Industrial Performance Center
Massachusetts Institute of Technology
Working Paper Series

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MIT-IPC-06-005

September 2006

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Offshoring Radiology Services to India

For submission to *Journal of International Business Studies*, Special Issue on 'Offshoring Administrative and Technical Work: Implications for Globalization, Corporate Strategies, and Organizational Designs'

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Abstract: We discuss teleradiology and medical image reconstruction from the perspectives of both India and its client countries. Radiology is an “extreme” professional service with extensive usage of tacit rather than codified knowledge. The importance of tacit knowledge leads to long training periods, a limited global supply of radiologists and heavy government regulation, all of which are obstacles to a “flat world”. Computerization of low-end diagnostic radiology ultimately poses a bigger threat to the profession than offshoring.

Keywords: offshoring, outsourcing, institutions, professional work, skills, technology

Introduction

When people discuss the world's new flatness, the conversation often turns to teleradiology - how U.S. medical images are now read by radiologists in India. Since U.S. radiologists train for five or more years after medical school, teleradiology has become a paradigm example of how globalization threatens highly educated workers as easily as call center operators (Sperling, 2005; Elliot, 2006).

There are enough isolated facts for a good news story. An Indian radiologist in Mumbai or Bangalore likely earns less than the equivalent of $35,000 a year, about one-eighth of a U.S. radiologist's income. U.S. medical images are read in Bangalore and other offshore locations. Indian teleradiology firms are developing new markets in the United Kingdom and Singapore. Beyond reading images per se, Indian firms are also doing 3D image reconstruction for U.S. hospitals, work done in the U.S. by trained medical technicians.[3]

But an examination of all the facts suggests that teleradiology is not garden variety offshoring. About fifteen (15) Indian radiologists currently read U.S. images. This number is unlikely to expand much in the near future. When U.S. images are offshored to other countries, the typical reader is a U.S. radiologist living abroad.

Indian radiologists are developing a stronger presence in the United Kingdom and Singapore. But even in these countries potential expansion is limited in the short run and

[3] 3D image reconstruction involves assembling cross-sectional "slices" (two dimensional images) from, say, a CT scan of the brain, into a virtual three-dimensional model. Image reconstruction is discussed further in Section 4.

uncertain in the long run. And no client country, including the U.S., shows evidence of radiologist or technologist displacement.

Many of these outcomes reflect the characteristics of radiology including its extensive training requirements and its heavy government regulation. But significant training and regulation characterize many professional services and so the teleradiology story provides a useful caution about just how flat the world is.

In this paper, we discuss teleradiology and image reconstruction from the perspectives of both India and its client countries. In the course of our discussion, we explore how trade in a highly skilled professional service can differ from trade in services involving less training and regulation – e.g. call center operators – and trade in manufactured goods.

The body of the paper is divided into five sections. In Section 1, we describe professional services in cognitive terms. A cognitive perspective helps to explain why an offshore professional service provider faces two related obstacles in entering client country markets: how to demonstrate that they can do the work, and how to negotiate the profession's regulations in the client country. In Section 2, we explain why, in these same cognitive terms, diagnostic radiology[4] is an "extreme" professional service.

[4]A diagnostic radiologist, the largest radiology subspecialty, reads and interprets images. An interventional radiologist, the second largest subspecialty, performs image-guided procedures like inserting a catheter in an artery. These latter procedures cannot be done remotely and so are not targets of offshoring.

In Section 3, we describe the state of radiology in India including the educational system and the supply of radiologists who are qualified to work in the global teleradiology market. In Section 4, we discuss how Indian firms, after some false starts, obtained limited entry into U.S. markets in both diagnostic radiology and 3D image reconstruction. We then explain why these same firms see potentially greater markets in the U.K and Singapore. In Section 5, we use the findings of the previous sections to make a few observations on the future of offshore teleradiology and to discuss the relevance of teleradiology for the offshoring of other professional services.

The descriptions of Indian teleradiology are based on a short visit to India by the second author in the summer of 2004, followed by three weeks of extensive Indian field research by the second author in the summer of 2005. Other parts of the paper are based on the first author's interviews and observation of radiologists at work in the U.S and on an unpublished PhD dissertation by Goelman (2005). Both authors conducted telephone interviews with radiologists and researchers in the U.K. and in Singapore.

1) Offshore Professional Services

With the spread of broadband communications, providing professional services has become a potential route by which developing countries can move up the value chain, engaging in higher profit activities that stimulate domestic skill formation. Despite this opportunity, offshored professional services have grown far more slowly than offshored back office services - call centers, credit card processing, and so on (Baily and Lawrence, 2004).

Part of the lag reflects shortages of appropriately skilled labor, a subject to which we shall return. But the lag also reflects obstacles facing new entrants to professional service markets. These difficulties have their roots in the cognitive structure of professional work.

To appreciate the point, consider the cognitive structure of work that is moving offshore rapidly – back office services and manufacturing. Levy and Murnane (2004) have described the similarities between this work and the work most vulnerable to computer substitution. Their argument can be summarized as follows:

> All workplace tasks involve processing information: an engineer reading a report, a chef tasting a sauce, a farmer looking to the sky to check for rain, and so on. The tasks most vulnerable to computer substitution are those where the information processing can be described in rules. When a task's information processing can be fully described in rules, it can be programmed for a computer. When significant parts of a task can be described in rules, it is a candidate for offshoring since it can be assigned to an offshore firm with reduced risk of miscommunication and lower costs of monitoring. When a task's rules cannot be articulated —when the task involves extensive tacit knowledge—neither computerization nor offshoring is a readily available alternative.

Processing information by rules is an idea central to both cognitive psychology and artificial intelligence. In the context of production, we can think of "rules" as a step-by-step procedure to produce the manufactured good or service with an action specified for each contingency[5].

Multiple examples illustrate the computer-offshoring overlap. Routine tax returns can be sent to offshore accountants because the U.S. tax code itself is a set of step-by-step rules that govern the return's preparation. These same step-by-step rules are the basis for

[5] Reference purposefully omitted.

