

A Online Appendix: Patent data

While the patent filings by Indian companies at the USPTO are readily available in EPO's PATSTAT database, patent filings with the Indian Patent Office have to be assembled using three databases. First, the Indian Patent Offices' electronic patent search facility iPairs provides information on published patents from 2005 onwards. For patent filings before 2005, we rely on the EKASWA database assembled by the Patent Facilitating Centre (PFC). EKASWA contains all domestic patents published between January 1995 and early 2005. We complement the dataset on domestic filings by using the online portal BigPatents India. The patent data are matched to the Prowess firm-level data. Due to the absence of a unique identifier shared by the firm-level and patent data, we matched patent and firm-level data based on a combination of an automated name-based matching algorithm and extensive manual matching and checking.

B Online Appendix: Figures

Figure A-1: Patenting companies – Indian Patent Office vs USPTO, 2000-2011

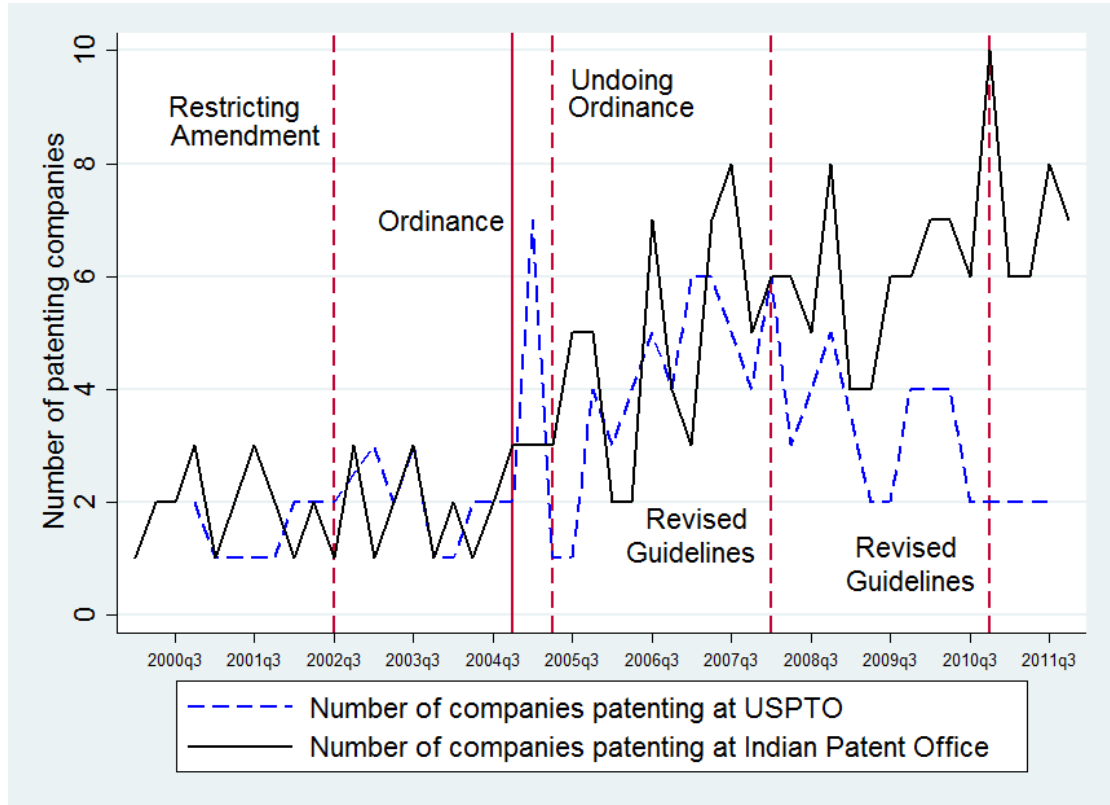
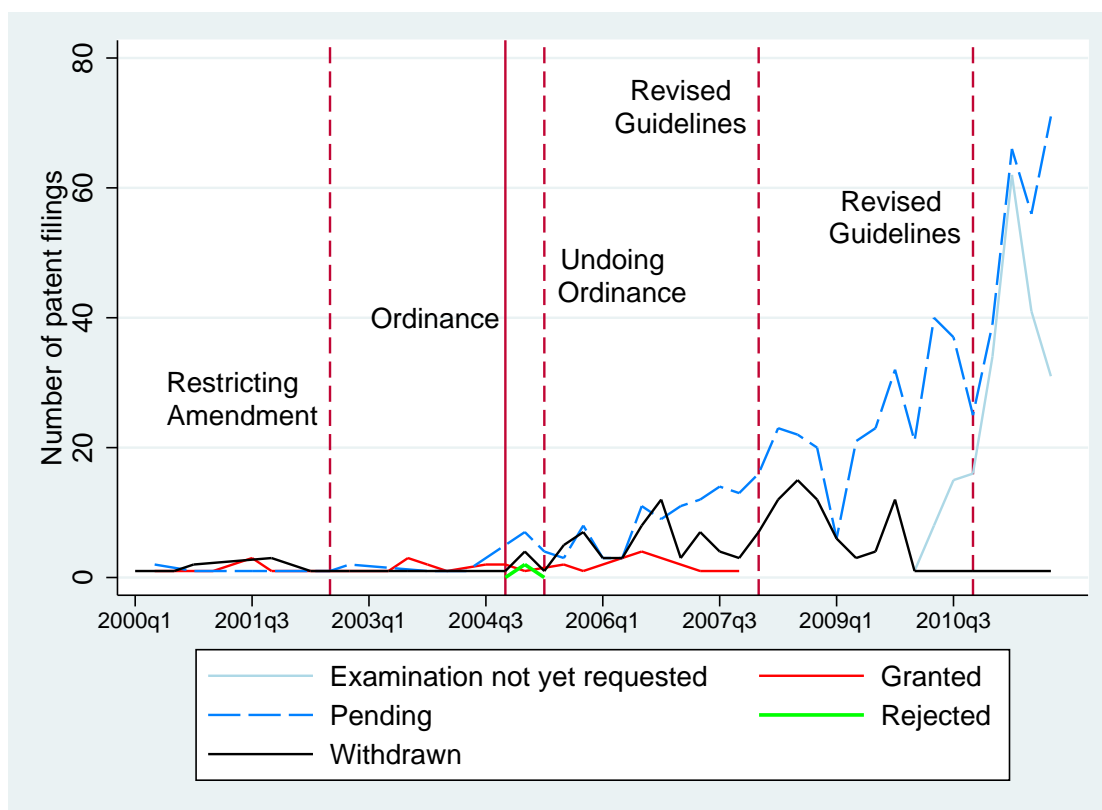


