Paper Title:

Diffusion of Diagnostic Medical Devices and Policy Implications for India

Short Title:

Diagnostic Medical Devices in India

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Abstract

Objectives: To describe the diffusion of advanced diagnostic devices in India and to assess implications for efficiency in resource use and equity.

Methods: Commodity-level import statistics, household survey data and interviews with medical device sellers were used to assess the spread of diagnostic devices. Published qualitative evidence, case studies of diagnostic service providers and cross-country analyses were used for analyzing the reasons underlying the spread of medical devices in India. Case studies of public and private providers and data from 150 hospitals in one Indian state were used to assess efficiency in resource use and the distributive impacts of diagnostic devices.

Results: High-end medical device inflows rose during the 1990s with both supply- and demand-side factors influencing this trend. Although our results suggest that the overall quantity of advanced diagnostics in India is not excessive, there is some evidence of inefficiency in public facilities and possibly unethical practices in private diagnostic facilities. The unequal geographical distribution of MRI facilities, coupled with inefficient use of medical devices in public facilities suggests inequality in access.

Conclusions: The paper points to major regulatory gaps and health system inefficiencies and suggests ways in which these gaps can be addressed.

Key Words: Medical Technology, CT-scans, Diagnostics, Medical Devices, India

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1. Introduction

Policy discussions and research relating to the introduction and spread of modern medical technology are limited in developing countries. By contrast, in developed countries, the subject of medical technology has attracted much attention, with inquiries about the impact of innovations on health expenditures, factors influencing the development and diffusion of new technology and benefit-cost assessments of expenditures associated with technological advancements (e.g. Baker and Wheeler (1), Bryce and Cline (3), Jonsson and Banta (11), Lleras-Muney and Lichtenberg (12), Newhouse (13)). Among the conclusions of the existing literature is that increases in expenditures associated with medical technology are, in many cases, worth the cost (Cutler and McClellan (4), Fuchs and Sox Jr. (6)).

These issues ought to concern health policymakers in developing countries. The rapid transfer of knowledge and skills made possible by closer global links can greatly improve developing country populations' health. Moreover, many developing countries will experience *demand side* pressures to adopt medical innovations owing to increased awareness, rising incomes, increased insurance coverage and global trade links. These demand pressures may be accentuated by ageing populations and "medical tourism" (Fernandes (5)). There will also be *supply side* pressures, as medical institutions seek to adopt the latest innovations to attract not only customers but also leading medical professionals in developing countries who might otherwise choose to practice elsewhere (Baru (2)). These factors may have a cascading effect on the training provided in medical institutions towards more diagnostic technology-intensive care with less focus on clinical skills. Suppliers of new drugs and medical devices are also likely to expand efforts to sell their products in rapidly growing developing country markets such as India.

How might these developments influence policy outcomes of interest, such as the cost of care, inequality in access to care and ultimately, health outcomes? In thinking about these issues in developing countries, a major handicap is the lack of good information on medical technology diffusion, the factors driving this process and associated outcomes. This paper takes a first step in this direction by focusing on the case of India, and seeks to address three questions relating to medical devices:

- What do we know about the spread of new medical device technology in India and what are the main factors underlying this tendency?
- How effectively is available medical device technology being used in terms of its impacts on the costs of providing health care and on inequalities in access to health care?
- What is the appropriate strategy towards medical innovations and the available basket of medical technology?

2. Data and Methodology

Because data on the spread of medical devices in India are limited, we focused primarily, although not exclusively, on diagnostic equipment such as MRI and CT-scans. An absence of domestic production for such diagnostic devices implies that reliable estimates of their spread can be constructed from commodity-level foreign trade statistics that are available for India. We combined information on commodity trade statistics with data on diagnostic service use from nationally representative household surveys conducted in 1986-87, 1993-94, 1995-96 and 1999-2000 by the National Sample Survey Organization of India to assess whether supply-side data from foreign trade statistics was broadly consistent with available information on the demand side. For purposes of comparison, we also obtained estimates of the number of CT-scans and MRIs from the Indian Radiology and Imaging Association, an organization of diagnostic service providers in India, and from a sub-set of wholesalers of new CT-scans and MRIs.