TurboTax and TaxCut software. Call center work that is sent offshore is usually heavily scripted – the scripts act as rules - while other call center work is handled partially or completely by computerized interfaces. In the case of manufactured products, Vernon (1966) argued that production moves offshore when product design and processes have stabilized – that is, production can be described by rules. Stabilized production also permits the use of assembly line robots.[6]

Because rules allow standard operating procedure to replace what would otherwise be a series of special cases, rules also facilitate offshoring by making output easy to monitor. Simple tax returns require few judgment calls and so it is straightforward to examine a sample of returns to establish whether an accountant is applying the proper rules. Customer service calls can be sampled and monitored to establish whether an operator follows his/her script, and manufactured parts can be sampled and measured to establish whether they meet specifications.

In contrast to these examples, the most important skills in a professional service cannot be described in rules. The typical professional requires extensive training that includes hands-on experience in internships, a medical residency, laboratory work, and so on. The training indicates the aspiring professional is going beyond rules-based solutions to learn problem-solving that relies on tacit knowledge and so is not quickly taught.

In the absence of rules-based solutions, professionals often solve new problems

[6] Leamer and Storper (2001) generalize Vernon's findings in a discussion of how codified knowledge - rules - sent over the internet can change the geography of production.

through case-based reasoning, a kind of pattern recognition (Bransford et. al, 2000, Chapter 2).[7] In case-based reasoning, the professional constructs analogies between the new problem and problems she/he has previously solved. The solutions to those prior problems serve as a starting point for the new problem (Lesgold, 2001).

Solving problems through case-based reasoning requires substantial prior experience and an ability to recognize features in the new problem that link to relevant previous problems – an ability usually learned through experience. For example, preparing a complex tax return requires both knowing the tax code's rules and having the experience to recognize which parts of the tax code are likely to apply in ambiguous cases.

This description of professional skills has two caveats – one large and one small. The large caveat is that people innovate. A professional may develop a rules-based solution to a particular problem that allows future occurrences to be handled by offshore workers or by a computer. Twenty years ago, a mortgage underwriter had the job of reading a mortgage application and assessing the likelihood of default. Now the assessment is performed by a computer applying an equation (an inductive rule) and computers continue to encroach on other professional tasks.

The smaller caveat is that even though rules cannot describe the professional's core work, rules and protocols typically govern other aspects of the profession. Vocabulary is

[7] We refer here to pattern recognition problems where rules cannot be articulated. If inductive rules can be articulated in a particular case, it is possible to write pattern recognition software. All machine vision and speech recognition software are of this type. See Levy and Murnane (2004) for details. The inability to articulate rules also applies to much of the work of craftsmen including plumbers, carpenters, auto mechanics, etc.

an example: Unless two professionals assign the same meaning to the same word, communication between them can break down.

In the absence of fully articulated rules the professional's work becomes a series of special cases and monitoring output quality becomes difficult. Since the product is no longer uniform, testing of a few samples is not proof of competence. As a result, the individual firm - domestic or foreign - who would start providing a professional service must find other ways to demonstrate to potential clients that they can do the work.[8]

For the offshore professional firm, demonstrating competence can be aided or undermined by the client country's regulations. Since professional competence is hard for a layman to judge, the client country's government may regulate the profession in question[9]. Doctors are an extreme case but architects, engineers, accountants, lawyers, and numerous other professionals who want to practice legally must demonstrate their ability to a professional body, another reason why a common vocabulary is needed. This body may also set standards for practice – accounting standards, engineering standards, lawyers' code of conduct, etc. – and disbar the professional in the event of serious breaches.

The client country's professional regulations may specify a path by which an offshore professional can demonstrate competence and practice. Alternatively, the client

[8] Again, computer programming is an intermediate case since the rules of the programming language allow the program to be debugged.
[9] Immergut (1992) points out that democratic processes mediate the government's regulation of healthcare professions.

country's regulations may ban offshore professionals altogether. The choice depends in part on the power of client country professionals to limit competition, but it also depends on general market conditions. A country with a surplus of architects will not feel pressure to learn how to assess the quality of offshore architects and to admit the good ones to practice. Conversely, a country with a serious shortage of architects will be more willing to admit offshore architects even at the risk of accepting some who do not meet its standards.

We return to all of these issues in the remainder of this paper.

2) Diagnostic Radiology

In this cognitive framework, diagnostic radiology is an extreme example of a professional service. In the U.S., a radiologist's education begins with medical school, sometimes followed by a one year residency in internal medicine, followed by a four year radiology residency and, increasingly, by a one or two year post-residency fellowship. Much of the post-medical school education involves learning to recognize images of different abnormalities – heart, brain, muscle/skeleton, vascular system, etc. – taken by different modalities - CT, MRI, ultrasound, PET Scan, mammograms and plain film X-rays. In the language of the previous section, the radiologist resident is building up a large quantity of experience for use in case-based reasoning.

A cognitive psychologist might argue that the radiologist's image recognition, like all other human information processing, rests on mental rules. While this may be true, those

rules have, so far, proven too complex to articulate. Researchers have worked for a number of years on pattern recognition software to read these images – that is, to mimic the cognitive rules the radiologist uses to recognize abnormalities. To date, the Food and Drug Administration has approved only two applications, and these only as digital second opinions: software to examine mammograms for microcalcifications (a potential cancer marker) and software to examine lung images for cancerous nodules.[10] Most other medical images are too complex at present for software to replicate what the radiologist does. Even normal scans of the abdomen or the brain vary significantly among individuals and each scan can reveal many normal variations as well as multiple abnormalities.[11]

The importance of the radiologist's tacit knowledge combined with the potential harm of mistakes explains why radiology in most countries is a heavily regulated occupation. An offshore teleradiology firm must determine how, if at all, its radiologists can navigate the client country's regulations: by possessing appropriate credentials, by undertaking a demonstration period, by demonstrating a track record, and so on. All of these methods assume the firm has a supply of appropriately skilled labor. As we will see, none of this is easy.

3) Radiology in India

[10] In our own observations, computer assisted diagnosis software for mammograms pick up some irregularities that radiologists miss but they miss other irregularities that radiologists recognize.
[11] Given this individual variation, radiologists often identify problems by looking for changes between a current image and an image taken at an earlier time. Computer vision researchers have long used similar "image differencing" as when a security camera automatically detects movement in a hallway and these techniques may ultimately become a tool for computer diagnoses of images.