Figure A-2: Legal status of patent filings at the Indian Patent Office – 2000-2011



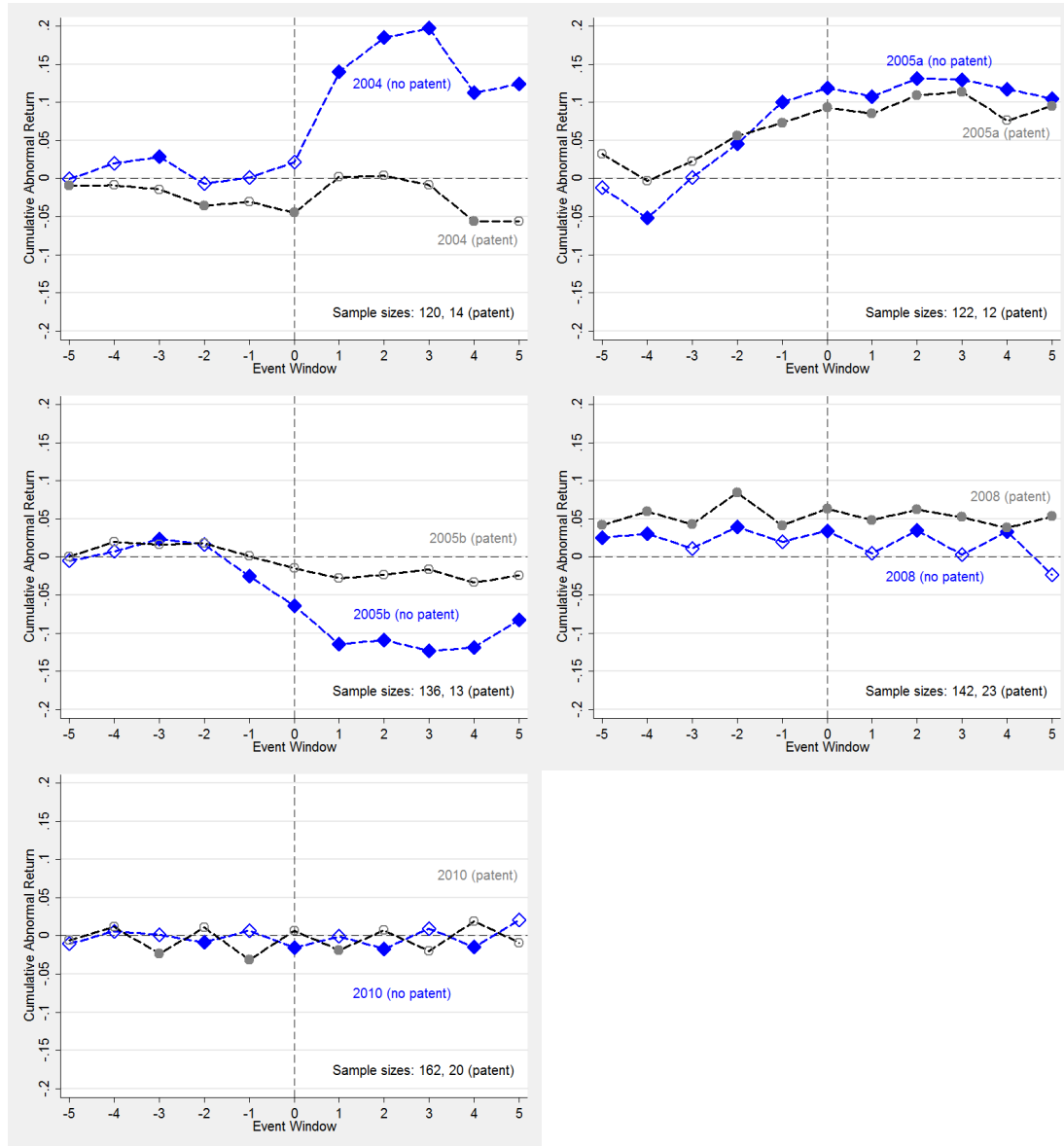
Notes: The legal status was obtained from the [iPairs](#) website of the Indian Patent Office in February 2014.

Figure A-3: Legal status of patent filings at the USPTO – 2000-2011



Notes: The legal status was obtained from the [PAIR](#) website of the USPTO in February 2014.

Figure A-4: CAR for patenting and non-patenting firms



Notes: Each plot compares the CAR for patenting versus non-patenting firms for the five ‘events’ outlined above (event window of 11 days). We label a firm as patenting if it has filed for a patent with the Indian Patent Office or USPTO prior to each respective event date.