The data on the spread of diagnostic equipment were supplemented by analyses of factors underlying their spread. We relied primarily on published qualitative evidence, interviews with diagnostic service providers and wholesalers of diagnostic equipment in India. We supplemented our analysis with findings from a cross-country regression relating MRI equipment imports for a set of low- and middle-income countries to a collection of explanatory variables, using data from the United Nations commodity trade statistics database and from the World Development Indicators database of the World Bank.

To assess resource inefficiencies, we inquired whether the estimated number of MRI and CT-scan technologies had spread beyond levels observed in developed countries. We also assessed capacity utilization of imaging equipment from case studies of facilities in India, both in the public and private sectors. These analyses were supplemented by an assessment of efficiency in equipment use in a large sample of public sector hospitals in the Indian state of Andhra Pradesh. A limited amount of information on the geographical distribution of diagnostic medical devices was obtained from the Indian distributors of these devices.

3. Findings

Tables 1 and 2 present data on the volume and the value of imports of selected diagnostic medical devices to India, such as CT-scans, MRI systems, the linear ultra-sound scanner, angiographs, endoscopes and electro-cardiographs (ECG). Note that some categorizations are potentially overlapping – for instance “whole body scanners” can be of both the X-ray or of the magnetic resonance imagining (MRI) variety and Indian trade statistics do not make a clear distinction between the two. Moreover, the distinction between “CT apparatus” and “CT-scanner” is not obvious, since these terms are used interchangeably in the profession. Based on discussions with the Indian customs department, we made the conservative assumption that the “CT-apparatus” and “MRI-apparatus” categories consist of add-ons, or spare-parts, with CT-scanner (NW) units referring to individual non-whole (NW) body CT-scan units, and whole-body scanners referring to both MRI- and X-ray technology based units.

The Indian Radiology and Imaging Association (IRIA) provides an un-sourced estimate of roughly 50 MRI’s and 350 CT-scan facilities in India and separate discussions held by authors with a sub-set wholesalers of diagnostic equipment yielded estimates of 70-100 MRI’s, and 300 CT scans. Both sets of statistics appear to be underestimates of the actual number of CT scans and MRI’s in India, given that the information on the IRIA website has remained unchanged for some years and the information from wholesalers reflects their own sales. Table 1 suggests that at least 931 CT-scans and MRIs currently exist in India (we have included only non whole-body CT-scanners whole-body scanners imported since 1991). Thus the actual number of CT-scans and MRIs in India exceeds IRIA estimates by nearly 133 percent.

The quantity as well as the real value of imports of diagnostic medical devices experienced increases during the 1990s. For devices that serve as consumables, or have well defined units, such as cardiac catheters and endoscopes, this seems clear-cut. For MRIs and CT-scans, the imports of spare parts would also have increased, as the cumulative number of devices present (installed) rose over time. Trends in CT-scan unit imports and the increases in “CT apparatus” and “MRI apparatus” imports in tables 1 and 2 are consistent with this claim.

From tables 1 and 2 we can infer that price per unit (total value/total volume) for most devices in our data either remained stable, or declined during the period under consideration. Three scenarios consistent with this observation: (a) lowered prices of older model imports and their spare parts; (b) newer models becoming available at prices that are essentially similar to past prices of older models; and (c) changing composition of the “apparatus” category for MRI and CT scans. Since explanation (c) applies only “CT apparatus” and “MRI apparatus”, we favor the conclusion that price declines in medical devices, or better quality equipment, or some combination of both is driving these trends. These conclusions are stronger if values are expressed in US$ terms, since the Rupee depreciated against the US$ during this period (Government of India (7)).

Corroborating evidence from the demand side, although not sufficiently device- or test-specific, is available from household surveys in India. Table 3 suggests that the proportion of patients undergoing a diagnostic test increased over the period from 1987 to 1996. Table 4 shows that household expenditures on diagnostic services nearly doubled over the period 1993-94 to 1999-2000, whether taken as a proportion of aggregate household spending, or of aggregate household health care spending. Diagnostic expenditures accounted for one-fourth (25 percent) of the *increase* in the *share* of health care in total spending by households that occurred during this period.