India's seemingly vast pool of medical talent is credited for making the country the destination of outsourced teleradiology work. But while the total pool of medical graduates has almost doubled in the last two decades, the number of radiologists educated at an international standard remains quite small. This standard includes the ability to read multiple modalities and to recognize basic abnormalities in most regions of the body, all learned at an internationally recognized institution.[12] Training to this standard requires extensive time spent working on a variety of expensive scanning equipment.

In the U.S. a radiology resident is exposed to all modalities and body systems. If the radiologist goes to work in a hospital emergency department, they will use many of these skills on a regular basis.[13] If they work in a group practice, they will usually specialize in a particular body system (all modalities), and read in other systems as demand requires.

In India, both training and work experience is often more restricted. Advanced scanning equipment is not available at all medical institutions, and graduate resident medical education often emphasizes specialization in a particular scanning mode – e.g. ultrasound - rather than all modes in a particular body system. The scarcity of equipment also affects how hospitals and clinics organize their radiology work and so reinforces specialization in particular scanning modes. As a result of formal education and job practice, only a limited number of Indian radiologists acquire the ability to utilize a range of scanning modes to investigate abnormalities.

[12] See Kevles (1998) for a good overview of both the technology and the profession.
[13] An emergency room radiologist is unlikely to read mammograms or PET Scans that are used to locate the metabolic activity associated with malignant tumors.

India's entry into teleradiology has, by itself, limited power to solve equipment access problems. In manufacturing, an offshore producer must acquire the capital equipment needed to produce the product. While the teleradiologist reads medical images on a computer terminal,[14] the actual scanning takes place in the patient's home country – the client country. Similarly, economic reimbursement for the use of scanning equipment goes to the client country facility, a point to which we return. Despite no infusion of new equipment, we will see that there are still ways in which teleradiology may be able to shape the offshore country's radiology education.

India has two broad tracks of radiologist training at the post-bachelors level: the lower level Diploma in Medical Radiology & Electrology and Diploma in Medical Radio Diagnosis (DMRE & DMRD), and the higher level Medical Doctor and the Diplomate in National Board (MD & DNB). Though radiologists holding a DMRE/DMRD read some images, they do not complete residencies and so they have limited experience in the complexity of cases during their training. Large hospitals in urban areas typically avoid hiring this lower track degree to fill positions in diagnostic radiology. The Diplomate in National Board (DNB) and the Medical Doctor (MD) are considered equivalent to graduate medical residency training in the U.S. and the U.K.[15]

[14] These terminals are part of what are called PACS (Picture Archive Communication Systems) used to transmit, manipulate and view images.

[15] Interviews with UK policy makers indicate that there is a preference in the UK for cross-recognizing Indian doctors who are DNB holders because the DNB is a standardized national examination system that is virtually identical to the UK accreditation system. Examinations in MD programs are specific to the universities that host them and leave room for some institutional variability.

As in the U.K., medical education in India begins at the undergraduate level with a four-and-a-half year Bachelor of Science/Bachelor of Medicine (MBBS), which is typically followed by a year of mandatory internship. The two higher-track degrees – the DNB and the MD - both require three-year residencies at a hospital upon completion of the MBBS.

When graduates of *both* the higher and lower tracks are counted, the number of practicing Indian radiologists still is not large. In 2005, the national professional association for radiologists, the Indian Radiology & Imaging Association (IRIA), accounted for 5,500 registered and active radiologists for an Indian population of 1.08 billion.[16] The number of radiologists who are potentially able to perform teleradiology is smaller since IRIA officials estimate at least a third of the 5,500 radiologists to be DMRE/DMRD (lower track) graduates. By contrast, the American College of Radiology estimates about 27,000 U.S. radiologists for a country of 298 million.

In India, the relatively small number of graduate resident radiologists is not growing rapidly. There are currently 7,698 graduate resident seats for all medical specialties in institutions recognized by the Medical Council of India, more than double the number of seats in 1980.[17] But only 156 of these seats award an MD in diagnostic radiology and another 100 award a DNB in diagnostic radiology[18]. Thus India's pool of radiologists qualified for the international market is increasing at 256 per year minus retirements and

[16] According to the IRIA, over 90% of radiologists in India are members of the IRIA. The count is most accurate for MD holders, who become automatic members upon completion of their residency.
[17] See http://medindia.net/education/index.htm
[18] Official figures posted on Medical Council of India (http://mciindia.org/) and National Board of Examinations (http://www.natboard.nic.in/) websites.

a limited number of Indian medical residents who migrate to other countries each year. (U.S. radiologists are increasing at approximately 500 per year less retirements.[19])

The supply of radiologists to the Indian domestic market is growing somewhat faster. The gap between domestic and international markets involves an issue noted earlier – how offshore professionals demonstrate their competence to client countries. In many countries, an Indian doctor is judged by whether his/her residency program is accredited by the Medical Council of India (MCI)[20]. The figure of 256 graduate radiology residencies refers to MCI accredited seats. Recently, however, some Indian doctors have questioned the timeliness and legitimacy of MCI accreditation and some newer and private sector Indian hospitals are forgoing the process. [21] To our knowledge, no data exist on the number of qualified MD/DNB residency seats not accredited by the MCI, but some number of well-trained Indian radiologists is entering domestic practice even as they are excluded from teleradiology.

Even counting these additional graduates, the Indian economy could absorb more radiologists than it now produces. The rise of the Indian middle class and increased health consciousness make radiological technology one of the most profitable investments for private hospitals. In metropolitan areas, demand is reinforced by wider use of advanced scanning equipment. Standing agreements between large government treatment centers and equipment providers such as GE and Siemens usually make government hospitals the first to acquire advanced technology; large private metropolitan

[19] Personal communication with a staff member of the American College of Radiology.
[20] Cross-recognition of certifications in different countries is discussed further in Section 4.
[21] Personal interviews with Indian radiologists.

hospitals are not far behind. For a recently trained radiologist, a job with access to a broad array of advanced scanning equipment is the primary route for gaining broad, on-the-job expertise and so jobs in these hospitals should be easy to fill. Nonetheless, the number of radiology graduates is sufficiently small that interviews with office-holders in the IRIA and IndianRadiologist, a second professional association, suggest that all Indian hospitals perceive a shortage of radiologists. Dr. Satish Kumar Bhargava, current president of the IRIA, argues that even in the Delhi area, considered a mecca for medical education, the number of residency seats in radiology is not enough to fill the current vacancies in the city's medical institutions. Public investment in medical education and the number of radiology faculty both fall far short of the recent growth in demand for radiological services. As a result, shortages are likely to persist.

