology upgradation.

17. **Family Firm** ($Familyfirm$): It is a dummy variable. It takes a value 1 if a firm has positive ownership share by undivided families (Hindu) and 0 otherwise.

18. **Number of Independent Directors** ($IndDir$): Number of independent directors at the Board of Directors of a firm.

19. $HighIP$: It takes a value 1 if an industry falls into the category of High-IP group or clusters as defined by Delgado et al. (2013).

20. **Exporter/Non-Exporter**: It takes a value 1 if a firm's export earning is greater than zero and 0 otherwise.

21. **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-durables.

22. **Capital employed**: Total amount of capital employed by a firm.

23. **Assets**: Total assets of a firm. It is an indicator of size.

24. **Age**: Age of a firm in years.

25. **Ownership**: It indicates whether a firm is domestic-owned or foreign-owned.

B Tables

Table 14: Intellectual Property Regimes and Wage Inequality: Additional Results

	Total Managers		Man Comp		Avg Man Comp	
	(1)	(2)	(3)	(4)	(5)	(6)
IPR_{02}	0.104 (0.078)	−0.046 (0.129)	0.319*** (0.039)	0.371*** (0.043)	0.431*** (0.121)	0.596*** (0.162)
$IPR_{02} \times HighTech_{i,90-01}$	0.460*** (0.051)	0.063** (0.032)	0.714*** (0.023)	0.712*** (0.023)	0.460*** (0.051)	0.457*** (0.051)
$(\text{CapEmployed})_{t-1}$	0.122** (0.056)	0.084** (0.041)	0.088*** (0.012)	0.073*** (0.011)	0.122** (0.056)	0.096* (0.051)
$HighTech_{i,90-01} \times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm Controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.58	0.61	0.74	0.74	0.78	0.80
N	5,935	5,935	57,461	57,461	5,935	5,935
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
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), (3) – (4), and (5) - (6) use total number of managers, absolute managerial compensation, and average managerial compensation as the dependent variable, respectively. 'IPR_{02}' is a dummy variable, which takes a value 1 if year $\geq$ 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Capital Employed' is the total amount of capital used by a firm. 'Firm Controls' include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 15: Intellectual Property Rights and Wage Inequality: Non-Managers

	Total Non-Managers	Non-Man Comp/ Total Comp	Avg Non-Man Comp	Avg Non-Man Wages	Avg Non-Man Incentives
	(1)	(2)	(3)	(4)	(5)
IPR_{02}	0.487*** (0.101)	0.065*** (0.021)	0.152 (0.099)	0.177* (0.093)	0.011 (0.030)
$IPR_{02} \times HighTech_{i,90-01}$	1.040*** (0.097)	−0.019*** (0.003)	0.032 (0.025)	0.027 (0.019)	−0.003 (0.004)
$(\text{CapEmployed})_{t-1}$	0.020 (0.028)	−0.011** (0.005)	0.005 (0.099)	0.003 (0.017)	0.003 (0.006)
Firm Controls$_{t-1}$	Yes	Yes	Yes	Yes	Yes
R-Square	0.54	0.62	0.82	0.85	0.85
N	2,082	57,461	2,082	2,082	2,082
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE (5-digit)*TimeTrend	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1) - (5) use total number of non-managers, share of non-managerial compensation in total compensation, average non-managerial compensation, average non-managerial wages and average non-managerial incentives, respectively as the dependent variable. 'IPR_{02}' is a dummy variable, which takes a value 1 if year ≥ 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Capital Employed' is the total amount of capital used by a firm. 'Firm Controls' include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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 16: Intellectual Property Regimes and Wage Inequality: Disaggregating the Compensation - Additional Results

	Managerial Wages/ Total Compensation	Managerial Incentives/ Total Compensation
	(1)	(2)
IPR_{02}	0.015^{***} (0.005)	0.004^{***} (0.001)
$IPR_{02} \times HighTech_{i,90-01}$	-0.011^{***} (0.003)	0.002^{*} (0.001)
$(\text{CapEmployed})_{t-1}$	0.004^{**} (0.002)	0.0003^{*} (0.000)
Firm Controls$_{t-1}$	Yes	Yes
R-Square	0.63	0.39
N	57,461	57,461
Firm FE	Yes	Yes
Year FE	Yes	Yes
Industry FE (5-digit)*Year Trend	Yes	Yes

Notes: Columns (1) and (2) use ratio of managerial wages to total compensation and ratio of managerial incentives to total compensation of a firm as the dependent variable, respectively. 'IPR_{02}' is a dummy variable, which takes a value 1 if year $\geq$ 2002. '$HighTech_{i,90-01}$' is a dummy variable which takes a value 1 if a firm's GVA share of technology adoption expenditure (R&D + Technology Transfer) on or before the year 2001, is greater than the median of the corresponding industry (to which the firm belongs). 'Capital Employed' is the total amount of capital used by a firm. 'Firm Controls' include age, age squared of a firm and size (assets) of a firm. Both 'Capital Employed' and 'Assets' are used in $t-1$ period and 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.

