Medical Equipment

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The surge in U.S. economic growth after 1995 focussed attention on the contribution of the high-tech sector to U.S. productivity and output growth. Among the studies of this topic are Jorgenson and Stiroh (2000), Oliner and Sichel (2001), and Gordon (2000). In these studies, "high-tech" meant IT—computer and communications equipment. The authors estimated that as much as one-half to two-thirds of the post-1995 U.S. labor productivity acceleration was attributable to productivity change in the IT-producing industries, and to the effect of more IT capital per worker in the industries that used IT equipment. These and other studies are reviewed in Bosworth and Triplett (2001) and Dedrick, Gurbaxani, and Kramer (2001).

None of these studies on the impact of IT could have been performed without the extensive U.S. database on real output, investment, and capital services for IT equipment,. Beginning with the IBM-BEA hedonic computer price indexes (Cole, et al. 1986; Cartwright 1986), the U.S. statistical system has steadily increased the comprehensiveness of its measures of real output of IT, and improved their quality. The most recent extensions are the incorporation of the telecommunications equipment study by Doms and Forman (2001) into the U.S. national accounts (Moulton, Seskin, and Sullivan, 2001) and the planned improvement in the PPI indexes used as deflators for IT described by Holdway and Gerduk (2001). This work on IT is not yet completed, as Jorgenson (2001) has emphasized. However, its substantial contributions are evident both in the successful analytic use of U.S. IT data, as illustrated in the studies cited above, and by studies abroad (such as Schreyer, 1999, Daveri, 2001, and Oulton, 2001) that bemoan the absence of parallel IT data for other OECD countries.

High-tech equipment manufacturing in the U.S. is not exclusively IT. Medical equipment also belongs in the high-tech category. Some of the same technical changes that drive the advance in the capabilities of IT equipment—miniaturization, for example—are also present as drivers of technological advance in medical equipment. The medical equipment producing industries are prominent users of semiconductors, and indeed of embedded computer-like components, but they also benefit from non-electronic miniaturization and other technological advances that are breathtaking.

Moreover, like IT, technical change in medical equipment is transforming the output in the industries that use the equipment. Fuchs and Sox (2001) report the results of a survey of physicians on the importance of medical innovations: MRI and CT scanners are at the top of the list, and diagnostic medical equipment innovations including mammography, ultrasound scanning, and endoscopic devices also appear high on the list of significant innovations. Other medical equipment examples are implanted devices for patient treatment and monitoring. Annex 1 to this paper contains an interesting list of products sold by the largest U.S. (and world) producer of high-tech medical devices, along with the medical conditions for which they are used. One could compile a very long list of other technological marvels for which innovations in medical equipment were sources or facilitators of improved medical procedures.

For the needs of economic and public policy analysis, however, a huge difference exists between high-tech IT equipment data and high-tech medical equipment data. In the IT equipment case, data on price indexes and output are fairly well measured, and the Bureau of Economic Analysis has integrated the data into its national accounts and its industry and I-O (input-output) accounts. Economists could certainly still wish for data improvements and improvements are still needed (see the contributions to the morning session of this workshop), but the fundamental data for analysis are substantially in place.

No such luxury exists in the case of medical equipment. It is natural to look for medical equipment data for analytic purposes in the National Health Accounts (NHA), because the NHA are intended to bring together all expenditures on medical care in the U.S. economy. The NHA contain *no* data on medical equipment. "Investment" in the NHA includes only buildings (structures) plus R&D, not medical equipment.

Economists are accustomed to a first-order definition of investment that encompasses "plant and equipment," so it must strike an economist as odd to encounter an investment definition in the medical sector that does not even include medical equipment. The 1999 Census Bureau Annual Capital Expenditures Survey reports that half of the $51 billion of capital expenditures made by the Health and Social Assistance sector was equipment, so the equipment investment missing in the NHA for that one year ($25.4 billion) is not a small amount of resources.

Neglect of data on medical equipment seems doubly odd because there is an acrimonious public policy debate on the contribution of medical technology to medical care costs. It is not unusual to see an estimate that some high proportion of the increase in medical care costs is caused by advances in medical technology. A widely publicized example is the Project Hope report (Mohr, et al., 2001).

One would have thought that such studies would have utilized analyses of costs—the cost behavior of those disease treatments or medical procedures that are heavy absorbers of new technologies, or perhaps price trends for high-tech medical equipment (quality-adjusted, of course). Despite its title, Mohr, et al. (2001) contains no data on costs of diseases that are affected by advanced technology, nor does it discuss prices of technological inputs into medical care, or even suggest that information of this kind is relevant to the study of the impact of medical technology on medical costs.[1] Actually (to anticipate a point of this paper), the appropriate data do not exist, either on costs of treating different medical conditions, or on the quality-adjusted prices of medical equipment and its distribution to medical

[1] The Project Hope study estimates the contribution of medical technology to rising health care costs by (1) subtracting out of rising medical care costs the change in the CPI and in demographics, and (2) calling the *residual* (what is not explained by the two "causal" factors) the impact of technology on medical care costs. The procedure would be ludicrous, but for the fact that it has also been used by others.

treatments. But one would have thought that at least there would be recognition in the medical care policy analysis community of the crucial importance of these missing cost and price data for health care policy and cost-containment analysis.