In theory, another source of new radiologists would be returning Indian graduates of U.S. radiology residencies who have passed U.S. board exams. The returning graduates would be qualified to serve both the domestic and teleradiology markets. The number of such returning graduates is very small, however. In 2001, one-fifth of all foreign-trained physicians practicing in the U.S. graduated from medical schools in India; many more physicians in the U.S. are of Indian descent (Forcier, Simoens, and Guiffrida, 2004).[22] But within the U.S. there is fierce competition for the current 500 radiology residency slots and interviews suggest that the majority of Indian medical students in U.S.

[22] To practice in the U.S., a graduate of a foreign medical school must do their medical residency in a U.S. program and pass U.S. medical boards. About one-fifth of U.S. medical residents (all medical specialties) attended medical school outside the U.S.

residencies choose a specialty other than radiology. [23] For the few Indian medical students who do become U.S. board certified radiologists, the decision to return to India rests on considerations of life style, values and career development.

In sum, India's success in teleradiology hinges on Indian firms' abilities to attract and retain qualified professionals from a limited domestic pool as well as to repatriate Indian medical professionals practicing in other countries. In the next section we describe how Indian firms have dealt with these problems in providing radiology services to three client countries.

4) Failures and Successes

The U.S. Market

As Willy Sutton would have said, teleradiology firms look first to the United States because that's where the scans are.[24] Medicare alone reports 106 million scanning procedures in 1997 increasing to 150 million procedures by 2003 (Cohen, 2006). But while the U.S. market is lucrative, it is also highly protected by regulation and entry is very difficult.

Friedson (1970) describes how U.S. doctors have a professional dominance in which they themselves determine who can legally practice medicine – a power that software

[23] The competition reflects high radiologist salaries and the fact that a radiologist has reasonable control over his or her hours. We discuss both factors below.
[24] In reality, Japan uses MRI scans (but not CT scans) more intensively than the U.S. does, but language issues make Japan a problematic client for teleradiology. For more on Willy Sutton, go to http://www.fbi.gov/libref/historic/famcases/sutton/sutton.htm.

programmers, call center operators and production workers do not have. Not surprisingly, the doctors set high hurdles. To demonstrate competence - to be allowed to legally read images generated in the United States - a radiologist must have completed his/her medical residency in a U.S. program,[25] passed U.S. medical board examinations, be licensed in the state where the image was taken and have privileges in the hospital where the image was taken. A radiologist who does not fulfill these requirements cannot obtain malpractice insurance and a doctor who refers an image to an uncertified radiologist risks his or her own malpractice insurance.

Within these restrictions, a market for U.S. outsourcing to both domestic and foreign providers does exist – the market for "nighthawk" services.[26] Nighthawk firms use U.S. board certified radiologists and carry malpractice insurance. Their typical client is a radiology practice at a small hospital whose emergency room generates several images a night requiring immediate reads. The small hospital's practice cannot afford a fulltime night radiologist to read half a dozen images.[27] The alternative, of putting a daytime radiologist on night call – potentially waking him/her up at 3:00 in the morning, risks errors, reduces the number of the more remunerative day shifts they can work[28], and makes the practice a less desirable place to work at a time when the U.S. radiologist market is tight. In this situation, sending images to a nighthawk service is an attractive alternative. The nighthawk service, in turn, keeps its rates competitive by consolidating

[25] As noted in the previous section, a graduate of a foreign medical school can apply to do their medical residency in a U.S. program.
[26] See Goelman (2005) for more details.
[27] The website www.salary.com reports that average salaries for diagnostic radiologists average $275-$300,000 depending on the metro area.
[28] While most radiologists are paid on salary, their compensation ultimately rests on the number of images they can read in a shift.

the work generated by multiple hospitals to keep its radiologists busy for the duration of their shifts. Thus a nighthawk firm's advantage is not low wage labor but economies of scale. Correspondingly, nighthawk services are "cheap" only when compared to the very costly alternatives for covering nighttime work in a small practice.

Despite using board certified radiologists, nighthawk services chiefly perform what are called "wet" or preliminary reads. These wet reads inform the patient's immediate treatment. On the following morning, the referred images are given a second read - a "dry" read – by a staff radiologist at the referring practice who signs off on the report. The two-read system is a (costly) way to monitor work. It is also required by Medicare regulations that deny reimbursement for medical procedures done outside the United States.[29] In addition, this second read assuages the fear among the referring practice that they might lose control over their patients (Goelman, 2005).

The first U.S. based nighthawk firm entered the market in 2001. By 2005, nighthawk services were being purchased by at least 1,000 hospitals - about 20 percent of all U.S. hospitals (Goelman, 2005)[30]. For an offshore provider, nighthawk services are a logical entry point and by 2003, two Indian firms were attempting to enter the U.S. market in this way - we will call them Firm A and Firm B.

[29] This restriction was adopted a number of years ago to guard against, for example, people going to Mexico or Canada for treatment.

[30] Some observers interpreted this 20 percent figure as meaning that U.S. radiologists were under siege (e.g. Sperling, 2005). The interpretation mistakenly assumed that images outsourced to nighthawk firms involved standard, low wage offshoring.

Firm A has a more routine story and experienced greater initial success than Firm B. It is headed by two U.S. board certified radiologists who returned to India for personal reasons after training in the U.S.[31] Both radiologists obtained their initial graduate training in India. When the senior member of the pair first returned to Bangalore, he retained his post as faculty at a major U.S. teaching hospital as he began to establish teleradiology services. He published an analysis of his service in an academic journal that demonstrated the productivity gains that could arise from exploiting the time difference between the U.S. and India.

Firm A does two kinds of reads for the U.S. market - standard nighthawk reads done in India and a smaller number of daytime reads done by U.S.-based radiologists employed by the firm. Firm A also employs a number of India-certified radiologists who serve multiple roles. They assist U.S. board certified radiologists in U.S. work (much as radiology residents assist attending radiologists in a U.S. hospital) and they work independently on images from India and from countries other than the U.S.

