IPR and Composition of Tasks

Sourav Battacharya[1] Pavel Chakraborty[2] Chirantan Chatterjee[3]

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Abstract

Production requires knowledge. And, patent rights may induce a firm to use more knowledge in production structure. In particular, stronger intellectual property rights (IPR) can reallocate a firm's task composition towards more knowledge-intensive as opposed to routine tasks. In other words, monopoly rights can shift more tasks towards managers, who are contributors of knowledge in a firm. We use the setting by Garicano (2000) to bridge a gap between organizational economics and innovation by developing a task-based model to analyse how organizational knowledge, process and structure, changes as a result of stronger intellectual rights protection. To the best of our knowledge, this is the first paper to explore this. We argue that stronger intellectual property rights induce *apriori* technology-leaders to re-organize their production more towards knowledge-intensive tasks as compared to technology-laggards. And, this is turn would create demand for managers. In other words, the firms, which are closer to technological frontier, employ more managers relative to non-managers in order to reorganize their production tasks. Using a novel dataset for Indian manufacturing firms, which reports detailed data on managerial compensation and utilizing a quasi-natural experiment in terms of the imposition of an IPR reform, we show that firms which are technology-leaders, before patent policy, reorganize their production towards more knowledge-intensive tasks relative to routine tasks. Our results also reveal that this reorganization happens through an incentive-based approach rather than a fixed wage component. This pattern is acute among firms, which are: (i) exporters; (ii) both domestic and foreign (higher for foreign firms); and (iii) in sectors, where India holds comparative advantage. Finally, stronger IPR expands a firm vertically, i.e., it adds hierarchical layers within a firm.

Keywords: 2002 IPR reform, Task composition, Knowledge-intensive tasks, Managers, Managerial Compensation, Vertical Layers

JEL: D21, D23, L23, O1, O34

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[1] Department of Economics, Royal Holloway University of London, 305 Horton Building, Egham, Surrey TW20 0EX, UK; email: sourav.bhattacharya@rhul.ac.uk; Tel: +44 784443968

[2] Centre for International Trade and Development, School of International Studies, Jawaharlal Nehru University, New Delhi – 110067, India; email: pavelchakraborty@mail.jnu.ac.in; Tel: +91 9821778098

[3] Department of Corporate Strategy and Policy, Indian Institute of Management, Bangalore, Bannerghatta Road, Bangalore – 560076, India; email: chirantan.chatterjee@iimb.ernet.in; Tel: +91 9620046388

1 Introduction

Production requires knowledge. Therefore, in order to produce technology-intensive goods, firms need workers who have specialized knowledge to organize inputs, solve the set of problems that arise in production, among other tasks. Following Garicano (2000), where managers provide knowledge to a firm and every firm is a knowledge-based hierarchy, greater production of technology-intensive goods will significantly increase the demand for managers, more in case of technology-leaders. Imposition of patent rights give entrepreneurs temporary monopoly rights, which may induce a firm to produce higher proportion of technology-intensive goods as the returns are high. This will increase the demand for managers by reallocating more tasks towards managers. As a result, firms will experience a change in the composition of tasks within the production, with more reallocation towards greater use of knowledge, and this will induce changes in the compensation structure of the managers.

However, how much a firm is going to re-organize the knowledge function within its production by hiring a hierarchy of managers, with different amounts of knowledge and particular tasks within the firm, depends primarily on two things: (a) whether there is a sufficient gain in doing so; and (b) on the scale and composition of its output. For e.g., technology-leaders, after the imposition of patent rights, will reallocate the share of tasks (which requires more knowledge) more towards the managers and less towards non-managers as opposed to technology-laggards. As a result, the organizational design of a technology-laggard would be completely different from that of a technology-leader after the imposition of the patent rights. In other words, property rights will tend to increase the gap between technology-leaders and technology-laggards. These differences in organization of knowledge in production are obvious to anyone that has bought an electronic good (say, speaker) from '**Bose**' and, at the same time, has bought a similar product from a local firm. The implications of organization of knowledge and organizational decisions for the gains from intellectual property rights (IPR) and other changes in the economic environment and less obvious. In fact, organizational structure is virtually absent in all theories related to IPR or innovation. How do imposition of IPR impact organization of knowledge in the production? How are they reflected within and between firm-distribution of knowledge? If IPR induces some change in the organization of tasks in the production, does it have an impact on organizational structure? These are the fundamental questions that we intend to ask in this paper. To the best of knowledge, this is the first paper that tries to bridge the gap between innovation and organizational economics by addressing the fundamental question: how does imposition of patent rights influence organizational decisions?

We study the organization of knowledge and organizational structure within and between firms as a result of stronger property rights. We assume that the market is formed by a continuum of differentiated products and that this differentiation is based on technology-intensity of products. We model an economy in which production requires labour and knowledge. We follow Garicano (2000) and Garicano and Rossi-Hansberg (2004, 2006 and 2012) and model firms as knowledge-based hierarchies where managers deal with non-routine or complex problems. Problems need to be

solved in order for output to be realized. And, in order to solve problems, agents acquire knowledge. Acquiring knowledge is costly, so in general, it is not efficient for a firm to make workers learn how to solve non-routine problems. Instead, a firm creates hierarchies to recruit managers to solve the less-common problems and workers continue to deal with the routine problems. And, this set of non-routine problems will increase as the complexity of production structure increases. Patents increase the production of complex (or technology-intensive) goods, which in turn induces a larger and new set of non-routine problems. This will increase the demand for managers, which will result in a change in the organizational design of a firm.

Trade economists, on one hand, have long been interested in understanding the economic implications of globalization on the labour market of which one aspect relates of firm organization. On the other hand, people are also interested in investigating the effect of patent rights on innovative activities of a firm. We put these two aspects together with this paper. The primary focus of this paper is: what is the effect of patent rights, vis-à-vis imposition of an exogenous IPR reform, on the reallocation of task composition more towards managers for technology-leaders and technology-laggards, i.e., how the demand for managers relative to non-managers undergoes a change within a firm and across firms. We include the non-managers side, rather than focusing on absolute change in the demand for managers, in order to understand the change in within-firm inequality. We utilize a quasi-natural experiment in terms of imposition of patent rights by the Govt. of India in 2002 in order to investigate such effects for manufacturing firms in India. We study the causal link, look into the sources and identify the underlying mechanism through which it operates. We additionally present results on a wide array of related issues ranging from organizational design to pay structure, shedding light on the more general aspects of organizational culture adjustments to IPR rights. Our main findings are that imposition of patent rights significantly increase the allocation of tasks towards managers by increasing the compensation share of the managers, as well as their numbers. This is true for both technology-leaders and laggards, with the effect for the former more robust than the latter. Reallocation of tasks happen through increasing incentive-based payments for managers' and vertical expansion of the firm.

We start by presenting the share of managerial compensation (in total compensation) in our sample of Indian firms for the period 1990-2006. This is plotted in **Figure 1**. Though, it exhibits a secular increasing trend steadily throughout the period, except for a drop in couple of years, the rate of growth of increase post-2002 is significantly high. The average share of managerial compensation of a firm is around 2 percent in 2001, which increases to 5 percent in 2006, a growth of more than 200 percent in four years. Further, we seek to understand whether there is a categorical difference in the increase in managerial compensation between technology-leaders and laggards, which we plot in **Figure 2**. The figure reveals that share of managerial compensation doubled in case of both categories of firms between 2002 and 2006, but the levels of increase for technology-leaders is double that of technology-laggards.

We repeat this in case of the number of managers; **Figures 3** and **4** plot the share of executive managers in total workers of an average manufacturing firm from 1990 to 2006 and between

technology-leaders and laggards, respectively. The result is the same. There has been a significant increase in the proportion of executive managers for an average manufacturing firm in India after 2002, for both technology-leaders and laggards, with a bit more for the former. This refutes the possibility of observing a simple administrative re-labelling (an option we elaborate on later), paving the way to turn the discussion to IPR reform and provide causal inferences. To test whether this significant change in the number and price for the managers in post-2002 period can be associated with the case of patent rights in India in 2002, we exploit the exogenous nature of India's imposition of IPR reform in 2002, in conjunction with a rich dataset on Indian manufacturing firms that uniquely reports data on investments on technology by firms' and disaggregates total labour compensation into managers and non-managers over a period of one and half decades.

The firm level panel dataset that we use to investigate is unique as it contains direct measures of spending on several dimensions of technology, namely R&D expenditure, royalty payment for technical knowhow or technology transfer, import of capital goods and fees for adoption of information technology (IT). It also reports detailed labour compensation, divided into managerial and non-managerial, with the former across several management layers. This allows us to build a direct and comprehensive measure of investment in technology instead of relying on some subjective or other measures potentially identified with measurement errors. Our analysis begins by dividing the firms into technology-leaders and laggards, following Branstetter et al. (2006) and applying to our case. We sum the investments by a firm on technology upgrading before the reform, i.e., before 2002, to create technology-leaders and laggards. We classify a firm as 'high-tech' or technology-leader, if a firm's expenditure on Research and Development (R&D), royalty payment for technical knowhow or technology transfer and import of capital goods between 1990-2001 is greater than the median of the industry's investments on technology, to which the firm belongs. In other words, we create a pseudo 'treatment' and 'control' group. We interact this 'high-tech' dummy with a IPR reform dummy, which takes a value 1 if year is greater than or equal to 2002, to estimate the change in task composition across 'high-tech' and 'low-tech' firms, as a result of the imposition of the 2002 reform. The key point is that we use the quasi-natural experiment of the 2002 IPR reform as the basis for our identification strategy and this helps us to pinpoint the underlying mechanism.

We find a remarkably robust, persistent and economically meaningful positive effect of the 2002 IPR reform on the demand for managers; with the difference in the effect between technology-leaders and technology-laggards significant and positive. In other words, the 2002 IPR reform led to a reallocation of tasks more towards problem-solvers or knowledge-providers, higher in case of technology-leaders. Our benchmark estimations indicate that the 2002 IPR shock led to an increase in the share of managerial compensation of the technology-leaders as compared to technology-laggards by 0.3-1.5 percent. The effect is robust to various controls, specifications, estimation techniques and time periods. In addition, testing various possible channels, we note that it is not an outcome of industry-specific trends or potential associations between managers and trade reform, skill, capital complementarity, establishment of new factories and productivity. Digging deeper, we identify the subset of firms that drive the result are exporters, both domestic and foreign and belong

to consumer non-durable and intermediate goods industry. Put together, these results provide suggestive evidence for a quality upgrading mechanism reminiscent of Caliendo and Rossi-Hansberg (2012). Imposition of patent rights induces technology-leaders (compared to technology-laggards) to reallocate its set of tasks more towards managers, who solves non-routine problems, and this would increase the compensation share of the managers in total compensation. In other words, patent rights contribute to two types of inequality: (i) increases the gap between technology-leaders and laggards by reallocating more tasks towards knowledge-intensive goods; and (b) within-firm wage inequality. This is the most crucial and primary contribution of the paper.