There are many plausible explanations for these trends in India. On the supply side, the liberalization in the foreign trade regime in India in the 1990s is likely to have allowed for greater imports of high-end equipment. This hypothesis is not easily tested, since the definitions of various commodities in foreign trade records are not specific enough for the period prior to 1991. The role of medical practitioners is also potentially relevant, with many non-resident Indian doctors familiar with modern diagnostic methods, returning to India during this period (Baru (2)). There is also evidence of unethical practices, such as medical practitioners receiving commissions of between 10-30 percent from private providers of diagnostic services in lieu of referrals (Baru (2), A. Varshney, Unpublished data 2005). With the 1990s also having been a time of severely constrained government budgets in India (Government of India (7)), medical technology diffusion was driven by the private sector. Household survey data show that during the period from 1986-87 to 1995-96, the share of "free" diagnostic services accessed by outpatients declined from 25 percent to 10 percent; and the proportion of inpatients reporting free diagnostic services also fell, albeit more slowly (A. Mahal, Unpublished data 2005). These trends, as also the data presented in table 4, are consistent with the hypothesis that increased proportions of household spending on diagnostics are directed to the private sector in India. Correspondingly, rising incomes experienced by India in the 1990s possibly contributed to increased demand for better quality care, including modern diagnostic services.

To supplement the above discussion on drivers of the diffusion of diagnostic devices in India with the broader context of technology diffusion in developing countries, we assessed the correlation between a measure of the value of MRI imports and a set of supply- and demand-side explanatory variables for a collection of non-MRI manufacturing, primarily developing, countries. Specifically, we inquired whether inflows of MRI equipment into these countries were systematically related to per capita income (a proxy for effective demand), doctor-to-population ratios (a catch-all for supplier driven factors), the role of foreign-aid (a demand side factor) and a measure of past MRI imports (to capture country-specific factors that may influence imports). We used country-reported import data on MRI equipment flows in a sample of MRI equipment- importing countries with negligible capacity to produce MRI equipment on their own. We considered two specifications, one with and the other excluding Africa. The main findings are reported in table 5. While it is difficult to assign causality to the estimated relationships, the fairly strong correlations in the expected direction between imports of MRI equipment per capita, per capita real GDP and the doctor-to-population ratios are worthy of note.

Technological change, efficiency and access

Our outcomes of concern were efficiency in resource use and improved equity in access to services. To assess efficiency, we inquired if the stock of equipment was excessive relative to some pre-agreed norm, or if the equipment was underutilized, relative to some notion of full capacity. For MRIs and CT-scans in India we used the number of MRI sites per capita in developed countries as a norm. Baker and Wheeler (1) estimated about 1.45 MRI sites per 100,000 people in the United States for the mid-1990s. The use of United States data to define a norm is potentially troublesome given concerns about excessive medical technology use in that country. Rublee (14) estimates 0.11 MRI per 100,000 people in Canada. This range of MRI per-population estimates – for Canada and the United States – was used as a norm. Our estimates of the combined numbers of CT-scans and MRI facilities (931) in India amount to 0.093 CT/MRI units per 100,000 people, not particularly excessive, even in comparison to Canada.

Another way to infer excessive supply, or otherwise, of diagnostic equipment is to examine utilization rates relative to some standards. The Bryce and Cline (3) study for Pennsylvania suggests a utilization norm that ranges between 3,000 and 3,500 scans per MRI per year. Lower utilization rates could be used to conclude that an MRI unit is operating as less than full efficiency. We obtained utilization information on two MRI facilities in Delhi, one located within a large public hospital and one a stand-alone private diagnostic facility, which we consider to be a reasonably representative of the facilities in Delhi. In the private sector, the MRI units conducted 7,500 scans per year while being operational for a total of 360 days a year. By contrast, the public sector MRI unit located in one of the more popular public hospitals was used for only 740 scans and was operational for 300 days per year. This underutilization is symptomatic of government facilities, often the sole affordable source of advanced technological devices to the poor in India. We also assessed CT-scan utilization in the two facilities above and in a private hospital. The three facilities did not differ by much in their utilization of CT-scans and possibly the public hospital is substituting CT-scans for MRI services.

To explore further the issue of efficacy of equipment and resource utilization more generally, we assessed utilization of medical devices in the public sector, mainly durable equipment, for 150 public hospitals in the Indian state of Andhra Pradesh, along with case studies selected public and private facilities in the states of Delhi and Rajasthan.