Firm A now harbors aggressive expansion plans, ranging from the establishment of a comprehensive diagnostic center providing imaging services – initially ultrasound followed by CT, MRI and mammography - as well as clinical laboratory services to the people of Bangalore. Firm A also provides full reads of daytime X-rays to Singapore, and plans to provide services to the UK that we describe below. The firm's present and future expansion is contingent on recruiting and retaining qualified Indian radiologists from nearby hospitals, as well as from other metropolitan hubs of radiology. In particular,

[31] Since our interviews, a third U.S. trained, board certified radiologist has joined the firm.

individual radiologists desired a mix between teleradiology work and more "clinical" diagnostic work that would allow them to interact with other medical professionals and sometimes patients. The firm has accommodated the career advancement interests of these newly recruited radiologists through agreements with a local hospital to run the hospital's radiology department.

Firm B has a more complicated history, beginning with its attempt to recruit U.S. board certified radiologists, an attempt that failed. It then took a different approach to the U.S. market based on two facts:

- Even established nighthawk firms do only wet (preliminary) reads that are read again the next day in the sending hospital.
- In U.S. teaching hospitals, as noted above, images are often read by radiology residents – persons not yet board certified – who work under an attending radiologist's supervision.

Combining these points, Firm B offered U.S. hospitals a nighthawk service where wet reads would be done by fully-trained Indian radiologists acting as "Virtual Residents". Under the plan, Indian trained radiologists would have sent reports directly to U.S. emergency rooms without prior review by a board certified radiologist (as is done in Firm A).[32] Firm B piloted this service for several months: but without review by a board certified radiologist based in India, it could not obtain malpractice insurance. Without malpractice insurance, the firm could not attract customers and so Firm B discontinued the service.

[32] As in all nighthawk services, the report would have been reviewed the next morning by a U.S. radiologist in the sending hospital – the dry read.

Firm B did not, however, wholly abandon the U.S. market. Rather, it sought out segments of radiology work where it "would not circumvent legalities or tread on anyone's toes". It found an opening in the 3D reconstruction – the process of combining two-dimensional CT, MRI or ultrasound "slices" into a virtual three-dimensional model that a doctor would use to highlight pathology on the surface of the brain, the heart, or another anatomical area of interest. [33]

3D reconstruction relies heavily on computer software but it also requires human judgment from a radiologist or radiologic technologist who understands anatomy and physiology. In the U.S., the person doing this work typically begins as an experienced CT/MRI technician who receives 6 - 9 months of additional training in software use and human anatomy. The result is a person who has the combined skills of CT technologist and medical illustrator. The market for such technologists is very tight, a fact illustrated by Hospital X, a large U.S. teaching hospital and one of Firm B's reconstruction customers.

Hospital X's 3D lab began operation in 1999 with an initial demand of two or three reconstructions per day. As doctors became familiar with the technique, demand grew quickly. Within two years, requests exceeded 50 reconstructions a day along with 24/7 service- the lab currently does about 120 reconstructions daily. Fulfilling the demand presented a problem since technologists, as noted, required significant training and

[33] A "slice" refers to a cross-sectional image of the brain, abdomen, or other body region. The power of CT and MRI is their ability to produce a single cross-sectional image rather than superimposing multiple cross-sections as in a standard X-ray. A good introduction to 3D imaging can be found at the web site, www.slicer.com.

trained technologists were occasionally poached by other institutions. Covering night and weekend work was proving very difficult.

In 2003, the 3D lab director was introduced to Firm B by an Indian-born radiologist who had trained in the U.S. Firm B was a logical candidate to do the night and weekend reconstructions. Their personnel were talented – the firm proposed using fully trained Indian radiologists rather than technologists. The question was whether Firm B could do the work to Hospital X's specifications. Assembling slices into a 3D image involves a number of choices – how to deal with slices taken at various angles, how to deal with images of varying quality. A technologist's choices affect the details of the 3D image a doctor will see. To limit variation, the 3D lab in Hospital X had developed a set of protocols for its technologists. Before Firm B could win a contract, it had to demonstrate it could execute the protocols at a level that was indistinguishable from Hospital X's own work – i.e. demonstrate its competence.

The demonstration took the form of a trial period that lasted more than six months. The Hospital X reconstruction lab continued to do all its own reconstructions during this period. Simultaneously, Firm B worked on duplicates of Hospital X's night and weekend cases and sent them to Hospital X for evaluation (at no charge to Hospital X). Hospital X lab staff would critique Firm B's reconstructions (they were not used by doctors during this period) and the cycle would continue. After seven months, the Hospital X lab judged that Firm B's work was indistinguishable from its own work and Firm B was hired to do the hospital's night and weekend work.

Despite expressing satisfaction with Firm B's service, Hospital X is not interested in expanding the offshoring of 3D reconstruction beyond night and weekend cases. As in the case of nighthawk diagnostic services, Firm B's reconstruction service is not cheap - it is more expensive than what Hospital X pays for weekday 9:00-5:00 work. But as with diagnostic nighthawk services, Firm B's reconstruction service is cheaper than the very high cost of covering night and weekend work. Beyond cost per se, Hospital X is also unwilling to disrupt the interaction between reconstruction technologists, 3D researchers, and doctors - interaction the 3D lab views as integral to innovation.

From Firm B's perspective, the reconstruction work is profitable but it raises staffing issues. Interviews with Firm B's radiologists indicate they find the reconstructions tedious and not fully exploiting their professional training. Firm B has addressed this problem by increasing the training of its own technologists so they can assist the radiologists in reconstructing easier cases. This training, however, makes these technologists attractive candidates for jobs in U.S. and U.K. hospitals. Thus, retaining Indian-trained radiologists and technologists over the long run appears to be a challenge for Firm B.

At the same time, Firm B working with a clinical partner, Medical Group Y, continues to try to recruit U.S. board certified radiologists. While the two partners hope to reenter the U.S. nighthawk market, they also have a longer run educational goal. Medical Group Y owns several universities and teaching hospitals both in and outside of India. The head

of the group's radiology department believes that if younger Indian radiologists can work with U.S. board certified radiologists (much as a resident would do), the experience will push Indian training toward the U.S. model - specialization in particular anatomical systems studied with multiple modalities. Building on the radiologists' experience in working with U.S. customers, Medical Group Y plans to move to restructuring radiological departments in its hospitals across the country, and eventually to help diffuse systems-based specialization through its medical schools.