C Online Appendix: Tables

Table A-1: Descriptive statistics – product-level regression sample, 2000-2010

Variable	Mean	Median	St. dev.	Min	Max	Obs
Software companies						
# patents Indian Patent Office	0.29	0	3.22	0	71	1,942
# patents USPTO	0.11	0	0.97	0	28	1,942
Age	15.30	14.00	7.45	1	66	1,942
R&D intensity	0.002	0	0.02	0	0.54	1,942
Total assets (100mio Rs)	44.40	3.60	214.29	0	3,443.50	1,942
Sales (100mio Rs)	36.21	1.70	199.98	0	2,927.70	1,892
Control sample						
# patents Indian Patent Office	0.02	0	0.18	0	3	666
# patents USPTO	0	0	0	0	0	666
Age	16.10	12.00	12.94	2	79	666
R&D intensity	0.001	0	0.005	0	0.45	666
Total assets (100mio Rs)	345.09	15.28	1348.00	0	15,603.62	666
Sales (100mio Rs)	133.68	12.43	424.68	0.2	38,017.70	615

Table A-2: Companies patenting in India (in alphabetical order), 2000-2011

Company	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
3I Infotech									1			
Aftek								1				
Bartronics India									1			
Bodhtree Consulting					1							
Cranes Software Intl.								2				
Flextronics Software Systems						1		2				
Geodesic						1	3	1		1	1	
HCL Technologies					1			3	3	3	8	30
Hinduja Global Solutions												1
ICSA (India)								1				
Infosys				1		14	31	24	69	21	48	163
Infotech Enterprises			2								1	
Intellvisions Software						2						
KLG Systel						2	4	8				
KPIT Cummins Infosystems									3	6	11	10
Mindtree								3		1	7	1
Mold-Tek Technologies								1				
Mphasis						1						
NIIT	3	2	2	1	2	2	1					
Odyssey Technologies				1								
Om Energy						1						
Onmobile Global									4		9	2
Persistent Systems							2		1	1	1	2
Polaris Financial Technology					1						1	
Prithvi Information Solutions										2		
Ramco Systems						11						
Rolta India											1	
Sasken Communication Technologies	1		1	1		2	2	1	1		1	3
Satyam Computer Services		3										
Tanla Solutions							2		2			
Tata Consultancy Services	5	3	2	6	3	8	10	19	30	63	71	185
Tata Elxsi									9	9	1	1
Tata Infotech		2	2									
Wipro	1						1	1	3	1	3	2
Zensar Technologies											1	1

Table A-3: Companies patenting in the US (in alphabetical order), 2000-2011

Company	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Encore Software								1				
Flextronics Software Systems								1				
Frontline Business Solutions											1	
Geodesic								2				
Geometric						1					1	
Infosys			1			3	17	28	7			
KPIT Cummins Infosystems									2	1		
Mascon Global							1				1	
Megasoft						2		1				
Mindtree									3			
Moschip Semiconductor Technology									2			
Onmobile Global							1	4		1	1	1
Oracle Financial Services Software									2			
Patni Computer Systems											1	1
Ramco Systems					1	6			2	2	1	
Sankhya Infotech					2	1					1	
Sasken Communication Technologies	1	6	6	4	2	2	2	1	2		4	1
Satyam Computer Services	1		1	4	1	4	3	3	8	7		
Tanla Solutions							1	2		1		
Tata Consultancy Services			5	2	1	2	4	3	5	1	3	8
Tech Mahindra				1								
Wipro				1		1	9	8	4		1	

Table A-4: Before and after comparison of means – 2002, 2005, 2008 policy shocks, 2000-2010

Variable	Software companies			Control sample		
	≤ 2002	> 2002	t-test [†]	≤ 2002	> 2002	t-test [†]
Share of services in sales	0.840	0.850	0.571	0.718	0.772	0.127
	≤ 2005	> 2005	t-test [†]	≤ 2005	> 2005	t-test [†]
Share of services in sales	0.845	0.849	0.804	0.752	0.768	0.600
	≤ 2008	> 2008	t-test [†]	≤ 2008	> 2008	t-test [†]
Share of services in sales	0.846	0.855	0.626	0.762	0.753	0.804

† P-value.