Next, we investigate the potential mechanism to seek to understand the increase in the compensation share of the managers in practice. Since, the observed change is compensation based, it can be made either via income directly, or through a change in the number of managers; we look into both aspects. First, we decompose the compensation ratio of managers to wages and bonuses. We find that imposition of patent rights decreases the gap of the wages of managers between technology-leaders and laggards, whereas it does the opposite when we substitute wages with incentives. An IPR reform increases the managerial compensation through increase in the incentives, as more managers now deal with more non-routine problems. This indicates that the main result is not an outcome of outsourcing or any other schemes but an effect of the change in the monopoly rights of a firm. This pattern, increases in managerial compensation through incentives, is consistent with observed evidences in case of developed countries (e.g., Cunat and Guadalupe, 2009).

Moving on to the second aspect, we find that imposition of patent rights increases the number of managers. And, this could potentially change the organizational design of a firm. Realizing this, we explore the effect of the IPR reform on the horizontal and vertical changes in firms' structure. We proxy the horizontal dimension of a firm through the variety of products produced, whereas for the latter we exploit features in our dataset to create a dummy for the number of organizational layers, based on the notion of hierarchical layers laid out by Garicano (2000). We find no effect of IPR reform on the horizontal dimension of a firm, whereas, it significantly expands a technology-leader vertically as compared to a technology-laggard. In addition, the reform also expands an average manufacturing firm vertically.

The paper in contributes to two different strands of literature. First, the literature on organizational design (Garicano, 2000; Rajan and Wulf, 2006; Garicano and Rossi-Hansberg, 2006; Caliendo et al., 2014) and effect of a certain exogenous shock on organizational structure (Guadalupe and Wulf, 2010; Marin and Verdier, 2014; Wu, 2015). Studies on organizational structure on developed economies, such as France and the U.S., show us that firms tend to flatten over time. In contrast, we show that IPR reform expands a firm, specially a technology-leader, vertically. Second, the literature on the effects of IPR reform of innovative activities of countries, industries or firms. The effect of IPR reform has been significantly 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). In addition, it also contributes to the literature on the effect of the specific 2002 IPR reform in India.

The paper is structured as follows: Section 2 gives a detailed background of the specific 2002 IPR reform. Sections 3 and 4 outlines the firm level data in detail and the empirical strategy, respectively. The results are explained in Section 5. Section 6 explores the mechanisms underlying of the main effect. Section 7 does a variety of robustness checks, while section 8 concludes.

2 Background

The institutional history of India's tryst with stronger intellectual property right (IPR) regimes can be traced to the country's experience with the General Agreement on Tariff and Trade (GATT), a multilateral agreement signed in 1947 by 23 countries. GATT's overall aim was to reduce tariff and trade barriers and in 1986, when the group met in Uruguay for what is now famously called the **Uruguay Round**, it already had an assembly of 123 countries as its members. While several multilateral IPR treaties already existed around that time in the world (like Patent Cooperation Treaty or Berne Convention on Protection of Literary and Artistic Works of 1886), for the first time, IPR was linked to global trade and tariff barrier discussions and was brought under the ambit of GATT. The motivation behind linking trade to IPR came from the US's travails with a growing trade deficit at that point in time; with roughly 25 percent of all US exports IPR-based and a lack of IPR protection of these exports in overseas markets resulting in serious loses for US businesses, no less, for big pharmaceutical innovator firms like Pfizer located in the US, they exerted the requisite international pressure to link trade with IPR. Infact, the nodal association of these innovator firms, Pharmaceutical Research and Manufacturers of America have candidly admitted that "the Indian patent system was the most direct motivation for US efforts in the Uruguay Round negotiations relating to patents".[4] This can be attributed to the patent laws changes in India in 1970 when the country had enacted an IPR regime respecting only process patents and with reduced duration of protection, with even these patents being subjected to "licenses of right" permitting any person to use process patented technologies for a fixed royalty of four percent (Chaudhuri, 2005; Chatterjee, 2011). That environment had fostered the entry of imitator pharmaceutical firms in India, who were competing not just in domestic Indian markets but were also entering aggressively in Western markets, an event now well documented and acknowledged in past work (Chatterjee, 2011 among others).

Thus in 1986, when US first proposed the inclusion of IPR in the trade discussions at the **Uruguay Round** through what is now popularly known as the Trade Related Intellectual Property Rights (TRIPs), countries like India and Brazil expressed staunch opposition.[5] Subsequently a series of events indicated that bringing in IPR into the ambit of multilateral trade discussions was not an easy transition. First, the US under domestic political pressure engaged in aggressive trade terms

[4] "Special 301" Report on Intellectual Property Barriers, *Submission of the Pharmaceutical Research and Manufacturers of America* (Feb. 16, 1999).

[5] Paul Lewis, Aims on Trade Talks Outlined, THE NEW YORK TIMES, Jul. 19, 1986, available at http://www.nytimes.com/1986/07/19/business/aims-on-trade-talks-outlined.html (Last visited on September 8, 2016).

including IPR in the discussions.[6] This resulted in what is now famously termed as **crowbar diplomacy**[7], the formation of the Omnibus Trade and Competitiveness Act of 1988 which subsequently resulted in creation of the Super 301 and the Special 301 under the existing Section 301 of the US trade act, to study unfair trade practices of partner trading nations as a whole with the former and IPR policies of trading partners specifically with the latter.[8] While these series of changes in its own policies by the US faced its domestic detractors[9], the shifts in US trade policies had its desired effect with countries like South Korea and Taiwan opening up to bilateral negotiations and opening up their markets.

India meanwhile was itself transiting through a process of opening of its markets under the stewardship of the then Prime Minister Mr. Rajiv Gandhi since the mid-1980s (Panagariya, 2005, 2008). Yet, when the US new trade act of 1988 came around as discussed above, India engaged in what is now termed as the **Geneva Surrender**[10] of April 1989, allowing discussions to link IPR to trade. Recent commentary by experts from that period, including India's lead negotiator at that time with the US, A V Ganesan, indicates that this was possibly due to a potential *stick* and threat of being included in the Special 301 watch-list of IPR disrespecting countries, more than the carrot of access to international markets.[11] Whatever be the antecedents, the shift of the Indian stance broke the India-Brazil push back to US efforts to link IPR to trade, resulted in formation of staunch domestic Indian activism against patents, formation of alliances across industry and civil society groups like the National Working Group on Patent Laws (NWGPL) and a resilient national debate on the **Geneva Surrender** by India.

The surprising thing was what followed in May 1989, with India being still cited by the US both in the Super 301 and Special 301 list despite the **Geneva Surrender**. Clearly India's yielding stance had no effect and potentially the US wanted to steamroll India with a weak negotiating position, in its IPR stance going forward. At that time, India's trade relations with US were of such insignificance that such a hard measure on India only indicated that US potentially used it as a signalling tool and also to satisfy domestic interest groups pushing for aggressive trade sanctions. And while the domestic constituents protested, the country also at that time ran into its much discussed balance of payments crisis in 1991, leaving it further weaker in the global multilateral trade negotiations. The 1991 balance of payments crisis in India, created another twist in India's IPR journey, albeit indirectly. The economy had to then open up for access to international markets and for foreign

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[6] Paul Lewis, *U.S. Issues Threat in Talks on Trade*, THE NEW YORK TIMES, Sept. 7, 1986, available at http://www.nytimes.com/1986/09/07/world/us-issues-threat-in-talks-on-trade.html (Last visited on September 8, 2016).

[7] Louis Uchitelle, *A Crowbar for Carla Hill*s, THE NEW YORK TIMES, Jun. 10, 1990, available at http://www.nytimes.com/1990/06/10/magazine/a-crowbar-for-carla-hills.html (Last visited on September 8, 2016)

[8] *See generally* Elizabeth K. King, *The Omnibus Trade Bill of 1988: Super 301 and its Effects on the Multilateral Trade System under the GATT*, 12 U. PA. J. INT'L BUS. L. 245 (1991).

[9] Jim Powell, *Why Trade Retaliation Closes Markets and Impoverishes People*, Cato Institute Policy Analysis No. 143, Nov. 20, 1990, available at http://object.cato.org/sites/cato.org/files/pubs/pdf/pa143.pdf (Last visited on September 8, 2016).

[10] *Intellectual Property Rights: The Geneva Surrender*, EPW 1201-1202 (Jun. 3, 1989).

[11] A.V. Ganesan, *Negotiating for India* (Ed. Jayashree Watal & Antony Taubman, *The makings of the TRIPS Agreement: Personal insights from the Uruguay Round negotiations:* 2015)

investment to spur domestic economic growth, and thus it had to yield to becoming part of the proposed multilateral trading system that included IPR in the discussions in the **Uruguay Round** of discussions. Thus despite maintaining a strong anti-IPR stance in the multilateral **Uruguay Round** discussions, India also acceded gradually to US pressure around 1991, evident from public discussions at that point in time and during the USTR's official visit to India in October 1991.[12]

US subsequently (as all this dilly dallying continued by India on its IPR stance and amidst the 1991 balance of payments crisis) imposed sanctions on India on April 30, 1992 for failing to amend its IPR policies. The sanctions removed "the $35-million drugs and pharmaceutical imports off its duty free list, imposing 5 per cent customs duty."[13] While these sanctions were mild, Indian policy makers feared more the possibility of the sanctions being extended to the US$700 million textile exports from India to the US at that point in time. Subsequently, in April 1993, the Indian Parliament constituted a Department-Related Parliamentary Standing Committee headed by IK Gujral to study the Dunkel draft in detail that commented on the IPR situation under the ambit of GATT. This draft after various parliamentary and expert-committee deliberations came up with a report in 1994 documenting Indian unwillingness to budge to developed country interests and revoke India's existing process patent respecting regime.[14]

However the government was not bound to adhere to these recommendations and the final text of TRIPS agreed to by India, in 1994, did not adhere to any of these recommendations of the Standing Committee. That said, at the concluding ministerial meeting of the WTO talks in Marrakesh, Morocco in April 1994, Pranab Mukherjee, India's then minister for commerce and now President of the country, told his counterparts from other countries that India had "negotiated in good faith" and while it was acceding to implementing stronger IPR in India it remained concerned about pharmaceutical prices that might rise as a result. The speech also indicated that the Government of India at that point in time made a trade-off between increasing textile exports at the cost of hurting its pharmaceutical industry and patient population by reinstating pharmaceutical product patents. Associatedly it was also clear that India would exploit all safeguards to keep in check the rise of prices in the pharmaceutical sector.[15] Thus in 1994, India signed the Marrakesh Agreement (which established the World Trade Organisation (WTO)), eight years after the **Uruguay Round** of Talks began agreeing to be bound by TRIPs and got a 10 year transition period to shift from its existing IPR regime to stronger product patent respecting TRIPs-compliant IPR regime. India's transition

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[12] Sunil Jain, *Indo-US trade: Patent pressure*, INDIA TODAY, Oct. 21, 1991, available at http://indiatoday.intoday.in/story/india-has-not-liberalized-enough-says-us-trade-representative/1/318986.html (Last visited on March 22, 2015).