While the data from Andhra Pradesh could not be separated by diagnostic and non-diagnostic equipment, a *priori* there is no reason to believe that findings for the two sets of devices ought to be different. Our findings are: (a) government facilities face an acute shortage of basic equipment; (b) the equipment is not always functional; (c) and there are potentially serious problems with regard to time taken for installation and repairs. As of 2002, the value of medical equipment at public hospitals in Andhra Pradesh ranged from 70-85 percent of required norms specifying acquisition of the most basic equipment. The situation of Andhra Pradesh, after a long period of World Bank support, is likely to be better than other provinces in India. The latter likely resemble the Andhra Pradesh hospitals of 1993 – when shortfalls in basic equipment were more severe – 25-75 percent in value, relative to government norms. If even the most basic equipment is unavailable, adopting advanced technologies could mean an inefficient use of scarce resources, if not substituting for the missing equipment.

Equipment, when available, was not fully functional in public facilities, so that new technologies embedded in medical devices, even if introduced, are unlikely to be effectively used. In 2002, between 15-50 percent of "major" medical equipment at public facilities was classified as either non-usable, idle, or with low utilization rates in Andhra Pradesh. Moreover, it took an average of between 2-4 months to install X-ray and ultrasound equipment from the time it was *received* at district hospitals, longer at lower-level hospitals. Even these lag times were substantial improvements over previous periods. The findings for Andhra Pradesh are reflected in our case studies of diagnostic services at public hospitals in Delhi and Rajasthan. The average time from ordering to actual commissioning of MRI, CT-scan and Ultrasound equipment at the public hospital in Delhi was four times that of the two private facilities. This excluded the time taken for "needs assessment" a process that could potentially take years at a public hospital.

These inefficiencies have implications for the cost of production of diagnostic services and the overall quality of service. Our calculations of the unit cost of services based on these studies show that average private sector investigation costs for an MRI scan were about 10 percent of the unit cost in the public hospital and the cost of a private ultrasound examination was about 20-50 percent lower as well. There were quality differentials as well. An outpatient visitor scheduled for an ultrasound had a typical waiting time of 2 months, and a month for a CT-scan in the public hospital in Delhi. An inpatient waited 3-10 days for these diagnostic services in the public hospital. Following an examination, the report was available only after a delay ranging from 3 to 5 days, and hard copies of the report were not usually accessible to the patient. In the private sector, by contrast, the reports were typically available on a “same day” basis. Administrative procedures appeared to be considerably more complicated in public facilities.

Our case studies also point to the proximate factors underlying the poor functioning of equipment in the public sector. These range from the unavailability of personnel to operate equipment, poor co-ordination of procurement and installation processes, inadequately trained operating staff and a lack of accountability. Together with financial constraints, these explain the shortages of spare parts and long equipment shut downs in public facilities. Suppliers of medical devices confirmed this in interviews, pointing out that public sector facilities take a long time to pay outstanding dues and delay the reporting of equipment problems. Financial shortages mean that government agencies sometimes do not insure equipment once the warranty period has expired – rendering equipment non-functional as soon as it runs into a technical hitch following the expiry of the warranty period. Public facilities outside the major metropolitan areas, given their greater financial and human resource constraints, are especially vulnerable.

Further up the supply chain, there are regulatory deficiencies that affect both public and private sectors. There is effectively no quality regulation of high-tech medical devices in India, with the existing ISI (Indian Bureau of Standards) standards limited to a small subset of low-cost medical equipment. Imports of second-hand medical devices are allowed into India (Harper (8)), so substandard imports are likely to be common. There are some regulations on medical devices relating to environmental protections on radiation, but little is known about their implementation. There is also little or no check on how equipment performs relative to its claimed effects and its technical specifications.

Costs of diagnostic services in India are also pushed up by the low availability of good quality spare parts and inadequate follow-up service. Spare parts for older equipment are often discontinued by the original manufacturer, and the absence of oversight of the medical device market has helped low quality suppliers. A related concern is the shortage of technical experts for repairing medical equipment. Companies selling the equipment have the best engineers, but they often engage third parties whose personnel are not as skilled, to help execute maintenance contracts. The shortage of "company" engineers means that only the persistent clients are able to get them for maintenance and repair jobs. The private sector has been able to manage these challenges better than the public sector, with public facilities located in outlying areas the worst affected. Over time the market may well sort out more reliable suppliers, and push out the less-reliable ones. But the transition may well be long and costly, especially with rapidly changing technologies.