D Online Appendix: India’s software industry

The history of the Indian software industry is a remarkable success story of a shift from an original comparative advantage in factor endowment (cheap educated labour) in the 1990s to a ‘created’ comparative advantage in services outsourcing enabled by organizational capability less than a decade later (Athreye, 2005). Like many other industries the software and IT services sector benefited from full financial liberalization and increased openness in the early 1990s, which together with the Software Technology Parks government infrastructure scheme (Athreye, 2005, refers to the role of the state up to this point as ‘benign neglect’) enabled domestic firms such as Wipro and TCS to answer the phenomenal growth in global demand for software services by establishing dedicated Offshore Development Centres for overseas clients. During this phase the dominant business model however had not yet entirely moved on from the ‘body-shopping’ of the early export phase in the 1980s, when Indian firms simply provided programmers on-site for whatever jobs overseas clients needed done (Arora, 2008). For the time being the work carried out was limited to maintaining the software and systems designed by others (Economist, 2011) and the dollar value of service contracts was still modest, on average only around US\$100,000 (Arora et al., 2001; Arora, 2008), although then and up until today the lion’s share of the industry was produced for export. Throughout this phase, however, following a period of experimentation, major Indian players in the sector – see Table A-5 for the Top 5 firms – identified specific industrial niches for themselves (firm-specific capability in servicing the finance and insurance or the telecommunications industries) and the sector as a whole pushed for increased quality certification Athreye (2005) — both factors which enabled these companies to weather the period of slack demand following the burst of the dot-com bubble in the early 2000s and emerging from this experience as key actors in a consolidated industry.²⁷ Before this episode, the late 1990s brought severe challenges for the domestic industry, with a scarcity of experienced software engineers, rising wages and high levels of attrition (up to 40% employee turnover per annum) forcing Indian software firms to choose the ‘high road’ to export competitiveness rather than to continue its reliance on a low cost model: domestic firms developed organisational capabilities to operate within this challenging environment, building on in-house training and the adoption of formalised procedures to ensure worker attrition did not translate into loss of knowledge for the company Athreye (2005). The unique ‘created’ comparative advantage of Indian software and IT services firms relates to their capacity to ‘ramp up’ and ‘ramp down’ specific projects quickly in response to client demand, enabled by their expertise in how to split tasks between high- and low-capability workers as well as their ability in managing global operations (Arora,

²⁷Other important factors included improved access to venture capital and a lifting of restrictions on private investment in Indian telecommunications, which dramatically reduced the cost of connecting to the internet for these firms (Athreye, 2005).

2008). By the time the leadup to the Y2K bug forced many Western companies to update their software systems (Niosi and Tschang, 2009) the primary business model in the Indian software and IT services sector had moved away from body-shopping (on-site work) and toward an increased focus on off-shore operation (i.e. India-based software services): between 1999/2000 and 2002/3 the share of revenue from off-shoring operations increased from 39% to 57% (Athreye, 2005). Individual, multi-year service contracts secured by Indian firms in the 2000s now ran into the tens of millions or even hundreds of millions (Athreye, 2005; Arora, 2008), a far cry from the mere scraps of the late 1990s described in Arora et al. (2001).

Table A-5: Top-5 Indian Software/IT Services providers (by export value)

Rank	Firm	Exports (2010/11)	Global Workforce (2012)
1	Tata Consultancy Services (TCS)	\$5.1bn	254,000
2	Infosys	\$4.5bn	155,629
3	Wipro	\$3.5bn	140,000
4	Cognizant*	\$3.3bn	156,700
5	HCL	\$2.1bn	85,194

Notes: Ranking and exports taken from ESC (2012), global workforce in 2012 from company websites. * indicates foreign firms/MNCs.

Today (FY2010/11) the industry delivers the outsourced software requirements for over half of all U.S. Fortune 500 companies, contributes around 4.3% to domestic GDP and employs around 2.5 million mostly skilled ‘knowledge’ workers, with the top three firms (TCS, Infosys and Wipro) accounting for half a million employees alone. Over the past decade a steady 80% of total production in the Indian computer software and services industry has been exported, amounting to around US\$58bn of exports in 2010, almost five times the 2003 figure of US\$12.6bn — see Table A-6 for sectoral evolution of production and exports. In terms of global players in the US\$ 960bn world software/IT services market, India ranks fourth behind the U.S. (market share: 39%), Japan (12%) and the EU (8%), but ahead of its fellow BRIC China (6%) (all figures for 2010/11, taken from ESC, 2012). The local industry association NASSCOM further estimates that the potential market for software and IT services outsourcing will triple by 2020 (Economist, 2011).