[13] Sunil Jain, Special 301: US imposes 5% customs duty on drugs and pharmaceutical imports, INDIA TODAY, Jun. 14, 2013, available at http://indiatoday.intoday.in/story/special-301-us-imposes-5percent-customs-duty-on-drugs-and-pharmaceutical-imports/1/306918.html (Last visited on March 22, 2015).

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

[15] Trade Negotiations Committee (GATT), Statement by Mr. Pranab Mukherjee Minister of Commerce, Multilateral Trade (The Uruguay Round), MTN.TNC/MIN(94)/ST/38, Apr. 13, 1994.

however was not without its own hiccups, with uncertainty around the regime's implementation clearing only by 2002, which offers the structural break we exploit in our study.

Between 1995 and 2005, events in India in implementing stronger IPR transitioned through three stages broadly speaking. First, there was denial and refusal to comply with international obligations; second, India lost at the Dispute Settle Board of WTO-TRIPs and realised that it had no choice but to follow the law if it wanted to be a member of the WTO; third, India looked for ways to exploit the flexibilities of TRIPS to outsmart developed countries at their own game especially as we now know using the compulsory licensing provisions of WTO-TRIPs (for a detailed discussion see Chatterjee et al., 2015). India's initial transition since 1994 started with the failed Patents (Amendment) Ordinance of 1994 that was brought about by a weak government in power amending the Patents Act of 1970. It allowed for a 'mailbox' provision through which product patent applications could be filed with the priority date for them remaining static and undecided until India amended its patent laws to comply with TRIPs. This ordinance also granted exclusive marketing rights (EMRs). With this ordinance, while India started its transitional journey in IPR regime, assessments about the final outcome of it remained muted and weak. This was because as per Indian constitutional law, ordinances are valid for only six months from the day of promulgation, or six weeks from the day Indian Parliament reconvenes after the ordinance is promulgated. If the Ordinance lapsed, India would be in violation of its TRIPS obligations. A law was thus still needed which GoI introduced in Parliament as the Patents (Amendment) Bill, 1995.

Several events subsequently indicated that India was doing much less than expected for its transition especially with a weak government in power and facing significant opposition voice at that point in time. As per Indian law, a bill has to pass through both houses of the parliament and while the Upper House passed it, once the bill was in the lower house of the parliament, a new expert committee was formed to debate the merits and demerits of the Patents (Amendment) Bill, 1995. As all of this was going on, the Indian parliament dissolved for national elections and the 1995 bill automatically lapsed leaving the uncertainty around IPR transition alive in the country. This meant that the country was again in violation of its TRIPs agreement for stronger IPR and was vulnerable to be referred to the WTO's dispute settlement board (DSB). [16] Infact this was indeed what the US invoked in 1996, filing complaints to the DSB, against not just 3 other countries (Japan, Pakistan, Portugal) but also India.[17] India lost this case despite an appeal, with the US further bolstered by a European Community complaint as well, and negotiated with the US for a fifteen month window to return to amending its patent law by April 1999.[18] And despite several rounds of discussions in civil society and both the houses of the parliament, India did manage to implement the Patents

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

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

[18] 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.

(Amendment) Act, 1999 which came into effect from March 26, 1999. This was the first of the three formal legislations passed between 1995 and 2005 to ensure the country's transition to a strong IPR regime.

It was followed soon after by the second legislation, the Patents (Second Amendment) Bill, 1999. This second legislation proposed a new definition of the term "invention", recognised parallel imports of patented products and 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. In addition, it also increased the term of patents from 14 to 20 years and deleted the "license of rights" provisions as discussed earlier. It is important to note that this second legislation took its time to get enforced though, since it really broadened the scope of the IPR regime that India would commit to adopt under TRIPs and further also deliberated on compulsory licensing as part of its narrative. 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 (with the political regime that had signed TRIPs, under the Indian National Congress - Indira (INC-I) party now in opposition, while the Bharatiya Janata Party (BJP), a political party with more rightist leanings now in power) ensured that the 1999 bill faced lesser difficulties than the earlier legislation and thus Patent (Second Amendment) Act, 2002 was enacted. The political situation is important to note here, since it was the INC-I that had signed TRIPs in 1994, creating the national imperative to accede to it going forward and while BJP in the 80s and early 1990s had protested for example against the *Geneva Surrender*, it fell on them while in power in 2002 to get the IPR regime upgraded to escape the wrath of the DSB thereby sticking to the negotiation deadlines with US herein. 3 years later India also was able to push this second legislation further and with the addition of 3(d), the compulsory licensing provision, was able to enact the Patents (Amendment) Act, 2005 (see Chatterjee et.al 2015 for more details on 3(d) and India's recent travails with it).

While we spend some time in understanding the institutional milieu that impacted transition to TRIPs-compliance in India, it is important to appreciate that this transition went through three broad phases. The first two phases included considerable uncertainty around India's transition to TRIPs and product patenting protecting regime. This included the period leading up to India's final signing of WTO-TRIPs in 1994 and then it's chequered and sometimes debatable intentions to implement the commitments given to the WTO during the second phase from 1994 to 2002. The expansion of the scope of the Indian patent laws in 2002, including the addition of the Bolar exception (by which time India had already joined the Paris convention in 1998) finally indicated that the transformation of the Indian IPR regime was on its way, that finally saw a completion in 2005, during the third phase between 2002 and 2005. It is these broad phases that we exploit in our empirical identification strategy, arguing that India's shift to stronger IPR happened much before 2005, with the final signals on the transition already out in 2002 with more certainty than in the period before. We off course conduct a variety of sensitivity checks and robustness tests to ensure that we address any confounding ex ante impact that the transitional phases pre 2002 might have on the findings from our study.

3 Firm-level Data

We examine firms in the Indian manufacturing sector. The firm-level analysis is primarily based on the Prowess database, constructed by the Centre for Monitoring the Indian Economy (CMIE), an Indian government sponsored agency. We outline the features of this dataset in detail in this section.

The Prowess database contains information on approximately 27,400 publicly listed companies, all within the organized sector, of which almost 11,500 are in the manufacturing sector.[19] It reports direct measures on a vast array of firm-level characteristics including sales, disaggregated trade components, R&D expenditures, technology transfer, production factors employed, gross value added, assets, ownership, and others which we outline further within the empirical analysis. In addition, it covers both large and small enterprises; data for the former types is collected from balance sheets, whereas that for the latter ones is based on CMIE.s periodic surveys of smaller companies.

Prowess presents several features that make it particularly appealing for the purposes of our study, and puts it in an advantage compared to other available sources, such as the Indian Annual Survey of Industries (ASI), for instance. First, unlike other sources, the Prowess data is in effect a panel of firms, enabling us to study their behaviour over time; specifically, the (unbalanced) sample covers up to 8,000 firms, across 108 (4-digit NIC) manufacturing industries that belong to 22 (2-digit NIC) larger ones,[20] over the period of 1990-2006,[21] hence covering the 1990s trade reform, being an essential part of our analysis that we discuss later.

Second, the unique feature of the data set, upon which our study is mainly based, is that it disaggregates compensation data to those received by managers and non-managers, with a further disaggregation of compensation to wages and bonuses. Specifically, the division is done to three layers: non-managers, directors, and executives; the latter two comprise the managers. group.[22] While the definition of the former is that they do not manage other employees, directors are defined as managers without executive powers, as opposed to executives which do possess such

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

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

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

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

responsibilities. Executives include, for instance, the CEO, CFO, and Chairman, whereas Directors may cover positions such as Divisional Managers. In effect, we consider directors to be middle management, whereas executives are the top management.[23] These features enable us to study a wide array of management-related firm-level characteristics, over a relatively large period of time, ranging from the relative demand for managers to organizational design and pay structures, and by that trace down the underlying channel that affects the former.

Importantly, the data set provides much variation across firms and industries in the compensation of managers compared to non-managers, which enables us to better understand how they react to IPR reform. For instance, in **Figure 5** we plot the average share of managerial compensation in total labour compensation across 2-digit industries for the period of 1990-2006. It goes from a low of approximately 1.5 percent to a high of around 9 percent, the difference across industries is clearly observed. This is also seen when measuring changes 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 percent, in others it can get higher than 200 percent, hence providing quite large differences that we examine in the empirical part. This translates to the firm level, where such variation is even more prominent. One key related characteristic is that close to 25 percent of firms report having no managerial layer (in the form of reporting zero, or otherwise sufficiently low, managerial compensation). This is consistent with the family-oriented Indian firm culture (Bloom et al., 2013).[24]

Last, it has a relatively wide coverage, accounting for more than 70 percent of the economic activity in the organized industrial sector, and 75 percent (95 percent) of corporate (excise duty) taxes collected by the Indian Government (Goldberg et al., 2010). In terms of trade, it covers approximately 30-35 percent of India's total exports and imports activity, presenting a reasonably good aggregate picture on India's trade position. All variables are measured in Millions of Indian Rupees (INR), deflated to 2005 using the industry-specific Wholesale Price Index,[25] and are outlined in **Appendix A**. **Table 1** presents descriptive statistics for all variables.

3.1 Data quality

The Prowess database has been used in various previous similar studies on trade liberalization,[26] providing some reassurance for its relevance and applicability to the particular issues studied, as well as for its overall reliance. To the best of our knowledge, however, we are the first to study its

[23] There is scope for some subjective interpretation of this distinction by firms, when providing data; however, importantly it does not affect our main analysis, where we consider managers as a single aggregated group. In a later section, where this distinction is analysed, we consider different interpretative options for robustness, indicating it does not affect the key patterns observed.

[24] Realizing this might be, to some extent, a feature of measurement error due to firms' subjective interpretation (during the process of providing data), we note our main results are robust to the exclusion of them.

[25] We thank Hunt Allcott for sharing this data with us, used in Allcott et al. (2014).

[26] See e.g. Ahsan (2013), Ahsan and Mitra (2014), De Loecker et al. (2016), Goldberg et al. (2010), and Khandelwal and Topalova (2011).

organizational-related measures in this context. That said, we next discuss two quality-related aspects of these measures: accuracy and consistency, as these may take a central role in the empirical analysis.

Starting with accuracy, as mentioned CMIE retrieves most of the compensation data from balance sheets, reported in publicly-available annual reports. To test the accuracy of our measures of interest, we compare the data reported in Prowess to those reported in the annual reports for a random selection of firms, representing both relatively large and small ones, in the year 2011. Results appear in the **Appendix B**, **Table B.1**. We compare the reported compensation of executives (Columns 1 and 2) and directors (Columns 3 and 4). In both cases we observe a strong match between the compensation data reported in Prowess and those given in the annual reports, with correlations being higher than 0:99. In columns (5) and (6), we compare the number of reported executives in each of the sources, with the correlation being 1. Albeit not covering all years, firms, or the entire range of variables, these results provide some affirmation for the accuracy and reliability of the measures used.