The plan represents a frequently seen process in globalization: a developing country embracing the pressure to conform to international standards as a way to upgrade its own practices.[34] In this case, teleradiology may change Indian radiology practice even though it does not increase physician access to scanning equipment.

In the process of trying to recruit U.S. board certified radiologists, Firm B and Medical Group Y have learned that the small number of returning radiologists from the U.S. is looking for a mix of teleradiology and interaction with other physicians and, in some cases, patients. Medical Group Y is looking into providing this mix through its hospitals in India, but concerns of integrating U.S. board certified radiologists into an existing organizational structure have still not been resolved. In the meantime, Medical Group Y has studied the U.K. market and taken important first steps to enter.

[34] See Srinivas (2004), which includes a description of how Indian pharmaceutical firms used international generic drug standards in a similar way.

The U.K. Market

Where Indian firms face a highly restrictive U.S. teleradiology market, the United Kingdom market is emerging as a larger opportunity. The different outcomes reflect U.S.-U.K. differences in healthcare organization and funding.

In the United Kingdom, roughly 90 percent of all doctors work for the National Health Service.[35] It follows that the British government exerts significant power over total health care expenditures – expenditures that in the United States are more determined by the private market. Until recently, the British government had used its power to keep healthcare expenditures low. As Weisz (2006) writes:

> The most fundamental reason for recent unrest in the National Health Service has to do with the fact that the British medical system is one of the most poorly funded in the Western World. The gap between the proportion of the gross national product (GNP) spent on health care in the United Kingdom and that spent in the rest of Europe has grown markedly since the 1970s. There is no such thing as a "correct" level of funding, but spending significantly less than neighboring states tends to provoke low morale and a sense of crisis among personnel... Most important, since the early 1980s, the gap between demand for service and what the system can afford to supply has promoted a managerial ethos that has replaced the traditional deference of NHS administrators toward the consultant [i.e. specialist] elites. (p. 233, brackets added)

As with many other countries, rapidly evolving scanning technology increased U.K. demand for radiology services. With limited budgets, higher demand translated into higher radiologist workloads and longer waiting times for scans. One U.K. radiologist suggested in an interview that patients in some rural areas could wait as long as a year for an MRI.

[35] Among the private practice doctors, a significant fraction are National Health retirees.

In part reflecting the general doctor shortage, the U.K. has been much more open than the U.S. to admitting foreign trained doctors. As Weiz (2006, p. 237) writes, "the government has decided that bringing in teams of foreign doctors is the best way to deal with long waiting lists for medical services". With openness comes the problem of determining competence. Prior to the 1990s, individual U.K. hospitals had significant freedom in granting staff privileges to foreign trained doctors. In the mid-1990s, the government centralized the certification process under the Postgraduate Medical Education and Training Board (PMETB) and the new arrangement maintained openness to doctors trained elsewhere.

Today, a radiologist who wants to practice in the U.K. must take one of three routes to be listed in the General Medical Council Specialist Register of Radiologists.

- The radiologist can complete medical training and pass certification examinations in the U.K. The PMETB, with advice from the Royal College of Radiologists (the national specialist organization) will then award a Certificate of Completion of Training. With the certificate, the radiologist can apply to be entered in the Specialist Register of Radiologists.

- A radiologist certified in another E.U. country can apply to have their credentials reviewed by PMETB and a Committee of the Royal College of Radiologists. This review is relatively pro forma, a reflection of E.U. efforts to harmonize regulations across countries. A positive review allows the radiologist to petition to be entered into the Specialist Register of Radiologists.

- A radiologist certified outside the E.U. also must present their credentials to the PMETB and a Committee of the Royal College of Radiologists. This review is not automatic and credentials must include details of training and work experience, references, publications (if any) and so on. If the credentials are approved, the radiologist can petition to be entered into the Specialist Register of Radiologists.[36]

[36] Review committees appear to have discretion (rather than fully specified guidelines) in making their decisions. See http://www.rcr.ac.uk/index.asp?PageID=733

As long as government budgets remained tight, the system's openness to foreign doctors meant little in terms of Indian business opportunities. These circumstances changed several years ago when the government passed a National Health Service reform package including a significant increase in funding. This legislation affected National Health radiologists in two main ways: a general increase in salaries[37], and a new program to send some National Health scanning to U.K. private providers. The outsourcing decision reflected the government's judgment that long waiting times for scans were becoming a political and medical liability. The government's chosen solution was, in essence, to lease capacity from the private sector.

The first scanning contract was put out for bid and in June 2004, the National Health awarded a 5 year, 95 million pound contract to Alliance Medical, Ltd. Under the contract, the National Health could refer MRI patients to Alliance who would both do the scan and interpret the result. For several reasons, the reaction of National Health radiologists was milder than one might have expected in the United States. The contract helped improve patient care by addressing long waiting times for scans. It was accompanied by a salary increase. And the contract was promulgated by the National Health for whom most radiologists work. As one observer noted, "The NHS is like a bulldozer - you could stand in the way shouting if you wanted to, but you'd only get flattened!"[38]

[37] Interviews suggest that an experienced National Health Service radiologist currently earns the equivalent of $140,000 while data on www.salary.com states that a U.S. radiologist in a city like St. Louis or Miami earns an average $280,000.

[38] For an example of the limited opposition, see Davis (2005) who argues that the money would have been far better spent strengthening the National Health Service. By comparison, in 2003 a New York Times reporter wrote an article incorrectly suggesting that a major U.S. teaching hospital was beginning to send

To work through patient backlogs, scans were to be taken using mobile MRI machines housed in vans, equipment Alliance could provide. But the contract meant that Alliance had to quickly increase its capacity to read images.