Then there are *distributional* concerns. We identified the location of 70 MRI sites in discussions with wholesalers of these devices. If these locations are taken to be representative of all CT-scans and MRIs, they point to a lopsided geographical distribution: 63 percent (44) of the MRI units being located in 5 major cities (Bangalore, Chennai, Delhi, Hyderabad and Mumbai) with a combined population of no more than 45 million (or 4.5 percent of India's population), and the remainder in major urban centers as well. The little evidence that exists on the geographical distribution of MRI- facilities does not point to improved equity in access thus far, especially if the poor performance of public facilities is factored in.

4. Conclusions

Our findings lead us to policy recommendations of two types: (a) regulatory recommendations on the new and second-hand medical devices market; and (b) health systems features that influence medical device use.

The chaotic situation in the medical device market in India calls for institutions to ensure that devices perform as claimed by their manufacturers and that any harmful effects are an "acceptable" risk. No such institutions exist in India. A government of India committee recently proposed forming an Indian Medical Devices Regulatory Authority (IMDRA) which could, in the short-run, piggyback on publicly available information on licensing status and medical device performance from the European Union or the United States Food and Drug Administration. IMDRA could also help distinguish fly-by-night operators from more reliable sellers of devices and spare parts, and maintain price lists.

At the very least, information on the different sellers in the market and their terms and conditions ought to be available to potential buyers at this regulatory agency say, through a compulsory registration mechanism developed in consultation with the sellers of equipment and purchasers.

Beyond basic quality requirements and the requirements of clinical efficacy, issues of cost-effectiveness become pertinent – whether the outcomes achieved by the introduction of a medical device are worth the cost, or whether there is a case for limiting the number of medical devices. In a resource constrained setting such as India's, relying on an unregulated market to guide the growth of medical technologies may lead to a lot of wastage and inequity. The task requires, for a start, institutions that can undertake "technology assessment", which currently do not exist in India.

Certificate of need (CON) requirements are often used to impose limits. In India, perhaps it is much too early to be thinking about CON requirements given that medical devices such as MRIs and CT-scans are only just entering into the market. Moreover, CON requirements might introduce a "license-permit" regime with concomitant implications for corruption. Market-centered approaches, such as promoting HMO-type institutions in the form of regulatory requirements on insurance companies, or tax benefits, may help. Baker and Wheeler (1) argue that HMOs curtailed the pace of MRI diffusion in the United States. Extending the medical code of ethics to establishments that employ doctors (even if not owned by doctors) may curb unethical referral practices.

To better use resources invested in medical equipment in public facilities, procurement and installation processes must improve. The achievements of Andhra Pradesh in the 1990s, accomplished by hiring technically proficient staff, suggest that improvements are possible. Decentralized financing authority to hospital committees that run public hospitals in some states in India could help. In smaller towns, ensuring ready availability of trained individuals to operate and repair equipment is critical, possibly by training local district-level staff who could serve as franchisees to the supplier. The public sector could also transfer some responsibilities of device operation to private providers.

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Table 1. Imports of Medical Devices by Quantity, 1991-2003, All India

	Three Year Totals			
Device Type	**1991-4**	**1994-7**	**1997-00**	**2000-3**
CT Apparatus	n.a.	>73	206	1810
CT Scanner (NW)	113	167	181	176
MRI Apparatus	n.a.	78	113	807
Scanner (Whole Body)	68	61	49	116
Cardiac Catheters (000s)	1092.54	1000.35	1171.03	1774.93
ECG	171	231	3713	9347
Linear Ultrasound Scanner	742	1135	1737	4733
Endoscopes	1862	2114	2526	9590
Fibro-scopes	n.a.	627	1049	2691
Angiograph	n.a.	n.a.	72	176

Note: ECG = Electro-Cardio Graph, NW = CT scanner other than whole body; Measurement units of CT Apparatus, MRI Apparatus are based on Indian customs definitions. *Source*: Foreign Trade Statistics of India, published by the Directorate General of Commercial Intelligence and Statistics, Government of India (various years)

Table 2. Imports of Medical Devices by Value, 1991-2003, All India (1993-94 Rupees millions)