Moving to consistency, the analysis implicitly assumes there is consistency in the definition of managers across firms. However, the said family-oriented nature of many Indian firms, and the surveys CMIE uses for smaller firms, may give rise to some subjectivity in that respect. This deserves some comment. First, we note that all firms included in the analysis are listed in the Mumbai Stock Exchange, and hence are subject to the same corporate governance regulations, including the said definitions; this provides a more homogenous, and regulated, environment that mitigates the given concern. Second, as will be evident we show results hold irrespective of firm size (and across the size distribution), as well as irrespective of whether firms report having no managers; this further mitigates concerns related to sensitivities to CMIE.s source and to potential subjectivities.

4 Empirical Strategy

To assess whether stronger IPR induces a reallocation in the composition of tasks within a firm, we focus on the effect of imposition of patent rights on the share of managerial compensation in total labour compensation in a manufacturing firm in India. To explore the effect, we take a difference-in-differences approach following Branstetter et al. (2006, 2011). Individual firms are followed through time, and the basic specification tests how share of managerial compensation or the demand for managers change for an average Indian manufacturing firm as a result to the IPR reform in 2002, controlling for other firm and industry characteristics, simultaneous policy changes that might impact the outcome of interest. The basic specification takes the following form:

$$\left(\frac{Mcomp}{Tcomp}\right)_{it} = \alpha_i + \alpha_t + \alpha_{jt} + \beta_1 IPR_t * HighTech_i + \beta_r IPR_t + \beta_3 X_{it} + \epsilon_{it}$$

where, i indexes the individual firm, j the firm's industry group, t the year. $\frac{Mcomp}{Tcomp}$ is the share of managerial compensation in total labour compensation of a firm. We use this as an indicator for composition of tasks following Garicano (2000). The higher the ratio, the higher is the knowledge content of production of a firm. We argue that imposition of patent rights through an IPR reform will increase the knowledge content of the products produced by a firm thereby reallocating a higher share of tasks towards, which increases their share of compensation.

IPR_t is a post-reform dummy variable, which takes a value 1 for years greater than and equal to the reform year. In this case, IPR_t takes 1 if year is greater than or equal to 2002. Now, since our variable of interest is a time dummy, it will be difficult to distinguish between 'treatment effect' and 'time effect' unless we use a control group in our estimation. For such purpose, we interact our time dummy with $HighTech_i$, a high technology adoption dummy. The idea here is to understand if there is an increase in the share of managerial compensation of a firm from improved IPR protection, then the effect should be greater for firms that use technology before the reform. In other words, the IPR reform would reallocate the composition of tasks more towards knowledge-intensive goods of the firms, which has higher technology adoption in the pre-reform period. In particular, imposition of patent rights will increase the gap between technology-leaders and laggards. Therefore, in order to study the differential effects of IPR reforms across firms, we divide the firms into two groups according to the extent of technology adoption prior to the reform. Firms, for which the sum of R&D expenditure and technology transfer greater than the median of R&D expenditure and technology transfer (put together) of the industry to which the firm belongs, over the years' prior (1990-2001) to the IPR reform (which is in 2002), are assigned a high technology adoption use dummy, $HighTech_i$, equal to one. For the rest of the firms, $HighTech_i$ equals zero. Therefore, the interaction term, $IPR_t * HighTech_i$ estimates the response of a firm, who are technology-leaders, as a result of the IPR reform compared to technology-laggards.

X_{it} is a vector of firm characteristics which are likely to impact a firm's managerial compensation. For e.g., following Caliendo and Rossi-Hansberg (2012), we use an indicator for trade reform undertaken by India during the 1990s. Whereas, the vector X is continuously modified, we follow insights from Acemoglu et al. (2007) and Garicano and Rossi-Hansberg (2012) and include three basic controls: the age, assets and output of a firm. Older firms may have a more established structure and culture. Therefore, age would control for the potential differences in the flexibility of undertaking organizational reforms. We also include the square term of age in order to address the potential U-shaped effects. The second controls for firm size, given that larger firms may have greater management needs. The last controls for the idea that content of output, i.e., higher proportion of technology-intensive goods, may also drive managerial compensation significantly. All three are, therefore, potentially highly related to the managerial compensation of a firm.

α_i and α_t are time-invariant firm and year fixed effects, respectively. α_{jt} are industry-year fixed effects in order to control for other simultaneous trade and macro reforms that may have a potential impact on the share of managerial compensation of an average Indian manufacturing firm.

5 Results

5.1 Benchmark Results

Our benchmark results appear in **Table 2**. In this table, we seek to explore the effect of IPR reform interacted with technology-leader dummy on share of task composition of a firm. In other words, how imposition of IPR reform affects the organization of knowledge in production through the recruitment of new managers. We use share of managerial compensation in total labour compensation to understand the share of knowledge involved in the organization of production within a firm. Our prior is: IPR reform would increase the knowledge content in the production of the firms, those who valued technology higher than others in the pre-reform period. In other words, IPR reform would shift the production towards more complex goods, which would require more knowledge and this will induce an increase in the demand for managers to solve the new set of non-routine problems. This, in turn would increase the knowledge gap between firms. Columns (1) – (5) of **Table 2** confirms our hypothesis. With the IPR reform in 2002, the technology-leaders (prior to the reform) uses more knowledge in their production as opposed to technology-laggards. The $IPR_t * HighTech_i$ is highly significant and positive. The difference, between technology-leaders and technology-laggards, in the effect of the 2002 IPR reform is resoundingly robust across different specifications. We use interactions of industry fixed effects with time trends and various levels of industry-year fixed effects in columns (2) – (5) and our coefficient of interest continues to stay positive and significant. Our most conservative estimate suggests that IPR reform increases the knowledge gap between a technology-leader and technology-laggard by 0.6 percent at the mean.

We also use share of non-managerial compensation as our dependent variable in columns (6) – (10). Our coefficient of interest is consistently negative and significant. It portrays that the difference between technology-leaders and technology-laggards is decreasing in terms of routine problems of the production. We also use absolute levels of compensation, total, managerial and non-managerial in **Table B.2**. Our coefficients show that IPR reform results in significant increase in total compensation for technology-leaders or high-tech firms as when compared to technology-laggards or low-tech firms. The increase in the total compensation is significantly driven by the increase in managerial compensation. The difference between the technology-leaders and laggards in terms of managerial compensation is double that of non-managerial compensation as result of the 2002 IPR reform.

We also use the number of executive managers as our dependent variable to check the robustness of our benchmark result. In other words, we explore whether there the observed effect in case of price of managers holds, when we substitute it by number of managers. We do observe the same

trend. Results appear in **Table 3**. Technology-leaders employ significantly more managers as a result of the IPR reform, as when compared to technology-laggards. Our estimates say that a technology-leader would employ 9.9-13.8 percent of more managers than technology-laggards. However, all these results points at a underlying mechanism which we elaborate next.

A quality upgrading mechanism The difference in the effect between technology-leaders and technology-laggards as a result of the IPR reform relates to a key question: what is the underlying mechanism? IPR reform gives a firm temporary monopoly rights over the products they produce. This induces a firm to produce more of technology-intensive goods or goods of higher knowledge content, which will give rise to a new set of problems or non-routine problems in the production. This, in turn, will drive a firm to reallocate its tasks more towards managers in order to solve the non-routine problems in the production of new products. And, this will drive some of the firms, or the technology-leaders, to employ more managers compared to technology-laggards. Realizing that the main effect is completely driven by the IPR reform, it implies that there is an upgrading of the quality of the goods, but at a cost of the increase in the knowledge gap between these two set of firms.

5.2 Additional Controls

After establishing the basic result, we turn next to test some additional controls and further potential channels. All specifications in this sub-section follow the stricter specification of Equation (1), with industry-year fixed effects. Results are presented in **Table 4**. Our starting point is the potential connection between trade reform and demand for managers. Chakraborty and Raveh (2016) shows that drop in input tariffs significantly explains the rise in the share of managerial compensation. We find that to be true. But, our coefficient of interest continues to be positive and significant. The second is the correlation between managers and skilled labour. We measure the latter through the 3-digit industry level ratio of non-production workers to all workers, obtained from Ghosh (2014) (1990-2000), and the Indian **Annual Survey of Industries** (2001-2006). This is the standard skill intensity measure used in the literature. It is reassuring to note that our proxy for the knowledge content in the production or relative demand for managers and skill intensity don't appear to have significant correlation. The main result continues to hold, suggesting that it is not driven by broad increases in the demand for skill.

Next, we refer to the literature on organization of firms. Bloom et al. (2013) points out that better managed firms in India have higher productivity. To address that, we control directly for productivity, by following Ahsan (2013) and Khandelwal and Topalova (2011) and hence using the Levinsohn and Petrin (2003) methodology to control for firm-level TFP. The latter controls for the potential simultaneity in the production function by using a firm's raw material inputs as a proxy for the unobservable productivity shocks. Results are presented in Column (3). As the results demonstrate, our coefficient of interest is stable in sign, significance and magnitude, providing additional support that the underlying mechanism works through a different channel. Establishment

of new factories creates a demand for new managers as local knowledge is important. Therefore, despite controlling for firm assets, we follow Bloom et al. (2010) to dig deeper into the by testing an additional related measure: the number of factories and plants at the industry-level, derived from ASI. The inclusion of this additional control does little to change our benchmark finding. IPR reform significantly increases the demand for problem-solvers, higher in case of technology-leaders.

5.3 Firm Characteristics

Having identified the effect, and tested various potential mechanisms, let us now examine the issue by dividing the dataset according to various firm level characteristics. We do this to identify which set of firms drive the main result. **Table 5** presents the results. We start by dividing the sample of firms into exporters and non-exporters. The coefficients of $IPR_t * HighTech_i$ in columns (1) and (2) show us that the entire effect is driven by the exporting firms. The increase in the production of knowledge-intensive goods, as a result of IPR reform, is only concentrated with the exporting technology-leaders. Next, we divide firms by ownership – domestic and foreign. Results appear in columns (3) and (4). The interaction effect of $IPR_t * HighTech_i$ is significant for both domestic and foreign firms, with the effect double in case of the foreign technology-leaders. The reallocation of tasks towards managers, as a result of the IPR reform, is double for foreign technology-leaders as when compared to domestic technology-leaders. In other words, the knowledge content of goods produced by foreign technology-leaders are twice than that of domestic technology-leaders.

Lastly, we turn to test firms by end use. We follow Nouroz (2001) and use the input-output classifications to categorize firms by the end use of their products. The division is thus made to five groups: consumer non-durables, intermediates, basic, capital, and consumer durables. Here also we divide the sample to each of these groups, and estimate each separately. Columns (5) – (9) present the results. We can see that the main result is a feature of firms that belong to the consumer non-durables and intermediate groups. This result indicates that the knowledge content of the goods of the firms, which produce non-durables and intermediates as final products have increased, as a result of the 2002 IPR reform.