We belabor this point a bit because, surprisingly to us at least, it appears controversial with medical care policy analysts. Suppose one thought that advances in communications technology had impacts on communications costs. It would be quite natural to gather data on price trends for, e.g., local telephone service, long distance service, data transmission, and so forth (the outputs of the telecommunications sector). One might, in the next step, find out how these separate communications products make use of new technologically-advanced equipment, and how the proportions of the different types of equipment (which have different rates of technological improvement) differ across outputs. One might then measure the performance-corrected price change in the equipment (as in Doms and Foreman, 2001), or if possible, the prices of capital services from such equipment. Then, one would use this price and cost data, combined with information on usage of advanced capital goods, to determine the impact of technological change on the costs of communications.

A similar procedure for medical care would involve determining the case costs of treating different medical care categories, or disease classifications, and determining whether the categories that seemed to have more rapidly or less rapidly rising case costs were more or less intensive users of advanced medical technology. Then, one would estimate performance-corrected price measures for the high-tech components of medical equipment and other medical inputs, and carry out an analysis comparable to the one for communications equipment.

That such analyses are not routinely done in the analysis of medical care costs, cost containment proposals, and so forth is partly the fault of inadequate data. Partly, however, the inadequacy of the data for analysis is the fault of unperceptive analysis that fails to create the demand for it.

The first part of this health care data producing agenda (obtaining information on the costs of treatments, rather than on expenditures on hospitals) was the subject of an earlier Brookings workshop (Medical Care, December 1999), and is also the concern of various contributions on measuring the prices of medical treatment in Triplett (1999), Cutler and Berndt (2001), the review of medical care price indexes in Berndt, et al. (2000), and—for the cost of disease framework for improving the measurement of medical services in the NHA—Triplett (2001). The present paper addresses the other part of the story, compiling adequate measures of investment and capital stock for the high-tech capital inputs into the medical care sector.

We need to emphasize that medical technology is by no means restricted to medical equipment. The successful development of a new operation may owe much more to advances in human capital than to advances in physical capital. Technological advances in pharmaceuticals are as impressive as technical advances in medical equipment. This is not a paper on medical technology, however, but a paper on medical equipment.

I. Medical equipment in the health care sector

We begin by noting that a proportion of the health care sector's investment in equipment is not actually medical equipment. Non-medical capital goods constitute nearly 8% of investment by hospitals and by non-hospital health services. These non-medical capital goods range from computers and office equipment, to ordinary furniture (tables and chairs), tractors and farm equipment (for maintaining the grounds), vehicles (including in the hospital data some airplanes), and a wide variety of other things. See the tabulation in Annex 2. However, the overwhelming majority of the health sector's equipment investment is medical equipment.

Even among medical equipment, a great amount of it is not high-tech. For example, surgical appliances and supplies (7% of hospitals' investment in the BEA capital flow table) includes crutches, whirlpool baths, and other "low-tech" devices, much of which does not really constitute capital goods. Of the investment categories distinguished in the BEA capital flow table (see table 1), high-tech medical equipment is located mainly in the categories surgical and medical instruments (20% of hospitals' equipment investment, 27% of non-hospitals'), X-ray apparatus and tubes (only 3% of hospitals' capital investment, but 13% of non-hospitals'), and, especially, electromedical equipment (9% of hospitals' investment, a bit less than 7% of non-hospitals').

However, it is not the size or the share of high-tech medical equipment that matters most, but rather what that investment does. In the following, we focus on these high-tech categories—actually on the X-ray apparatus and electromedical equipment categories—because these industry classifications account for a large share of the equipment that is associated with advanced technology in the medical sector.[2]

Unfortunately, the capital flow table presents an estimate of investment at a point in time (currently, 1992). It does not track the medical sector's investment in medical equipment through time. One can extrapolate the capital flow table with Census Bureau production statistics by assuming that the composition of equipment investment by industry remains the same as it was in 1992. But we will not know whether those extrapolated allocations are correct until the 1997 capital flow table is published, currently scheduled for 2003.