Earlier in this paper, we argued that offshoring of a professional service can create communication problems when professionals don't share a common vocabulary. The initial days of the Alliance contract are a case in point. Initially, Alliance subcontracted much of the reading to E.U. radiologists, many of them in Belgium. Problems arose because of delays in reading images but also because Belgium and U.K. terminology differed in some respects, creating misunderstandings. The problems were large enough that the U.K. Department of Health appointed a well-known professor of radiology to act as "Guardian" and to head a small audit comparing NHS reads with Alliance reads.[39]

Over time, Alliance's performance improved, in part through solving start-up logistical problems. But Alliance also chose to shift much of its work back to English speaking radiologists.[40] It was this shift that opened the door to firms outside the E.U. including Firm A and Firm B from India. As one example, Firm B working with Medical Group Y, established a branch office in the U.K. and won subcontracting work from

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images to Indians who lacked U.S. board certification. In reality, the hospital had been exploring a nighthawk reading room that would be staffed by U.S. radiologists on a rotating basis. The outcry from U.S. radiologists was so overwhelming that the teaching hospital scuttled the project.

[39] The first audit can be downloaded at: http://www.rcr.ac.uk/docs/newsroom/pdf/MRI_AUDIT_REPORT_FINAL_17505.pdf

[40] Evidence of the improvement can be seen in a second Department of Health audit that can be downloaded at: http://www.rcr.ac.uk/docs/radiology/pdf/MR_CG_Audit_April2006.pdf

Alliance. The branch office currently employs only U.K. trained and registered radiologists to do the Alliance work.

Firm B's longer term goal is to offshore this work to India as soon as a requisite number of Indian radiologists can receive General Medical Council specialty registration. In pursuing this goal, Firm B (and other Indian firms) has one important advantage while facing a potentially significant obstacle. The advantage is the low average salaries of Indian radiologists (by U.K. standards). The National Health Service is now putting out a second round of scanning contracts for bids. One industry observer believes the N.H.S. will set low enough reimbursement rates that firms who only read scans (and do not take the scans) will have trouble turning a profit. With low reimbursements, any cost saving is important and a firm operating in India will be able to bid below firms using EU radiologists. The potential obstacle is the E.U. directive that prohibits sending patient information to any non-E.U. country that lacks adequate protections in the transfer of personal data.[41] If the patient consents to sending the information the directive is not binding, but obtaining consent requires patients to think about foreign doctors in ways they have not done until now. Interviews with Firm B and Medical Group Y tell us that despite having achieved compliance with the American HIPAA and the U.K. BS7799 standards that determine *corporate* standards in dealing with patient data, these firms feel they have little recourse over a directive that specifies compliance at a *national* level.

[41] See the EU Directive on Data Protection, Articles 25 and 26, http://www.cdt.org/privacy/eudirective/EU_Directive_.html#HD_NM_45

If this offshoring ultimately succeeds, the world will be a little flatter in the U.K. than in the United States. But even in U.K., teleradiology will not fit the standard offshoring story. No cheap labor will be involved and no domestic jobs will be lost. As in the case of U.S. nighthawk service, reducing U.K. waiting lines by offshoring images will be cheap only compared to the alternative: rapidly educating large numbers of British citizens to become radiologists.

The Singapore Market

In Singapore, the impact of teleradiology is shaped by the tension between the public and private healthcare sectors. The public sector provides roughly 80 percent of the nation's total healthcare, but something less than two-thirds of the nation's 150 active radiologists work in the public sector. The remaining radiologists work in the private sector where fees are higher and incomes are further boosted by the treatment of foreign "medical tourists", many from Indonesia.

Both Singapore's private and public sectors are exploring teleradiology, but the interest in teleradiology appears to be structured differently for public and private entities. Singapore's Ministry of Health has initiated a trial phase of teleradiology in which plain X-rays from two government-controlled "polyclinics" are being sent for diagnostic reading to Indian Firm A. If the trial phase is successful, the government may expand offshoring of X-ray reads to all polyclinics in the public sector, and perhaps to some public hospitals.

The government's decision was driven in part by the problem facing the U.K. National Health Service: the need to expand capacity at low cost. Waitlists for X-ray results were particularly long for Singapore's secondary healthcare institutions - the "polyclinics". Offshoring reads to Indian Firm B cut the waiting time from 2 weeks to same-day delivery of results. But the government's decision had a strategic dimension as well. In an exchange of op-eds with concerned radiologists in the *Singapore Straits Times*, the government explained offshoring X-rays (i.e. 'simpler work') as a strategy to free public sector radiologists to transition more quickly to more advanced modes of investigation including CT and MRI (Tan, 2006).

Interviews with Singapore radiologists including a radiologist in a prominent national university suggest the government believes that Singapore can eventually deliver teleradiology services for higher-end scans, particularly to the U.S. This belief begins with a reasonable cost advantage. In Singapore's private sector, an "associate consultant" radiologist earns the equivalent of $95,000 a year; public sector fee structures are considerably lower. The $95,000 figure is three times as much as an Indian radiologist earns but considerably less than salaries in Australia, the U.K. and the U.S. The government argues that modest fees combined with upgraded quality and infrastructure will allow Singapore to compete in the global teleradiology market.

As the government experiments with the public sector, one private Singapore radiological group has started offshoring its daytime emergency reads to the Indian Firm B. Why should a private radiology group - usually a partnership of radiologists – offshore

work? One reason, again, is capacity. Correspondence with Singapore's private radiology groups and interviews with Firm B indicate that the offshored cases are those that can't be handled in-house in a timely manner. A second reason is the unusual economics of imaging noted earlier. If private Singapore groups own their own scanners, they will receive payment for taking the scan even if the scan is read by another (offshore) firm. We have been unable to learn the details of Singapore fee structures but examples from other countries indicate that scanning itself (without reading) can be a profitable activity. In the United States, for example, 80-85 percent of the Medicare reimbursement for a CT scan or MRI goes to the owner/operator of the equipment – the "Technical Fee" – while the radiologist receives the remaining 15-20 percent "Professional Fee".[42] If Singapore fee structures are anything like this, a privately held radiology practice can still profit substantially even as it sends some images offshore to be read.

When the government first offshored X-ray reads to Indian Firm A, it was not clear whether the offshore reads would fall under Singapore's domestic regulations including quality checks on outcomes. Since then, largely in response to criticism from Singaporean radiologists, the government has made a series of policy statements that substantially tighten regulation. [43] Specifically,

- The ministry of health appointed Singapore's College of Radiologists to "determine the (outsourced) provider's suitability,"
- Singaporean entities that outsource reads abroad will be "held accountable" for maintaining quality standards and,

[42] The high U.S. radiologist salaries, reported earlier, reflect the fact that a radiologist who practices full time (no teaching or research) reads about 13,000 cases a year. Note that because of this fee structure, U.S. insurers and HMO's who want to control imaging are using benefits managers to limit the number of scans rather than trying to open the market to lower cost radiologists.