6 Mechanisms – Tracing the Source of the Effect

6.1 Disaggregating Compensation

Our analysis so far indicated that the 2002 IPR reform increases the relative demand for problem-solvers or managers in the technology-leaders (which are exporting firms) more than that of technology-laggards, which produce consumer non-durable and intermediate goods as final product. With these results, we provide suggestive evidence that points at an IPR reform-triggered quality upgrading mechanism. To understand the channel better, we tested various potential avenues such as administrative reclassification, industry-specific trends and indirect channels that

may work through managers' possible association with trade reform, skill, productivity etc. The question remains: how does the above mentioned channel operate to increase the compensation share of managers higher for technology-leaders in practice? Since the observed change is both through compensation and the number of managers, we now address pay structure and firms' organizational design.

The first step to understand the changes in the compensation share of managers is to examine the changes in its separate components. Thus, we disaggregate the total managerial compensation into wages and incentives. Results appear in **Table 6**. The former is the pre-determined salary received by the employees, whereas the latter is incentive-based, often being linked to performance, which is very closely related to problem-solving. Columns (1) and (2) examine the ratio of managerial wages, whereas, columns (3) and (4) uses incentives ratio, similar to our benchmark dependent variable in Equation (1). Thus, we use $(Managerial\ Wages/Total\ Wages)$ and $(Managerial\ Incentives/Total\ Incentives)$ as the dependent variable in columns (1) – (2) and (3) – (4), respectively. The coefficient of $IPR_t * HighTech_i$ in columns (1) and (2) is negative and significant. It points out that as a result of IPR reform, the difference in managerial wages between technology-leaders and technology-laggards' decreases. However, the effect of IPR reform on differences between managerial incentives of technology-leaders and laggards is positive and significant. In other words, IPR reform increases the incentive-based payments of the managers of technology-leaders as compared to that of technology-laggards. Patent rights pushes a firm towards more knowledge-intensive goods, which leads to formation of more non-routine problems only to be solved by the managers. And, this creates a reallocation of tasks more towards managers followed by an increase in their compensation through increase in incentives. And, this is not the case for technology-laggards. Connecting the results on the incentive-based payments to the previous ones, it becomes imperative that firms' division of profits is managers-biased. This becomes all the more relevant in our case given that the key subset of firms are the ones that export, keeping in mind that those who export are also relatively more profitable (Bernard and Jensen, 2004).

6.2 Organizational Design

Following the examination of the compensation components, we next look into the effect of the IPR reform of 2002 on the organizational design of a firm. We build on the results from **Table 3**, where our estimates suggest that IPR reform significantly increases the number of managers recruited in a firm, which is technology-leader. Realizing that the recruitment of new managers within a firm can change the organizational design of a firm, we hereafter examine the various aspects of the organizational structure of a firm. Results of the effect IPR reform on the organizational design of a firm appear in **Table 7**.

An organization can change either horizontally or vertically. A horizontal expansion refers to the addition of horizontal layers such as new divisions with similar managerial and non-managerial layering, whereas a vertical expansion refers to the addition of vertical hierarchical layers, following

the definition of Garicano (2000), such as extra managerial roles between the CEO and the non-managerial workers. We first consider the former. Ideally, we would use the number of within-firm divisions as a direct measure. Since, this is not available, we measure this indirectly through the number of varieties produced. Assuming different products require distinct same-level divisions, we use this proxy for horizontal size. Columns (1) – (3) report the results. We don't find any effect of the 2002 IPR reform on the differences in the horizontal dimension of technology-leaders and technology-laggards.

Next, we study the vertical change. To proxy for vertical expansion we construct a dummy that measures the number of layers in the organization. As was described earlier, the data enables us to consider three types of workers: non-managers, directors, and executives (the latter two representing the aggregated managerial layer). Since executives are managers with executive powers, and hence make the top management of a firm, we consider it as being the highest layer. Thus, this dummy is assigned a number between 1 and 3. We assign 1 when either overall managerial or non-managerial compensation is zero; this can occur when a firm lists no managers or reports sufficiently small compensation for the ones that are listed, or otherwise when the firm is a one-man operation or one which simply lists no non-managers. A 2 is assigned when there are non-managers and executives' compensation is zero while directors' is non-zero or vice versa, or when both executives and directors are listed yet there are no non-managers. Finally, 3 is assigned when non-managers', directors', and executives' compensation is non-zero, indicating there are three layers in the firm.

As mentioned, due to data limitations we treat each level as one aggregate layer, yet this does not preclude having further sub-layers within the managerial ones, which our data doesn't capture. Columns (4) – (6) looks into the effect of the IPR reform on the vertical dimension of a firm. Our coefficient of interest points out that the imposition of patent rights for a firm significantly enhances its vertical layers. In other words, the 2002 IPR reform significantly increases the differences in vertical structure of technology-leaders and laggards. **Figure 6** shows the evolution of the average value of vertical layers for technology-leaders and laggards. The vertical layers increase for both the set of firms, but significantly more in case of the technology-leaders.

7 Robustness Checks

Table 9 checks the robustness of our benchmark results by using alternate methods and sample. We start by reducing the time period from 1990-2006 to 1990-2005. We do this in order to see whether the observed finding is a result of the final implementation of the TRIPs agreement by India in 2005, even though the time period we use to obtain the earlier results uses only one year after the implementation of the agreement. Reducing the time period doesn't affect our benchmark finding. The estimates confirm that the IPR reform of 2002 continues to have significantly contributed to the differences in task composition towards managers of technology-leaders and laggards. Column (2) aggregates our dependent variable and $HighTech_i$ to the industry-level, where $HighTech_i$

changes to $HighTech_j$, where j denotes any industry. We check whether there is any change in the results obtained so far if we change the level of aggregation. Our benchmark result is robust to this kind of aggregation.

Column (3) additionally controls for the 1999 domestic patent reform. Policy shifts in relation to patents didn't occur immediately after India signed the TRIPs Agreement, but took place only after a domestic constituency emerged that supported patent reform. In 1998-99, a domestic policy enabled India to start to revise its patent laws, which laid the foundations for redefining the balance towards the rights of patent holders, and led to a strategy aimed at raising the patent activity of domestic actors. We control for this first policy change, which was towards encouragement of patenting activity, to explore whether there is any prolonged effect on task composition of firms. In particular, we use $IPR_{99} * HighTech_i$ in addition to $IPR_{02} * HighTech_i$ in our estimation equation to check whether the effect of the 2002 IPR reform on the reallocation of task composition holds even we control for the initial policy change. We find this to be untrue. $IPR_{02} * HighTech_i$ is significant and positive.

In column (4), we use simple Average Treatment Effect (ATE). The ATE measures the difference in mean (average) outcomes between the units assigned to the treatment and control group, respectively. Since, ATE averages across gains from units, we use average treatment effect of the treated (ATT), which is the average gain from treatment for those who are actually are treated. We utilize the previous classification of firms as technology-leaders and laggards as the treatment and the control group, respectively. We estimate the following equation to calculate the gain from 'treatment' or the 2002 IPR reform:

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

where, τ_{ATT} denotes the gain received by the firms which belong to the group of high-tech or technology-leader. The expected gain is assumed to be in response to the randomly selected unit (firms) from the population. This is called the average treatment effect of the treated. $Y(1)$ is the outcome with the treatment and $Y(0)$ is without the treatment. The binary "treatment" indicator is W, where $W = 1$ denotes "treatment, which in our case is the 2002 IPR reform. As previously, we expect the coefficient to be positive and significant, which indicates increase in the knowledge-intensity of the production for technology-leaders (before the reform) as a result of the 2002 IPR reform. Everything else being equal, technology-leaders hire more managers than technology-laggards. That is, relative to technology-laggards, technology-leaders are expected to produce more of technology or knowledge-intensive goods in the post-reform period. We estimate the above equation by considering a sample of all possible pairs.

Columns (5) and (6) uses fractional logit and Poisson Pseudo-Maximum Likelihood (PPML) using Silva and Tenreyro (2006), to deal with the problem of zeros. Since, our dependent variable is a ratio, therefore including zeros when estimating with OLS may produce biased estimates. We

understand that dealing with zeroes is a huge issue and we use these two methods to control for such. Both the methods estimate the coefficients in terms of percentage changes and the dependent variable doesn't need to follow a Poisson distribution or be integer-valued (it can be continuous). We estimate the standard errors using Eicker-White robust covariance matrix estimator. As the point estimates demonstrate, the IPR reform induces significant reallocation of tasks towards managers for technology-leaders vis-à-vis technology-laggards.

Lastly, we conduct a placebo test, using an ex-ante ex-post approach to prove that the 2002 reform is not endogenous. We argue in our background section that implementation of the 2002 reform was very uncertain till it was implemented as there was a lot of debate around it. But, in order to be absolutely certain, we use this test following Branstetter et al. (2006). It could presumably be possible that firms' (in our case, technology-leaders) sentiment has been growing in support of production of more knowledge-intensive goods well before the imposition of the 2002 reform. Therefore, they may have adjusted themselves according to the modalities of the reform, thereby having significant differences in the reallocation of tasks vis-à-vis technology-laggards. We argue that this is not the case. We use three ex-ante variables, $2002IPR\ Reform\ (t-4)$, $2002IPR\ Reform\ (t-3)$ and $2002IPR\ Reform\ (t-2)$, which takes a value 1 for all the year less than four, three and two years of the reform, respectively. We also use ex-post variables, $2002IPR\ Reform(t+1)$, $2002IPR\ Reform(t+2)$, $2002IPR\ Reform(t+3)$ and $2002IPR\ Reform(t+4)$, which takes a value 1 for the year greater than year, two, three and four years of the IPR reform. The reason for not using any dummy for the year $(t-1)$ is that the coefficients on the reform dummy will provide estimates relative to that year (Branstetter et al., 2006). The results show that the ex-ante estimates are less than the concurrent effect of the reform, whereas the ex-post estimates portray amplification effect of the 2002 IPR reform, proving that the reform is not endogenous.

8 Conclusion

We follow Garicano (2000) and extend it to understand whether there is any effect of an IPR reform on the organizational dynamics of firms. And, in doing so, we argue that the effect will be different for a technology-leader vis-à-vis technology-laggard (as in classified before the reform). We argue that imposition of an IPR reform will induce a firm to produce more of knowledge- or technology-intensive goods, which will lead to a rise of a new set of non-routine tasks. Since, managers are knowledge providers, firms will reallocate more of its tasks towards managers. This will create a demand for managers, more in case of technology-leaders than laggards (as they produce more of knowledge-intensive goods), and will lead to a change in the organizational design.

We test this argument by utilizing a quasi-natural experiment from India in terms of utilizing a IPR reform in 2002. We find a remarkably robust, persistent and economically meaningful positive effect of the 2002 IPR reform on the demand for managers; with the difference in the effect between technology-leaders and technology-laggards significant and positive. In other words, the 2002 IPR reform led to a reallocation of tasks more towards problem-solvers or knowledge-providers, higher

in case of technology-leaders. Our benchmark estimations indicate that the 2002 IPR reform led to an increase in the share of managerial compensation of an average technology-leader as compared to technology-laggard by 0.3-1.5 percent. This effect is robust to various controls, specifications, estimation techniques and time periods. In addition, we identify the subset of firms that drive the result are exporters, both domestic and foreign and belong to consumer non-durable and intermediate goods industry. Next, we find that imposition of patent rights decreases the gap of the wages of managers between technology-leaders and laggards, whereas it does the opposite when we substitute wages with incentives. An IPR reform increases the managerial compensation through increase in the incentives, as managers now deal with more non-routine problems. Lastly, we find that imposition of patent rights not only increases the compensation of the managers, but the number as well. This leads to a change in the organizational design of a firm by expanding a technology-leader more vertically than technology-laggard.