The capital flow table itself is not without problems. Data on production of high-tech equipment (IT and medical equipment) are available, as are imports and exports required to get domestic investment. But the allocation of U.S. investment by equipment type to using industries rests, in many cases, on indirect extrapolators such as the Bureau of Labor Statistics' industry-occupation employment matrix, which is itself a product of somewhat shaky data combined with assumptions. On the other hand, the allocation of medical equipment to using industries may be less problematic than, say, the allocation of IT equipment.[3]

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[2] Surgical and medical instruments includes some high-tech equipment, but also a great amount of low tech equipment, including surgical knives, clamps, and forceps.

[3] Not all medical equipment goes to the medical care industries—35% of electromedical and electrotherapeutic apparatus investment goes to non-medical industries, including agriculture, retail trade, and business services. The size of non-medical uses of this medical equipment is surprising, and suggests problems either with the industry classification or with the methods for allocating it across using industries.

We now turn to production trends. Three primary sources of production data on medical equipment exist.[4]

The economic censuses, taken every five years, provide information on medical equipment, classified by industry. On an industry basis, output of NAICS 334510 (Electromedical and Electrotherapeutic Apparatus Manufacturing) was nearly $11.6 billion in 1997.[5]

Industry statistics, including the economic censuses and the Census Bureau's annual surveys of manufactures (ASM), report value of shipments and other data for the establishments that are classified in an industry. This means that the data include secondary products—for example, products produced by electromedical equipment establishments that are not electromedical equipment. The 1997 economic census reports that NAICS 334510 has a specialization ratio of 93 %, which means that 7 per cent of the shipments of this industry are secondary products.

The economic censuses also report production of medical equipment products, wherever made. The 1997 economic census reported a coverage ratio for electromedical equipment of 96%, which means that 4 per cent of electromedical equipment is produced in other NAICS industries. Putting the specialization and coverage ratios together indicates that electromedical equipment, wherever made, is about 3 percent less than the output of the electromedical equipment industry (table 3).

The Census Bureau's annual surveys of manufactures (ASM), which are also classified by industry, provide annual data comparable to those from the economic census. The 1999 value of shipments for NAICS industry 334510 (electromedical and electrotherapeutic apparatus manufacturing) reported in the 1999 ASM was $12.2 billion, 5.5 per cent higher than the value for 1997.

The third major data source is the Census Bureau's Current Industrial Reports (CIR), which cover some manufacturing industries, including the medical equipment industries. The CIR are product

[4] Other data on medical equipment investment and production also exist. The Federal Reserve Board's industrial production index and the Census Bureau's manufacturing orders and shipments program (M-3 reports) contain fairly aggregated information on medical equipment. Donahoe (2000) discusses regulatory filings for hospitals that contain data for investment in equipment, but are not currently tabulated in usable form, and also formerly produced data on medical equipment investment from the American Hospital Association.

oriented, which means they report products wherever produced—for example, all electromedical equipment, and not just the outputs of establishments that are primarily electromedical equipment manufacturers. The CIR also reports data for product class 3345101, which is the NAICS electromedical industry (334510) without hearing aids and ionizing radiation equipment.

II. Classification matters

The U.S. is a world leader in the production of high-tech medical equipment. Understanding U.S. data on production and investment trends requires some unavoidable discussion of economic classifications.

U.S. (and Canadian) industry statistics were recently shifted from the two former (noncompatible) country SIC classification systems to the new North American Industry Classification System, or NAICS. NAICS produced comparability for industry data across North America (including Mexico), but at the cost of breaks in time series for all three countries.

Fortunately, in the three relevant medical equipment industries, reclassifications in NAICS are not extensive (see Table 2). In NAICS, establishments are grouped into industries according to one systematic principle—similarities in their production processes. Thus, guns used to shoot tranquilizers into animals were moved out of medical instruments manufacturing into small arms manufacturing, because they are, after all, guns. The largest shifts for our purposes are the move of CT scanners from electromedical apparatus to irradiation apparatus manufacturing and the shift of hearing aids into the electromedical apparatus industry.

On NAICS' own principles, some of the medical equipment manufacturing industries seem far too heterogeneous. Consider electromedical and electrotherapeutic apparatus manufacturing (NAICS 334510). There cannot be a great amount of production process similarities in the manufacture of electrotherapeutic arc lamps, blood and body fluid analyzers, MRI (magnetic resonance imaging) equipment, and dialysis equipment (see the product list in Annex 3). It is possible that some of these

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[5] This is the revised total, as reported in the 1999 Annual Survey of Manufactures, Statistics of Industry Groups and Industries, table 2**.**

products are produced in the same establishments; if so, these establishments could not be put into different industries, even if production processes are dissimilar. It is also the case that an industry classification system must sometimes of necessity group small industries together, for pragmatic reasons. But electromedical equipment is now roughly a $12 billion industry, and its value of shipments have more than doubled since 1992.[6]

Two principles exist for economic classifications.[7] One is the industry classification system, in which activities of *establishments* (not just products, but all inputs and outputs) are grouped according to their production processes. The manufacture of X-ray equipment, whether used for medical purposes or non-medical purposes, shares similarities in the way the equipment is produced. Accordingly, the irradiation apparatus manufacturing industry (NAICS 334517) includes not only medical X-ray equipment, but equipment for checking luggage at airports.