C Proofs

Proof of Lemma 2

Denote the set of active firms in equilibrium by A and assume that for some $j \geq 2$, $j \in A$, but $j-1 \notin A$. According to (7), we must have for firm j

$$\frac{\partial \pi_j}{\partial m_j} = \frac{k_j^\alpha \left[\sum_{i\in A, i\neq j} m_i k_i^\alpha\right]}{\left(\sum_{i\in A} m_i k_i^\alpha\right)^2} v - w = 0$$

and for firm $j-1$, $\frac{\partial \pi_{j-1}}{\partial m_{j-1}} \leq 0$. But,

$$\begin{aligned}\frac{\partial \pi_{j-1}}{\partial m_{j-1}} &= \frac{k_{j-1}^\alpha \left[\sum_{i\in A} m_i k_i^\alpha\right]}{\left(\sum_{i\in A} m_i k_i^\alpha\right)^2} v - w > \frac{k_j^\alpha \left[\sum_{i\in A} m_i k_i^\alpha\right]}{\left(\sum_{i\in A} m_i k_i^\alpha\right)^2} v - w \\ &> \frac{k_j^\alpha \left[\sum_{i\in A, i\neq j} m_i k_i^\alpha\right]}{\left(\sum_{i\in A} m_i k_i^\alpha\right)^2} v - w = \frac{\partial \pi_j}{\partial m_j} = 0,\end{aligned}$$

which is a contradiction.

Proof of Proposition 1

First, note that $c_j \leq c_T < \frac{1}{T-1}\sum_{i=1}^T c_i$ since $K_T > 0$. Therefore, $m_j^* > 0$ for all $j \leq T$. Thus, in the candidate action profile, the set of active firms is $A = \{1, 2, ..T\}$. Since $m_j^* = m_j^A$ for $j \in A$, , the active firms are best responding in the original game. Next, we verify that at the candidate action profile, $m_j^* = 0$ is the best response for $j > T$. We show that at the candidate profile, $\frac{\partial \pi_j}{\partial m_j} \leq 0$ for $j > T$.

$$\frac{\partial \pi_j}{\partial m_j} = \frac{k_j^\alpha}{\left(\sum_{i=1}^T m_i k_i^\alpha\right)^2}\left[\sum_{i=1}^T m_i k_i^\alpha\right] v - w = \frac{k_j^\alpha}{\sum_{i=1}^T m_i k_i^\alpha} v - w$$

From (5) we can plug in $x = \frac{T-1}{\sum_{i=1}^T \frac{1}{k_i^\alpha}}\left(\frac{v}{w}\right)$, which gives us after some algebra

$$\frac{\partial \pi_j}{\partial m_j} \leq 0 \text{ iff } \frac{1}{T-1}\sum_{i=1}^T c_i \leq c_j$$

For $j > T$,

$$\frac{1}{T-1}\sum_{i=1}^T c_i - c_j \leq \frac{1}{T-1}\sum_{i=1}^T c_i - c_{T+1} = \frac{T}{T-1} K_{T+1} \leq 0,$$

which implies that $\frac{\partial \pi_j}{\partial m_j} \leq 0$ for $j = T+1$ and $\frac{\partial \pi_j}{\partial m_j} < 0$ for $j > T+1$. This establishes that the action profile in the proposition is indeed an equilibrium.

It remains to verify uniqueness. By Lemma 2, it is enough to show that there is no $T' \neq T$ such that the set of active firms in equilibrium is $S = \{1, 2, ...T'\}$.

Suppose first that $T' < T$. If $T' = 1$, firm 1 has no optimal action. Assume $T' > 1$ and consider the firm $T' + 1$. At the candidate profile, we have

$$\frac{\partial \pi_{T'+1}}{\partial m_{T'+1}} = \frac{k_{T'+1}^\alpha}{\sum_{i=1}^{T'} m_i k_i^\alpha} v - w$$

Assume first that $T' > 1$. Now, From (5), plugging in $\sum_{i=1}^{T'} m_i k_i^{\alpha}$, we have $\frac{\partial \pi_{T'+1}}{\partial m_{T'+1}}$ has the same sign as $\frac{1}{T'-1}\sum_{i=1}^{T'} c_i - c_{T'+1} = \frac{T'}{T'-1} K_{T'+1} > 0$ since $T' < T$. Therefore, $\frac{\partial \pi_{T'+1}}{\partial m_{T'+1}} > 0$, which implies that firm $T'+1$ has a profitable deviation to a positive action.

Next, suppose that $T' > T$. Now, by Lemma 1,

$$m_{T'}^{*} = \left(\frac{v}{w}\right)\left(\frac{c_j}{\frac{1}{T'-1}\sum_{i=1}^{T'} c_i}\right)\left(1 - \frac{c_j}{\frac{1}{T'-1}\sum_{i=1}^{T'} c_i}\right) \leq 0$$

since $K_{T'} \leq 0$, which is a direct contradiction.