Put together, these results provide suggestive evidence for a quality upgrading mechanism. Imposition of patent rights induces technology-leaders (compared to technology-laggards) to produce more knowledge-intensive goods and this reallocate tasks more towards managers, who solves the non-routine problems. However, in doing so, patent rights also increases the gap between technology-leaders and laggards by reallocating more tasks towards knowledge-intensive goods; and within-firm wage inequality.

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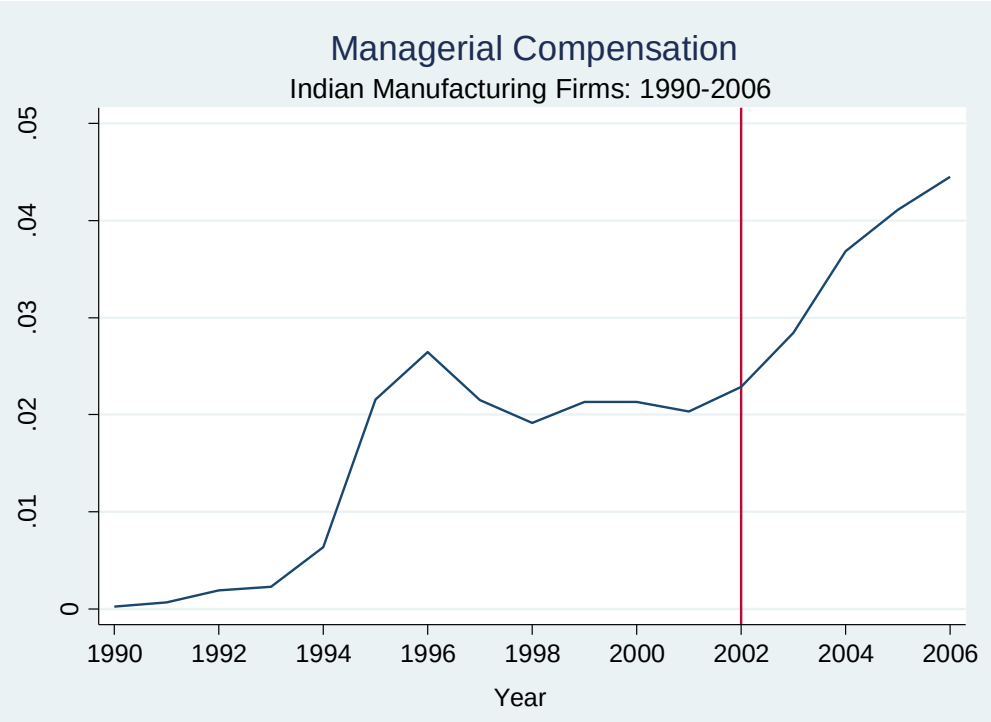

Figure 1: Managerial Compensation, 1990-2006

Notes: Figure presents the average compensation share of managers for a manufacturing firm in India, 1990-2006

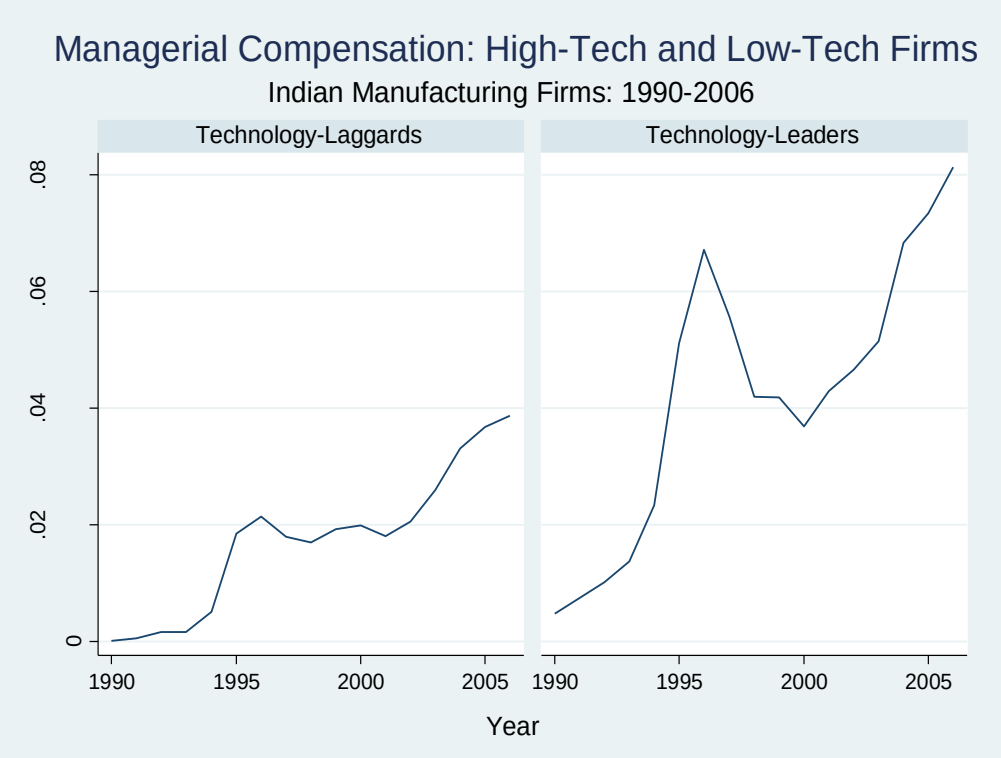

Figure 2: Managerial Compensation: High-Tech and Low-Tech Firms, 1990-2006

Notes: Figure presents the average compensation share of managers for technology-leaders and technology-laggards in India, 1990-2006

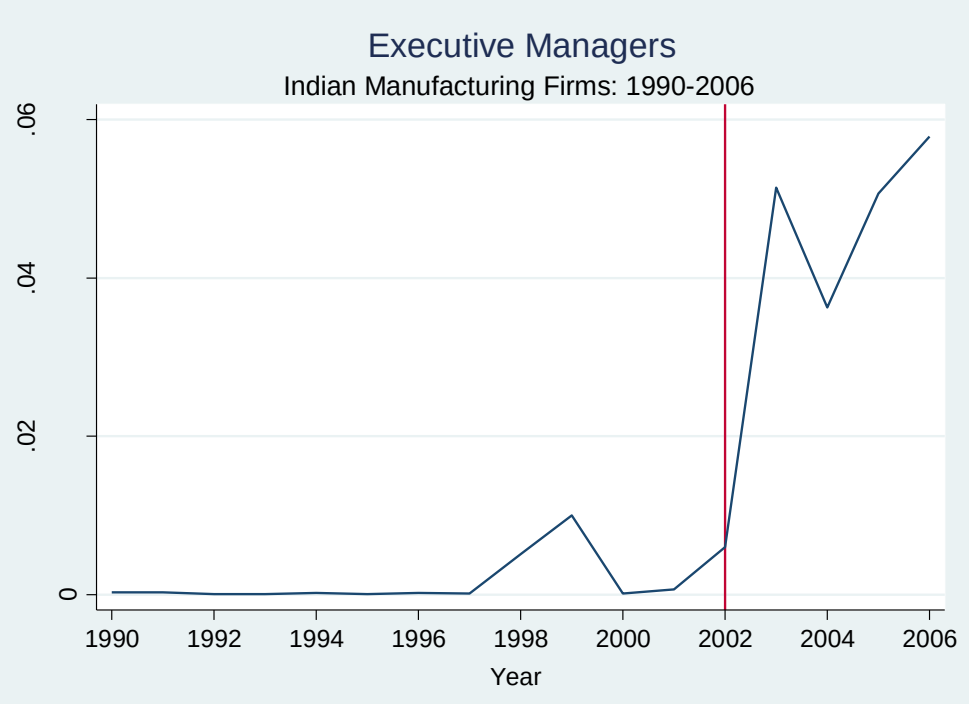

Figure 3: Executive Managers, 1990-2006

Notes: Figure presents the average proportion of managers in total employees of a manufacturing firm in India, 1990-2006

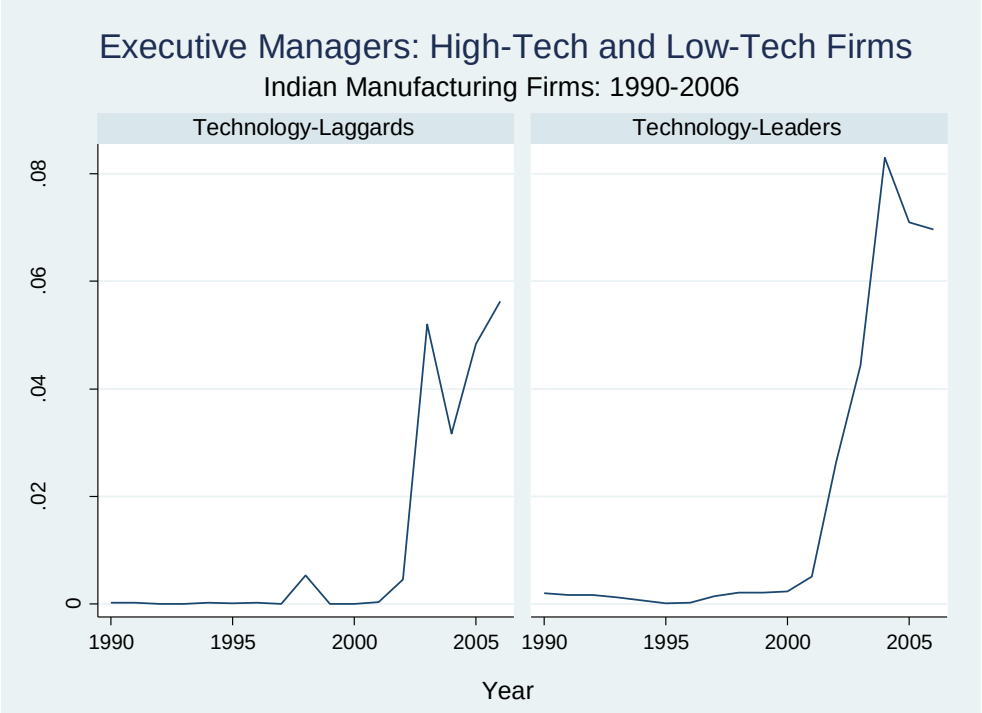

Figure 4: Executive Managers: High-Tech and Low-Tech Firms, 1990-2006

Notes: Figure presents the average proportion of managers in total employees for technology-leaders and technology-laggards in India, 1990-2006