A second classification principle groups *products* (not establishments) according to the uses of the products. I will call this a demand-side, or a use-oriented, classification system, as distinguished from the supply-side, production-oriented principle embodied in the industry classification system. *For analyzing investment expenditures by the medical care sector, a demand-side product grouping classification of medical equipment is the appropriate one*. In announcing the development of the NAICS industry classification system, the U.S. also committed itself to producing detailed demand-side, use-oriented product grouping classification systems for analytic purposes (OMB, 1994).

Fortunately, in the case of medical equipment a use-oriented product classification system already exists. Medical equipment data are published on a use-oriented product classification system in the Census Bureau's Current Industrial Reports (CIR).

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[6] In the design of NAICS, the size of an industry in the 1992 economic census was used as a reference. Very rapidly growing industries that have heterogeneous manufacturing processes are candidates for division when the classification system is reviewed, as it is periodically in consultation with Canada and Mexico. This particular case is complicated by the fact that the Canadian six-digit NAICS industry (Canada NAICS 334512) differs from the American one (North American compatibility is at the NAICS five-digit level).

[7] Triplett (1990) discusses economic principles and economic theory for classifications.

We want a use classification for medical equipment. The first step is to separate CIR estimates for non-medical irradiation equipment from medical irradiation equipment. Then, non-medical equipment can be removed from the total. Details are in Table 3.[8]

When non-medical irradiation equipment is removed from the CIR total (line 2 of table 3), medical equipment—electomedical and irradiation—can be aggregated (line 4 of table 3). Total medical equipment production exceeded $11.6 billion in 1997 (it approaches $14 billion 2000).

Having reached a (wherever produced) product total, the CIR takes the combined medical equipment total shown in table 3, and allocates it by detailed products into use-oriented classifications. For example, CT scanners are a form of X-ray equipment, MRI scanners are not X-rays, so they are in different industries in NAICS. But they are both used for medical diagnostic purposes, and are indeed substitutes. The CIR re-aggregates products from the two NAICS industries that are used for diagnostic purposes. Similar re-aggregations in the CIR correspond to patient monitoring equipment, medical therapy equipment, surgical equipment, and (as always in government data) a sizable "other." U.S. production according to these major use-oriented product groupings are shown in table 4A. Detailed product codes under each of these use-oriented classifications are presented in table 4B, along with recent trends in shipments for these products.

So far, so good. For analysis of medical care investment and costs, we need data classified by a use-oriented system, and this is provided by CIR (table 4A). Moreover, we need data at a detailed level where technological trends in high-tech medical equipment can be studied, and significant product detail is available in the CIR (table 4B).

However, a major problem with CIR data is its frequent need to suppress published detail because of the risk of disclosure. There is no satisfactory solution to this problem. For the analysis of the impact of medical technology on medical care, one needs the detailed categories. There is less value in data

[8] The CIR totals (which are in principle production wherever produced) do not agree with the ASM totals, considering the same 3345101 product grouping, on a wherever made basis. They are sometimes smaller, sometimes larger. In 1997, the CIR was around 4 percent smaller than the ASM, in 1999 it was a little less than 3 per cent larger.

aggregated up to (say) patient monitoring equipment, when technological trends, and trends in investment and prices, differ across different kinds of medical equipment.

Even allowing for the disclosure problem, however, CIR practices with respect to suppression of data to meet non-disclosure requirements are inconsistent and frustrate users' needs for time series. For example, before 1997 MRI equipment was collapsed with endoscopic equipment; after 1997, it is collapsed with EEG and EMG equipment. But before 1997, EEG and EMG were collapsed in a different direction (see table 4B). This creates a time series break at 1997. Sometimes, of course, time series must be broken, and in this case, there is only one break, so that consistently-collapsed data are available before 1997 and after. The patterns of disclosure suppression in the CIR are not the same as in the PPI, in view of the fact that a Producer Price Index for MRI equipment exists for years up to 1997 (though not after); this shows that statistical agencies do not always face the same disclosure problem in the same situation (Census must avoid a quantity or value disclosure, BLS a price disclosure).

A more disconcerting problem is inconsistent data collapsing, as in the example of radiation therapy equipment. From 1995 to 2000, radiation therapy equipment has been collapsed with (a) parts and accessories for x-ray equipment, (b) all other medical diagnostic irradiation equipment, and, most recently, (c) pacemakers. As a result, time series for three categories of medical therapy equipment are destroyed.

To obtain time series for detailed categories of medical equipment, we have estimated a large number of cells for table 4B, using a combination of data published in CIR for various years. The data we have estimated are presented in bold. Estimation details and assumptions are given in the extensive set of footnotes to table 4B.