Device Type	Three Year Totals			
	1991-4	**1994-7**	**1997-00**	**2000-3**
CT Apparatus	n.a.	>53.81	544.01	1647.47
CT Scanner (NW)	357.08	187.41	234.58	464.46
MRI Apparatus	n.a.	557.75	713.67	2687.96
Scanner (Whole Body)	422.94	213.04	312.33	436.45
Cardiac Catheters (000s)	542.32	473.47	1621.18	2364.04
ECG	102.12	109.60	289.03	226.43
Linear Ultrasound Scanner	388.63	689.66	816.16	2477.50
Endoscopes	97.00	125.33	108.65	399.02
Fibro-scopes	n.a.	47.55	71.53	90.42
Angiograph	n.a.	n.a.	567.05	804.11

Note: ECG = Electro-Cardio Graph, NW = CT scanner other than whole body; Measurement units of CT Apparatus, MRI Apparatus are based on Indian customs definitions; GDP deflator used to convert Rupee prices into 1993-94 prices. *Source*: Foreign Trade Statistics of India, published by the Directorate General of Commercial Intelligence and Statistics, Government of India (various years)

Table 3. Proportion of all patients getting an X-Ray/ECG/ ESG in 1986-87 and 1995-96, All India (%)

Care Type and Residence	X-Ray/ECG/ESG	
	1986-87	**1995-96**
Inpatients		
Rural	33.63	43.06
Urban	45.16	52.07
Rural + Urban	36.82	46.39
Outpatients		
Rural	2.90	3.61
Urban	5.47	6.34
Rural + Urban	3.57	4.41

Source: Authors' estimates based on data from the 1986-87 and 1995-96 household surveys of health care utilization and expenditure by the National Sample Survey Organization (NSSO). *Note*: ESG = Electro-Sonogram

Table 4. Expenditures on Diagnostics and Heath Care by Households, 1993-94 and 1999-2000, All India

Expenditure Categories	1993-94			1999-2000		
	Rural	**Urban**	**Rural + Urban**	**Rural**	**Urban**	**Rural + Urban**
Inpatients						
Diagnostic Exp /Total HH Exp (%)	0.05	0.05	0.05	0.09	0.10	0.10
Diagnostic Exp /Total IP Exp (%)	5.47	3.99	4.85	6.82	7.16	6.95
Total inpatient Exp/Total HH Exp (%)	0.89	1.19	1.00	1.37	1.44	1.40
Outpatients						
Diagnostic Exp /Total HH Exp (%)	0.06	0.09	0.07	0.15	0.15	0.15
Diagnostic Exp /Total OP Exp (%)	1.23	2.52	1.60	3.08	4.21	3.43
Total Outpatient Exp/Total HH Exp (%)	4.55	3.42	4.15	4.72	3.62	4.31
Inpatient + Outpatient						
Diagnostic Exp /Total HH Exp (%)	0.10	0.13	0.11	0.24	0.26	0.25
Diagnostic Exp /Total OP+IP Exp (%)	1.92	2.90	2.23	3.92	5.05	4.29
IP + OP Exp/Total HH Exp (%)	5.44	4.60	5.15	6.09	5.06	5.71

Source: Authors' estimates based on data on household surveys of consumer expenditure by the National Sample Survey Organization (NSSO) of India, 1993-94 and 1999-2000. *Note*: HH = Household; IP = Inpatient; OP = Outpatient.

Table 5. Correlating MRI Imports with Potential Explanatory Variables

Explanatory Variable	Dependent Variable: Average MRI Imports (2001-2003) per capita			
	Model I	**Model II**	**Model III**	**Model IV**
			No Africa	*No Africa*
Constant	-0.395	-0.369	-0.377	-0.365
	[0.155]	[0.154]	[0.184]	[0.183]
Per Capita GDP (1995 US$000s)	0.083**	0.070**	0.084*	0.076**
	[0.016]	[0.018]	[0.045]	[0.020]
Doctors Per 1000 Population	0.092**	0.084**	0.086**	0.080*
	[0.039]	[0.039]	[0.018]	[0.045]
Foreign Aid Per Capita (US$)	0.021	0.020	0.011	0.011
	[0.020]	[0.020]	[0.027]	[0.027]
Average MRI Imports 1998-00 Per Capita		0.300		0.253
		[0.202]		[0.226]
N	49	49	40	40
R-squared	0.508	0.531	0.488	0.506

Note: Data are from the United Nations Commodity Trade Statistics Database (2002) and World Development Indicators (2004) of World Bank. The sample of countries excluded all major exporters of MRI products. *significant at the 5% level; **significant at the 10% level. Standard errors in parentheses.