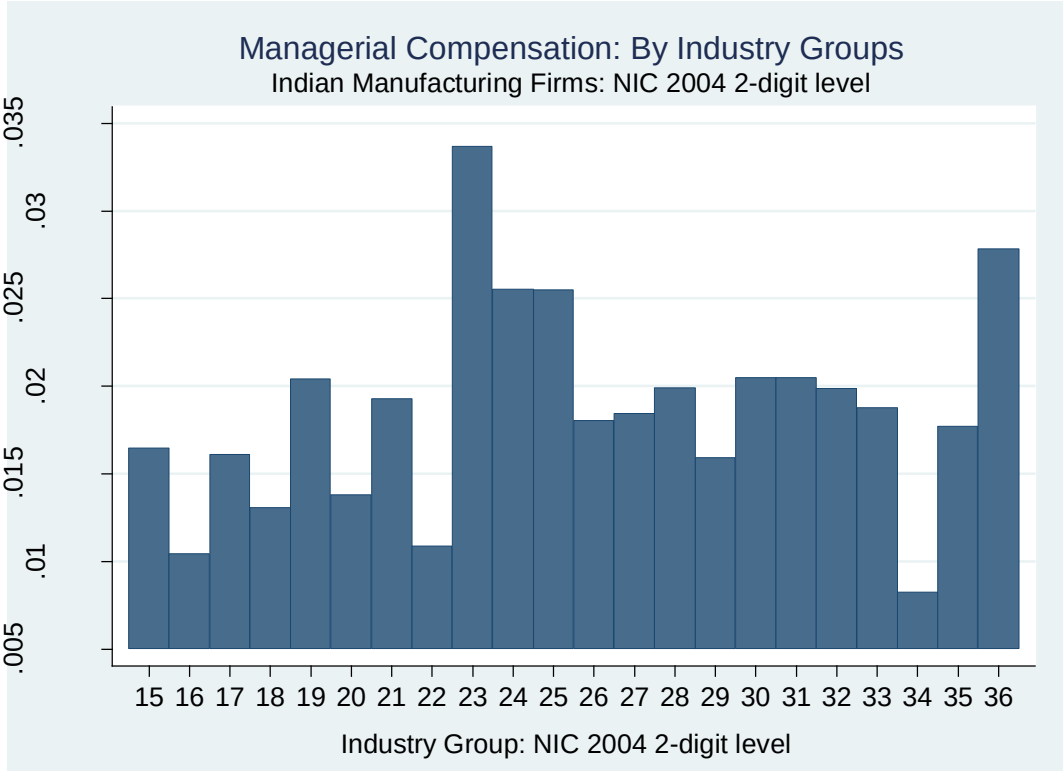

Figure 5: Compensation Share of Managers: By Industry Groups, 1990-2006

Notes: Figure presents the average compensation share of managers across NIC 2004 2-digit level industries, 1990-2006

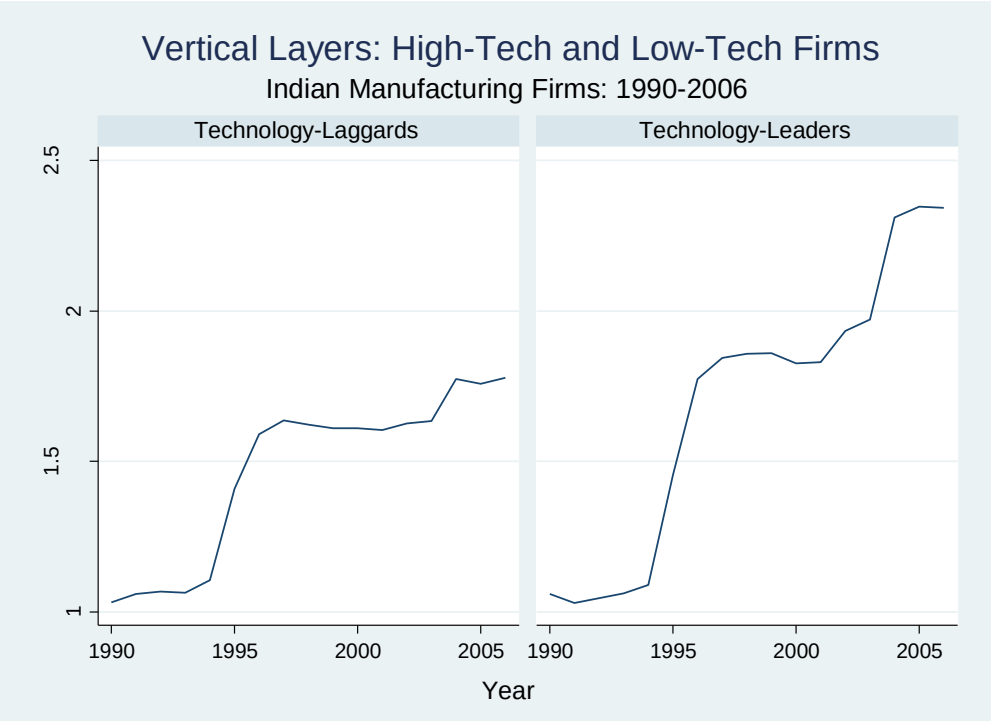

Figure 6: Vertical Layers: High-Tech and Low-Tech firms, 1990-2006

Notes: Figure presents the average number of vertical layers for technology-leaders and technology-laggards, 1990-2006

	Mean	Median	Std. Dev.	Min	Max
Panel A: Organizational Variables - Dependent Variables					
Managerial Compensation /Total Compensation	0.02	0.003	0.08	0	1
Layers	1.61	2	0.62	1	3
Product Scope	4.49	3	4.45	1	86
Managers' Compensation	1.31	0.2	169.65	0	66315.1
Non-Managers' Compensation	95.53	14.4	631.83	0	47619.5
Managers' Wages	0.63	0.04	147.11	0	57590.5
Non-Managers' Wages	93.73	13.6	624.18	0	39720.6
Managers' Bonuses	0.12	0	3.55	0	8724.6
Non-Managers' Bonuses	4.61	0	66.26	0	9053.9
Number of Top Managers	1.56	1	0.72	0	7
Panel B: Firm/Industry-level Determinants - Explanatory Variables					
Capital Employed	1049.62	128.1	10599.64	2	891409
Assets	1540.61	192.4	15736.8	1.4	1200000
Input Tariffs	69.95	46.95	49.17	17.34	202.02
Output Tariffs	72.71	49.29	56.72	14.5	298.07
Skill Intensity	0.26	0.25	0.07	0.04	0.71
Productivity	0.84	0.58	2.19	0.02	4.96
Factories	3920.77	3315	3037.77	15	14486

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

Table 1: Summary Statistics

	Managerial Compensation/ Total Compensation					Non-Managerial Compensation/ Total Compensation				
	1990-2006					1990-2006				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
IPR02	0.047***	–0.028	0.043***	0.059***	–0.006	–0.001	0.080**	0.012	–0.032	0.084***
	(0.008)	(0.018)	(0.009)	(0.015)	(0.011)	(0.016)	(0.038)	(0.019)	(0.043)	(0.028)
IPR02*HTech	0.006***	0.005**	0.006***	0.006***	0.006***	–0.020***	–0.019***	–0.018***	–0.017***	–0.018***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Capital Employed	0.005***	0.005***	0.005***	0.005***	0.005***	–0.010***	–0.011***	–0.017***	–0.017***	–0.016***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Assets	0.004*	0.003	0.003	0.003	0.004	0.076***	0.077***	0.084***	0.084***	0.084***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.50	0.50	0.50	0.51	0.52	0.62	0.62	0.62	0.63	0.63
N	62677	62677	62677	62677	62677	62677	62677	62677	62677	62677
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE*Year Trend	No	Yes	No	No	No	No	Yes	No	No	No
Industry FE (2-digit)*Year FE	No	No	Yes	No	No	No	No	Yes	No	No
Industry FE(3-digit)*Year FE	No	No	No	Yes	No	No	No	No	Yes	No
Industry FE(4-digit)*Year FE	No	No	No	No	Yes	No	No	No	No	Yes

Notes: Columns (1) – (5) and (6) – (10) use share of managerial compensation in total compensation and share of non-managerial compensation in total compensation as the dependent variable, respectively. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'Capital Employed' is the total amount of capital used by a firm. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. 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 2: IPR Reform and Knowledge-Intensive Tasks: Benchmark Results

	Executive Managers			
	1990-2006			
				Ordered Probit
	(1)	(2)	(3)	(4)
IPR02	0.566***	0.597***	0.487***	0.977***
	(0.041)	(0.112)	(0.061)	(0.239)
IPR02*HTech	0.098***	0.097***	0.095***	0.129***
	(0.016)	(0.016)	(0.016)	(0.032)
Capital Employed	0.018**	0.019**	0.018**	0.087**
	(0.008)	(0.008)	(0.008)	(0.025)
Assets	0.030***	0.029***	0.032***	0.111***
	(0.009)	(0.009)	(0.009)	(0.027)
Firm Controls	Yes	Yes	Yes	Yes
R-Square	0.56	0.56	0.56	0.12
N	46229	46229	46229	46229
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE*Year Trend	No	Yes	No	No
Industry FE*Year FE	No	No	Yes	Yes

Notes: Columns (1) – (4) use the number of executive managers as the dependent variable. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'Capital Employed' is the total amount of capital used by a firm. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table 3: IPR and Knowledge-Intensive Tasks: Benchmark Results with Executive Managers

	Managerial Compensation/ Total Compensation			
	1990-2006			
	(1)	(2)	(3)	(4)
IPR02	0.034***	0.038***	–0.009	0.039***
	(0.006)	(0.009)	(0.014)	(0.009)
IPR02*HTech	0.006***	0.006***	0.003*	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
Input Tariffs$_{t-1}$	–0.012*			
	(0.007)			
Output Tariffs$_{t-1}$	–0.009*			
	(0.005)			
Skill Intensity		–0.009		
		(0.009)		
TFP			–0.001	
			(0.004)	
Factories				0.001
				(0.006)
Capital Employed	0.005***	0.005***	0.003	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)
Assets	0.003	0.003	0.002	0.003
	(0.002)	(0.002)	(0.003)	(0.002)
Firm Controls	Yes	Yes	Yes	Yes
R-Square	0.50	0.50	0.73	0.50
N	61304	62672	30543	62672
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE*Year FE	Yes	Yes	Yes	Yes

Notes: Columns (1) – (4) use share of managerial compensation in total compensation as the dependent variable. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'Input Tariffs' and 'Output Tariffs' are input and output tariffs at NIC (National Industrial Classification) 4-digit level, respectively. 'Skill Intensity' is defined as the ratio of non-production workers to total employees. This is also at the NIC 3-digit level. 'TFP' is total factor productivity estimated using Levinshon and Petrin (2003). 'Factories' is the number of factories at the NIC 3-digit level. 'Capital Employed' is the total amount of capital used by a firm. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *, **, *** denotes 10%, 5% and 1% level of significance.