Disclosure is a serious problem for statistical agencies and creates unavoidable gaps in data. For some detailed categories of medical equipment, there are not a large number of producers. Even where there appear to be an adequate number of producers to prevent disclosure, there may be a dominant firm that accounts for a very high proportion of the output of certain products. For example, radiation therapy equipment is suppressed for non-disclosure in 1999, although the number of producers is listed as 10, and MRI is suppressed for all years other than 1997, even though the number of producers is given as 7.[9] Yet, patterns of collapsing data should be chosen by the CIR staff to maximize available time series. After all, knowing the production level for, say, electrocardiographs for one year is not very useful in itself. One wants to know something about growth rates, which can only be obtained from consistent time series. This does not seem a priority in the current production program. Constructing the estimates in table 4B took considerable time, which is no doubt multiplied across most of the users of the CIR.

III. Production trends for medical equipment

We are now in a position to use a combination of Economic Census, ASM, and CIR data to show production trends for medical equipment.[10]

Before 1997, one can only estimate industry time series using the old SIC industry definitions. The 1997 economic census was tabulated on both NAICS and SIC basis, to facilitate comparison with the 1992 economic census, which was tabulated only on the SIC. As Table 3 shows, electromedical equipment on the SIC definition was expanding rapidly (8 per cent per year), but the irradiation equipment industry exhibited slower growth (4 per cent per year), both in current prices.

The CIR, being on a product basis, is not affected by the changed industry definitions. As noted in section II, the CIR's use-oriented classification is the appropriate one for analyzing investment by the medical care sector.

For electromedical equipment (without CT scanners, that is, on the NAICS definition), the CIR shows a bit slower average annual increase (7.6 per cent, 1992-97) than the economic census (table 3). The CIR also shows that the medical equipment part of the irradiation equipment industry has expanded

[9] The largest domestic producer of MRI appears to be General Electric. According to GE's 2000 annual report, the company had $7.6 billion in medical equipment orders in 2000, undoubtedly not all MRI equipment. From table 4B, we estimated that total shipments of MRI combined with EEG and EMG were a little over $1 billion in 2000.
[10] The CIR measures domestic production and a proper accounting for investment must take account of exports and imports. The CIR for medical equipment industries presents a reconciliation of product detail between domestic production and foreign trade classifications.

very rapidly, both before and after 1997 (respectively, 7 percent and nearly 12 percent annually—see table 3). The non-medical part of this industry has been steadily declining (by 3 per cent before 1997, 8 per cent per year after 1997). Note that, because of gaps in the CIR data, the figures in bold in the tables have partly been estimated, as explained in the footnotes to table 4B.

Table 4A arrays the data by the CIR's use-oriented classifications, and covers the period since 1995. The post-1995 period covers the investment boom in high-tech equipment in the U.S. in the late 1990s.

Overall, production of medical equipment has grown by about 8.5% per year, led by growth in medical diagnostic equipment, in medical therapy equipment (and in "other"). As the table also shows, the groupings with the fastest growth—medical diagnostic and medical therapy equipment—are also the largest components of medical equipment. They are also the components where many of the data gaps (suppression for nondisclosure) take place.

Patient monitoring equipment has grown rather slowly (about 1.5% per year). Although some of the high-tech equipment items shown in Annex 1 would appear to be patient monitoring equipment, we were unable (through lack of sufficient skill) to place many of the Medtronic products in government data classifications (this will receive more attention later).

Turning to the detailed data in table 4B, the rapid growth in medical diagnostic equipment is led by the various types of scanners and related imaging devices, including digital radiography equipment, CT scanners, ultrasound scanners, and MRI scanners, all of which have been expanding between 7 and 12% per year. As noted earlier, the actual growth rates for MRI scanners cannot be extracted from the CIR data because of disclosure collapsing. After 1997, MRI scanners combined with EEG (electroencephalograph—brain scanner) and EMG (electromyograph—muscle imager) have expanded about 13% annually.

Medical therapy equipment has expanded even more rapidly than medical diagnostic equipment. As table 4B shows, the leaders here are pacemakers (12.5% per year), defibrillators (15% per year), and the ubiquitous "all other" (14.5% per year). The "all other" category has grown to be the largest “product” in the medical therapy equipment grouping, and needs disaggregation into more meaningful components.

The two product codes in patient monitoring equipment shown in table 4B are both declining, and only the “all other” is rising (by about 4.5% per year). Because the “other” category has grown to be the largest component in patient monitoring equipment, it needs to be disaggregated

In addition to large and growing “other” categories within each of the CIR’s use-oriented groupings, the CIR also contains an “other electromedical equipment, nec” (not elsewhere classified) component. Expenditure on this group of products has been growing at a spectacular 46% per year, post-1995 (table 4B). One fears that really significant items of medical equipment will be found in this grouping, as well as the “all other medical diagnostic,” “all other patient monitoring,.” “all other medical therapy equipment,” and “all other surgical support systems.”