[43] See, for example, http://www.moh.gov.sg/corp/about/newsroom/mediaforums/details.do?id=36601859

- The government will conduct regular randomized quality tests and audits of all radiology reads.

Earlier, we said that professional services were likely to be regulated and these regulations could either help or retard offshoring. The three cases described in this section represent a spectrum in this regard, a subject we address in the concluding section.

5) Conclusion

Truth wins out in the end and the story of U.S.-radiology-to-India will soon lose its luster. But before dismissing the story, it is worth considering why the story was wrong - why the world is not as flat for radiologists as it is for textile workers.

Most of the answer lies in supply and demand. "The world is flat" is a story about large numbers of developing country workers who can do industrialized country jobs at much lower wages.[44] In today's economy, there are three reasons why this story has particular force for back-office services and manufacturing jobs:

- Much of the work in these jobs involves rules-based tasks that can be easily taught. This makes the assumption about large numbers of developing country workers realistic.

- The rules-based nature of the work makes output quality easy to determine and so markets for back office services and manufactured goods are typically lightly regulated. The lack of regulation eliminates a possible barrier to offshoring the work.

[44] This assumption is part of what economists know as the theory of factor price equalization.

- Because much of the work is rules-based, workers in both developed and developing countries face competition from computerized work. Domestic and offshore workers are competing with each other in a declining market for labor.[45]

For the moment, diagnostic radiology satisfies none of these conditions. Because the work rests on pattern recognition and extensive tacit knowledge, it requires expensive, multi-year training in every country. As a result, relatively few people world-wide are capable of doing the work and the supply is not increasing very fast. Because tacit knowledge (i.e. unarticulated rules) is so important, radiologists currently face no computer substitution and, in fact, the opposite is true: radiologists are an indispensable complement to computerized medical imaging, and rapid advances in imaging expand demand for radiologists' services. The result is a tight labor market for radiologists – expanding demand and restricted supply – that is the mirror image of the global labor market for factory and back office workers.

Within this tight labor market, wages do differ significantly across countries. Because most radiologists are concentrated in high wage countries and supplies in any country can change only slowly, an unregulated global radiology market would increase Indian wages more than it would lower U.S. and E.U. wages. But full convergence is purely hypothetical since, again unlike factory or back office work, the radiology market is heavily regulated. The regulations have a public purpose – a way for consumers to determine professional competence when the cost of incompetence is high. But the regulations also serve to restrict competition within and across countries. Because

[45] For example, the transcription of doctors' dictated case notes, now done in India, is slowly being replaced by speech recognition software. Similarly, a number of observers have pointed to the difficulties facing China as the modernization of manufacturing plants displaces factory workers.

radiologists provide healthcare, a politically charged product, teleradiology can stimulate public opposition as well. In client countries, patients may protest the use of foreign-trained doctors. In a sending country like India, people may object if the limited number of Indian radiologists serves foreign markets rather than medical needs at home.

Neither limited supply nor regulation has totally stopped teleradiology. The economic incentives are too strong for developing country doctors to perform the work and for firms to organize doctors into this work. A question going forward is how regulations will shape the activity.

The three cases in the previous section demonstrate the range of variation. The Singapore government actively promotes and directs offshoring both as a way to expand capacity and as part of a potential development strategy. The U.K. is moving into offshoring as a way of dealing with domestic capacity shortages. The United States sharply limits offshoring by excluding radiologists who lack a U.S. residency and board certification. But even in the Singapore case, market disruption from offshoring will not be very large – the limited world supply of radiologists ensures that.

Earlier we argued that radiology was an "extreme" professional service with extensive reliance on tacit knowledge and long training periods. While most professional services are less extreme, they still involve elements of tacit knowledge and regulation. While many of these services will move offshore more easily than radiology, they will not trade as freely as back office services and manufactured goods.

In particular, some observers expect professional service offshoring to evolve along two tiers, with simpler cases being sent offshore while the higher skilled cases are kept at home. In the case of radiology, we have seen how the Singapore government is experimenting with exactly this policy, sending x-rays to India while retaining the reading of CT scans and MRI's.

This division of labor may involve a negative externality, benefiting firms in the sending country while creating problems for the sending country as a whole. In many professions, "simpler" work is often an important part of the training process. In the course of our interviews two senior radiologists – one from the U.K., the other from Singapore - raised this point. As the U.K. radiologist wrote:

> One of the biggest criticisms of such offshoring/outsourcing is that a lot of the simple stuff will be outsourced leaving the complex and more time consuming work for local radiologists. This can have a deleterious effect on training. For example, if all the simple lumbar spine MR examinations are outsourced, there will be fewer standard MRI examinations available for training and for comparative purposes.

At the same time, the offshore producer can use simple work to build more complex skills that erode the sending country's advantage.[46] In the case of radiology, Indian

[46] Several years ago, a Motorola engineer emailed the following observation to one of us (an approximate quote from memory):

> People say computer programming will move offshore but software architecture will remain in the U.S. This is a false analogy with construction. In construction, bricklayers and carpenters don't become architects. In software, all software architects begin as computer programmers. As programming work moves overseas, the countries who do the programming will develop their own software architects.

Firms A & B and Medical Group Y are pursuing this strategy, hoping to retain their professionals by developing their skills and providing career continuity.

At first glance, a sending country can deal with these problems by restricting offshoring, much as the U.S. has done. But over time, computerized diagnosis is likely to provide even stronger competition for lower level work. Today, most medical images lie beyond computer recognition. Twenty years ago, most human utterances lay beyond speech recognition software. Today, software recognizes a growing variety of vocabularies including doctors' dictated case notes, carrying out transcription work that had been migrating to India and the Philippines a few years ago. When computers become proficient in diagnosing simpler images, the effects on the radiology profession are likely to be greater than anything from Bangalore.

Even in the globalized world, the biggest disruptions to a profession can still lie in its own back yard.

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Some references have been omitted in order to conceal the identity of the authors.

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