Table 4: IPR and Knowledge-Intensive Tasks: Additional Controls

	Managerial Compensation/Total Compensation (1990-2006)								
	Export Orientation		Ownership		End Use				
	Exporters	Non-Exporters	Domestic	Foreign	Consumer Non-Durable	Intermediate	Basic	Capital	Consumer Durable
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
IPR02	0.010	0.072***	0.040***	0.019	0.040***	0.080**	0.089***	0.016	0.024
	(0.010)	(0.017)	(0.009)	(0.049)	(0.013)	(0.032)	(0.027)	(0.027)	(0.020)
IPR02*HTech	0.004**	0.0001	0.006***	0.013**	0.008**	0.015***	–0.004	0.003	0.002
	(0.002)	(0.006)	(0.002)	(0.006)	(0.003)	(0.004)	(0.007)	(0.004)	(0.004)
Capital Employed	0.005**	0.006**	0.005***	0.007**	0.002	0.006*	0.012**	0.004*	0.004
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.005)	(0.002)	(0.004)
Assets	0.001	0.006*	0.003	–0.002	0.006	0.003	–0.002	0.004	0.002
	(0.003)	(0.004)	(0.002)	(0.007)	(0.004)	(0.005)	(0.006)	(0.004)	(0.005)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.65	0.56	0.50	0.61	0.45	0.53	0.50	0.57	0.60
N	31261	31416	58722	3955	20899	14905	11357	8126	7390
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1) – (9) use share of managerial compensation in total compensation as the dependent variable. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'Capital Employed' is the total amount of capital used by a firm. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. 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: IPR and Knowledge-Intensive Tasks: Firm Characteristics – Export Orientation, Ownership and Sectoral Analysis

	Managerial Wages /Total Wages		Managerial Incentives /Total Incentives	
	1990-2006		1990-2006	
	(1)	(2)	(3)	(4)
IPR02	–0.049***	0.011**	0.015	–0.263
	(0.017)	(0.006)	(0.077)	(0.190)
IPR02*HTech	–0.004**	–0.004**	0.012**	0.013**
	(0.001)	(0.002)	(0.006)	(0.006)
Capital Employed	0.002**	0.002**	0.0004	0.002
	(0.001)	(0.001)	(0.004)	(0.003)
Assets	–0.000	–0.0002	0.005	0.003
	(0.001)	(0.002)	(0.005)	(0.005)
Firm Controls	Yes	Yes	Yes	Yes
R-Square	0.42	0.43	0.78	0.77
N	62672	62672	26862	30919
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE*Year Trend	Yes	No	Yes	No
Industry FE*Year FE	No	Yes	No	Yes

Notes: Columns (1) – (2) use ratio of managerial to total wages of a firm, whereas, columns (3) – (4) exploit proportion of managerial incentives to total incentives as the dependent variable, respectively. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'Capital Employed' is the total amount of capital used by a firm. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. 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: IPR and Knowledge-Intensive Tasks: Disaggregation of the Compensation – Wages and Incentives

	Organizational Change (1990-2006)					
	Horizontal Expansion			Vertical Expansion		
	Product Scope			Management Layers		
			Ordered Probit			Ordered Probit
	(1)	(2)	(3)	(4)	(5)	(6)
IPR02	0.113	–0.273***	–0.322***	0.300***	0.375***	1.183***
	(0.093)	(0.101)	(0.093)	(0.045)	(0.028)	(0.078)
IPR02*HTech	0.009	0.013	0.0001	0.059***	0.060***	0.497***
	(0.014)	(0.014)	(0.015)	(0.005)	(0.006)	(0.034)
Capital Employed	0.006	0.005	0.014	0.016***	0.010*	0.111***
	(0.011)	(0.011)	(0.013)	(0.006)	(0.006)	(0.021)
Assets	0.118***	0.120	0.105***	0.079***	0.088***	0.160***
	(0.015)	(0.016)	(0.017)	(0.007)	(0.007)	(0.023)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.84	0.84	*n/a*	0.68	0.68	0.18
N	45251	45251	44702	62677	62677	62677
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE*Year Trend	Yes	No	No	Yes	No	No
Industry FE*Year FE	No	Yes	Yes	No	Yes	Yes

Notes: Columns (1) – (3) use natural logarithm of varieties produced, whereas, columns (4) – (6) exploit number of management layers of a firm as the dependent variable, respectively. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'Capital Employed' is the total amount of capital used by a firm. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. 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: IPR and Knowledge-Intensive Tasks: Change in Organizational Structure

	Managerial Compensation/Total Compensation (1990-2006)							
	Time Period: 1990-2005	Industry FE (4-digit)* Year FE	Aggregating at Industry-level	Controlling for the 1999 Patent reform	ATE	Fractional Logit	PPML	Endogeneity of Reforms
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IPR02	0.043***	–0.006	–0.028	0.030***	Yes	3.378***	–0.264***	0.006*
	(0.009)	(0.011)	(0.018)	(0.005)		(0.840)	(0.029)	(0.003)
IPR02*HTech	0.005**	0.006***	0.007**	0.005**	0.017***	0.126***	0.083***	0.006***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.006)	(0.029)	(0.027)	(0.002)
IPR99*HTech				0.001				
				(0.002)				
Capital Employed	0.005***	0.005***	0.001	0.005***	Yes	0.540***	0.563***	0.005***
	(0.002)	(0.002)	(0.003)	(0.002)		(0.040)	(0.035)	(0.002)
Assets	0.003	0.004	–0.001	0.003	Yes	–0.531***	–0.552***	0.003
	(0.002)	(0.002)	(0.003)	(0.002)		(0.040)	(0.037)	(0.002)
IPR Reform $(t-4)$								–0.009
								(0.007)
IPR Reform $(t-3)$								0.005
								(0.005)
IPR Reform $(t-2)$								0.001
								(0.003)
IPR Reform $(t+1)$								0.011***
								(0.003)
IPR Reform $(t+2)$								0.016***
								(0.004)
IPR Reform $(t+3)$								0.021***
								(0.005)
IPR Reform $(t+4)$								0.024***
								(0.006)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.50	0.52	0.60	0.50	NA	NA	0.04	0.50
N	57339	62677	1742	62677	68016	62677	62677	62677
Firm FE	Yes	Yes	No	Yes	No	Yes	No	Yes
Industry FE	No	No	Yes	No	No	No	No	No
Year FE	Yes	Yes	Yes	Yes	No	Yes	No	Yes
Industry FE* Year Trend	No	No	Yes	No	Yes	No	Yes	No
Industry FE* Year FE	Yes	Yes	No	Yes	No	Yes	No	Yes

Notes: Columns (1) – (8) use share of managerial compensation in total compensation as the dependent variable. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'IPR99' is a dummy variable, which takes a value 1 if year is greater than equal to 1999. IPR Reform $(t-4)$ 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 Reform $(t+4)$ 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. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. 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: IPR and Knowledge-Intensive Tasks: Robustness Checks

Appendix

A Data

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

Variable definitions

1. **Managerial compensation/Total compensation**: Share of managerial compensation in total labour compensation; compensation defined as the sum of all salaries, and additional bonuses.
2. **Executive Managers**: The number of top managers of a firm, who have executive powers.
3. **Managerial wage/Total wage**: Share of managerial wage in total wage of a firm.
4. **Managerial incentives/Total incentives**: Share of incentives or bonuses in total incentives of a firm.
5. **Technology-Leader** or **High-tech**: It takes a value 1 if the sum of R&D expenditure, royalty payments for technical knowhow and import of capital goods is greater than the median of the industry sum, to which the firm belongs and zero otherwise.
6. **Horizontal Dimension or Product scope**: The number of different varieties produced.
7. **Vertical Dimension or Layers**: The number of vertical layers – 1, 2 or 3. 1 denotes having no managerial layers, or otherwise only one such layer with no non-managers; 2 denotes having either directors or executives in a firm, but not both, when there are non-managers, or otherwise having both directors and executives, with no non-managers; 3 denotes having both directors and executives, together with non-managers, in a firm.
8. **IPR02**: It takes a value 1 if year is greater than equal to 2002.
9. **Capital employed**: Total amount of capital employed by a firm.
10. **Age**: Age of a firm in years.
11. **Assets**: Total firm assets.
12. **Productivity**: Firm TFP computed using the Levinsohn and Petrin (2003) methodology.
13. **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 the TRAINS-WITS tariff database.
14. **Skill intensity**: The 3-digit industry level ratio of non-production workers to all workers, obtained from the Indian Annual Survey of Industries (2001-2006) and from Ghosh (2014) (1990-2000).
15. **Factories**: The 3-digit industry level number of factories/plants.
16. **Ownership**: It indicates whether a firm is domestic-owned or foreign-owned.

17. **Intermediate goods**: The goods which are classified according to the I-O table as inputs by end-use. It combines intermediates, capital and basic goods.
18. **Final goods**: The goods which are classified according to the I-O table as final products by end-use. It combines consumer durable and consumer non-durable goods.

Appendix B

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

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

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

	Total Employee Compensation		Managerial Compensation		Non-Managerial Compensation	
	1990-2006		1990-2006		1990-2006	
	(1)	(2)	(3)	(4)	(5)	(6)
IPR02	0.060	–0.013	–0.042	1.186***	0.092	–0.032
	(0.104)	(0.076)	(0.109)	(0.092)	(0.101)	(0.076)
IPR02*HTech	0.319***	0.319***	0.627***	0.623***	0.314***	0.313***
	(0.016)	(0.016)	(0.023)	(0.023)	(0.016)	(0.016)
Capital Employed	0.110***	0.087***	0.091***	0.073***	0.104***	0.082***
	(0.018)	(0.018)	(0.011)	(0.011)	(0.017)	(0.018)
Assets	0.465***	0.492***	0.113***	0.132***	0.461***	0.487***
	(0.021)	(0.022)	(0.015)	(0.015)	(0.021)	(0.022)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
R-Square	0.94	0.94	0.74	0.75	0.94	0.94
N	62677	62677	62677	62677	62677	62677
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE*Year Trend	Yes	No	Yes	No	Yes	No
Industry FE*Year FE	No	Yes	No	Yes	No	Yes

Notes: Columns (1) – (2), (3) – (4) and (5) – (6) use natural logarithm of total employee compensation, managerial compensation and non-managerial compensation as the dependent variable, respectively. 'IPR02' is a dummy variable, which takes a value 1 if year is greater than equal to 2002. 'HTech' is a dummy variable which takes a value 1 if a firm's expenditure on account of R&D Expenditure, Technology Transfer and Import of Capital Goods before the year 2001, is greater than the median of the industry, to which the firm belongs. 'Capital Employed' is the total amount of capital used by a firm. 'Assets' is a size indicator. Both these variables are in their natural logarithmic form. Firm controls include age and age squared of a firm. Numbers in the parenthesis are robust clustered standard errors at the firm level. Intercepts are not reported. *,**,*** denotes 10%, 5% and 1% level of significance.

Table B.2: IPR and Knowledge-Intensive Tasks: Benchmark Results with Absolute Levels