Indeed, the combined “all other” categories of medical equipment (excluding the one for electromedical equipment) account for 22% of the total medical equipment reported in the CIR in 2000. The size of these “all other” categories is already a problem for analytic purposes, and the combined “all other” categories have also been growing at the rate of 11% per year. Very rapid growth is taking place in what is not classified into meaningful product categories in the CIR. Thus, the CIR classifications may be obscuring information on the growth of high-tech medical equipment.

IV. Price indexes and constant-price value of shipments for medical equipment

Estimating constant-price measure of U.S. medical equipment production requires price indexes for use as deflators. The Producer Price Index (PPI) contains price indexes for both the electromedical equipment and the irradiation equipment industries. All PPIs remain on the old SIC classification system (the BLS timetable from shifting all its industry data from the 1987 SIC to the 1997 NAICS extends to 2014). Inconsistency between BLS-SIC data and Census-NAICS data poses some problems after 1997, although as noted in an earlier section, the reclassifications between the two systems are not extensive in the case of medical equipment.

As is true generally for the PPI program, the PPI medical equipment industry indexes also contain component price indexes for products produced within the industry. The PPI is organized to give price indexes for industry output. Most deflation, whether in national accounts or elsewhere, takes place at the product level. Thus, in many ways the most useful part of the PPI's output is its often neglected product detail. Happily in this case, the product nomenclature used for the PPI is consistent with the CIR product classifications (this has not always been the case for other industries in the past).

The major problem we encounter in producing constant price production measures for medical equipment arises from (a) insufficient detail in the PPI product information, combined with or caused by (b) disclosure or perhaps non-reporting problems in some of the same cases discussed above in the CIR—in particular, MRI, EEG, EMG, and endoscopic equipment.

In Table 5A, we have re-aggregated PPI product indexes to match the product-oriented grouping system in the CIR, arrayed the detailed indexes for medical equipment, and calculated annual average rates of change to cover the 1995-2000 interval. Thus, table 5A presents PPI product price indexes, re-aggregated to correspond to the CIR use-oriented product groupings.

As noted earlier, diagnostic medical equipment appears in both the electromedical equipment industry and in the irradiation equipment industry. The CIR re-aggregates the detailed commodities to obtain a diagnostic medical equipment category. The PPI does not. Diagnostic equipment from the two industries are thus tabulated separately in the first two lines of table 5A.

Table 4B and 5A compare CIR and PPI detail. Table 4B contains five lines of irradiation medical diagnostic equipment. These five lines correspond to one line in the PPI (table 5A).

Electromedical diagnostic equipment corresponds to six lines in table 4B. PPIs exist only for ultrasound, electrocardiograph (EKG), and "all other." Electrocardiograph production is a small (around 4%) part of the production of electromedical diagnostic equipment, so the "all other" grouping in the PPI amounts to over half of electromedical diagnostic equipment.

Similar, though somewhat less severe problems arise in the remaining categories of medical equipment. In the therapeutic equipment category, we presume that radiation therapy equipment, shown in table 4B, is included somewhere in the PPI's aggregate index for irradiation equipment.

MRIs call for a special note. Before 1997, the PPI contained a separate price index for MRI equipment. It fell by 20.1% (total) between 1990 and 1997 when the price index was discontinued. Note also that CT scanners are not separately identified in the PPI product detail, nor are EEG, EMG, and endoscopic equipment.

The main conclusion to be drawn from this: The PPI contains some useful product detail on medical equipment, but not nearly enough of it. The combination of sample size, responses to government surveys, and disclosure problems are all no doubt factors. Whether more meaningful detail on the high-tech and rapidly growing portions of medical equipment can be obtained rests on analysis to be undertaken later.

In table 5B, we use available PPI detail to deflate production growth for items of medical equipment. Table 6 summarizes average annual growth rates for current-price CIR, PPI indexes, and deflated, constant-price CIR. The shaded areas designate components where a single PPI component index corresponds to a group of CIR components, and where deflation by necessity combines components that may have dissimilar characteristics, technologies, or price movements.

The main picture that emerges out of table 6 is that we can't get nearly far enough. Details are already largely familiar from the discussion of table 5A.

For irradiation diagnostic equipment, we have no detail at all. The aggregate-level PPI indicates very little inflation, so that the current-price and constant-price CIR are nearly the same.

For electromedical diagnostic equipment, the detail available, as well as the aggregate index for the category, indicates falling prices. Thus, very strong current-price rates of growth correspond to even stronger constant-price rates of growth. But for the categories of diagnostic equipment for which we think technical change has been the most rapid, we cannot tell very much about growth, either current-price or constant-price. We presume that the medical sector is investing heavily in scanners and imaging equipment, but government data do not tell us very much about it.