This historical overview and present competitive state of the sector is however marred by continued worries regarding the sustainability of the industry’s growth and corporate strategy (Arora, 2008). High-end software ‘solutions,’ packages of software and IT services which range from design of application to advising clients on how to restructure their operations are estimated to account for a mere 10% of revenues today (Economist, 2011). As discussed in Arora (2008) there are three sets of activities to add value in software production: (a) software design and development, with household names such

Table A-6: Evolution of the Indian Computer Software and Services Industry
Production and Exports (in million US\$)

Year	2003	2004	2005	2006	2007	2008	2009	2010
Total Production	16,141	22,058	30,404	42,312	55,144	61,984	64,956	74,890
Annual growth rate		37%	38%	39%	30%	12%	5%	15%
(a) Exports	12,609	17,216	23,718	33,757	43,467	49,540	51,001	57,616
Annual growth rate	42%	37%	38%	42%	29%	14%	3%	13%
ITES/BPO				9,480	12,295	13,700	14,418	16,572
w/out ITES/BPO				24,277	31,172	35,840	36,583	41,044
World exports	73,153		108,200	130,800	160,900	201,400	190,300	215,200
(b) Domestic market	3,532	4,842	6,686	8,555	11,677	12,444	13,955	17,274
Share of production	22%	22%	22%	20%	21%	20%	21%	23%

Notes: All figures in million US\$ (nominal) for the financial year with the exception of world exports (for the calendar year). Definitions: Total Production: Computer Software/Services; Exports: Computer Software/Services (including ITES, IT-enabled Services, and BPO, Business Process Outsourcing); Exports of ITES/BPO: IT-enabled Services and Business Process Outsourcing; World exports: Computer and Information Services (excluding ITES/BPO) – note that these figures are not directly comparable due to likely discrepancy in the definition of computer software and services. Sources: Indian data from ESC (2012) *Statistical Yearbook 2010/11*, the ESC website and UNCTAD (2006) for 2000-2003; world exports from UNCTAD (2006, 2012).

Microsoft or Adobe typical examples; (b) development and design of bespoke client software, typified by German software giant SAP; and (c) services to ‘user industries,’ e.g. banking and finance institutions, healthcare providers, or public institutions. It is in the latter domain that most of India’s software providers operate in, successfully substituting the provision of these services by in-house divisions within firms in these industries. The importance of this third type of operations cannot be underestimated, with around two thirds of software professionals in the U.S. suggested to work for IT-using rather than IT firms. This corporate strategy may be seen as the root of the problems in securing the future sustainability of the Indian software industry: while other recent export success stories like Israel and Ireland have focused on fostering start-up software development companies (the biggest of which are listed on U.S. stock markets but maintaining their primary R&D in Israel) and hosting MNC subsidiaries, respectively, Indian firms stuck to customised software services, often relatively low-value work and with revenue per worker substantially lower than in other activities (Athreye, 2005). Since Indian firms still primarily operate as contractor services to user-industries they face a natural barrier in moving into the higher value end of the software value-chain as their clients are unwilling to hand over this sensitive part of their business to outsiders or because Indian firms do not have the necessary human resources to carry out these complex tasks (Niosi and Tschang, 2009). In recent times, only one Indian firm, i-Flex, a provider of high-end banking software until its acquisition by Oracle in 2006, has been able to successfully develop own-brand software products, although a number of firms (in particular domestic industry-leader TCS) have engaged in co-development of prod-

ucts with clients while a considerable number has engaged in strategic acquisition to complement organic growth (see in particular Table 3 in Niosi and Tschang, 2009).