The rest of table 6 shows a similar story. Where we can learn something about it, prices for high-tech medical equipment are falling, as measured by the PPI. But we need more data, and more detail.

Accuracy of PPI indexes. Much recent research has raised questions about the accuracy of high-tech price indexes in the PPI program (for example, Jorgenson, 2001). Problems posed by quality change in price indexes are well known, dating back even before the famous article by Griliches (1961). In other high-tech components, such as IT, judgments such as Jorgenson's rest either on (a) available price index research that shows more sharply declining prices than are currently measured in the PPI (for example, Doms and Forman, 2001), or (b) knowledge that high-tech equipment is a substantial user of high-tech inputs, particularly of semiconductors.

We have been able to locate only one piece of economic research on medical equipment, the study of CT scanners by Trajtenberg (1990). This study is now quite old. Its price indexes extend only to 1982. Trajtenberg showed that CT scanners declined at an average rate of 13.6% per year, for the period that he studied. But (see table 5B), the U.S. government does not publish a price index for CT scanners, even though they remain a large and growing component of medical investment.

As for semiconductor inputs, the major source is the economic census list of products consumed by industry. The information for medical equipment is shown in table 7.

Not surprisingly, the share of semiconductors and related electronic components in the electromedical equipment industry is substantial. But surprisingly, less detail is published for this industry than for the irradiation industry, which is a smaller consumer of electronic components and semiconductors.

The economic census also collected, for the irradiation equipment industry, purchases of computers that were intended to be embedded into the final product. A scanner is basically a device for making images coupled with a computer to convert those images into three-dimensional portrayals of organs so that they can be studied by medical professionals. One would expect that the production of a piece of medical equipment that uses an embedded computer would benefit from the great expansion of computing power and consequent decline in the price of computers.

Regrettably, no information on embedded computers was collected for the electromedical industry, even though most of the scanning and imaging equipment is produced in this industry.

This fragmentary information on technological inputs is suggestive. We can be sure that the contribution of technological inputs lowers the cost of medical equipment and increases its performance, but we lack sufficient information to determine the magnitudes. Beyond semiconductors and computers themselves, miniaturization technology has contributed greatly to the effectiveness of medical equipment. It might not be possible to associate any of this with a high-tech input. But, clearly, we have too little information on the technological inputs into the medical equipment industries.

V. Recommendations and conclusions

We believe that gathering additional information on high-tech medical equipment is important for analyzing its contribution to improved health care. It is no doubt true that improving the database for medical equipment will not, by itself, answer all of the questions that have been posed about the contribution of medical technology to health care costs. But it is hard to see how one can address many of those questions without better information on the flows of medical equipment into the medical care sector. The following recommendations are important elements of a data production agenda to meet this objective.

1) The national health accounts (NHA) need to incorporate measures of investment in medical equipment. Even for a proper accounting of medical care expenditures, adding medical equipment is essential (Donahoe, 2000).

But beyond just counting medical care expenditures, obtaining good information on quantities and prices of medical care equipment should contribute to improving the analysis of the impact of medical technology on medical care costs. For this purpose, we think the emphasis in the NHA should be on compiling very detailed information on medical equipment. Aggregate spending on medical equipment is not adequate. We need to distinguish much better than we can at present investment in surgical knives and scalpels from investment in heart-lung machines.

In the past, the NHA have been thought of primarily as a vehicle for recording the sources of health care expenditures (government, insurance companies, and so forth) and the industries or institutions that receive funds (hospitals, for example). There is no reason to abandon the traditional NHA objective, it is obviously useful, and our recommendations on medical equipment do not imply abandoning it.

However, medical care policy analysis requires expanding economic information on medical care to provide more information for *understanding* health care expenditures and not just recording them. In this, the NHA plays a crucial role, just as the national accounts (NIPA) play a crucial integrating role for other economic statistics. Only a narrow (though useful) class of economic information is now presented in the NHA. There is an understandable tendency for medical care policy analysts to analyze the data that exist, rather than to call for new data that might be more relevant. On this, we concur fully with Cutler and McClellan (2001, page 27) who make a parallel point about a different medical data question:

"At least some of the [past policy] focus on reducing medical spending is because spending…is what is currently measured. A fuller set of National Health Accounts could allow policymakers to make more sound decisions."

We show that the detailed data the NHA needs are not presently available. How, then, can our recommendations be implemented?

Demand for data is an important element in creating its supply. The Census Bureau proclaims in some of its publications that a major user of its industry statistics is the Bureau of Economic Analysis, in its national accounts, industry accounts, and input-output accounts, and that needs for national accounts are important determinants of Census Bureau priorities. The NHA should be seen as another important user, a user that presses for more emphasis on medical equipment than BEA would normally need for its purposes, and indeed more emphasis on medical equipment than for some other investment goods that go elsewhere in the economy. The emphasis is justified by the size of the medical care sector in the U.S.

economy, it is also justified by the technological impacts of the products produced in the medical equipment industries, and by the policy relevance of better information to understand changes in medical care costs. Progress sometimes comes slowly, and the incorporation of equipment investment in the NHA will undoubtedly begin at a more aggregated level than is desirable. But the long term goal should be assembling detailed data on medical equipment and incorporating them into the NHA. Adopting this as the long term goal for the NHA would focus attentions of other data providers and analytic data users, and thereby contribute to the demand for data.

We hope that industry, and also scientific groups, can be organized to support these initiatives.

2) With respect to CIR disclosure collapsing policies, we recognize that disclosure limits the detail that can be produced by the Census Bureau. Even with the existing level of detail, patterns of data collapsing to prevent disclosure need to be thought through more carefully in order to preserve time series. Some of these patterns are hard for an outsider to understand. More careful attention to this problem, with an overall design for the time series that can be preserved from a more consistent pattern of collapsing, would benefit all users of the CIR.

3) Updating CIR product classifications: We noted above that the "other" and "all other" categories in the CIR have grown to unreasonable sizes. Very rapid rates of growth of these "other" pieces of equipment suggests that the dynamic parts of the medical equipment industries are falling into the junk boxes of "other" and "not elsewhere classified." This is of course an old problem in industry statistics. But whenever "NEC" and "other" groupings become as large as they are in the medical equipment classification of CIR, it is strong evidence that the classification needs to be rethought and revised.

4). Purchased technological inputs. For analysis of technological change and its sources, we need far more information about purchased inputs. The Census Bureau has long been urged to improve its information on purchased services, and is making headway. But we urge that this effort, while laudatory, should not obscure the similar need for information about purchased high-tech inputs, such as semiconductors and electronic components into the medical equipment industries, and purchases of medical equipment by the medical care industries. The lists of inputs will need to be tailored to particular industry technologies. For medical equipment, more information on purchased high-tech components and capital equipment is identical to what is required to improve the BEA capital flow table.

5) The BEA capital flow table is an essential device for analyzing high-tech (or any) investment. Analysts need an improved and more current capital flow table, and improving it rests on better source data on who purchases investment. This recommendation reinforces recommendation 4.

6) The PPI has expanded greatly in recent years, especially in services. Services are important, and the PPI expansion in the services area is highly praiseworthy.

However, we fear that the expansion in services has come at the expense, to a certain extent, of information on high-tech industries. Improving the detail in the PPI medical equipment indexes deserves high priority, and more resources if necessary. There are many products in the medical equipment industries, some of the most important ones are relatively small in total sales (compared to components and products elsewhere in the economy), so that a program of price indexes for medical equipment would probably require more PPI resources per unit of GDP than for the average industry. In many cases, the number of firms creates disclosure problems, even if they can be induced to report to the PPI. Nonetheless, more information on medical equipment is urgently needed for analysis of the medical care sector. The emphasis should be on the high-tech parts of the medical equipment industries.

We have some concern that the PPI's "industry" structure may be a bit of a problem. The decision to convert the old Wholesale Price Index into a PPI program for industry *output* price indexes was made a long time ago. At the time this decision was made, there was considerable discussion of creating a program for measuring price indexes for *inputs to* industries as an alternative to the output price index program, or perhaps as a supplement to it. In the case of medical care, we need better measures of the prices paid for medical equipment by the U.S. medical care sector, and not just measures of the prices charged by domestic producers of this equipment.

There might be more sellers of high-tech equipment to the medical care sector than there are producers in the U.S. If so, an input price index to the medical care sector would have fewer disclosure problems than an output price index for the same product in the industry PPI program. The BLS already collects import price indexes. But to our knowledge, there is no program in BLS for putting import prices (actually, the prices paid by medical institutions for imported equipment) together with domestic shipments prices to create an index of prices paid for items such as medical equipment. Surely, the CIR category "diagnostic equipment" is a better one for the NHA than having separate industry indexes for the industries in which diagnostic equipment is produced. But a CIR category for domestically produced diagnostic equipment, even if perfectly matched to a PPI, would not suffice for analyzing investment expenditures by the medical care sector.

We propose that the BLS consider a research program for combining its information on medical equipment prices to see if measures of input price indexes to the medical care sector can be devised. There is no better candidate than medical care for such an extension of BLS price programs (because of the analytic importance of medical care, as noted above), even though one might also consider it for some other industries as well.

7) We also think the analytic needs of the NHA, let alone the analytic needs of people who want to understand the impact of medical technology on medical care costs, will require combining public sector and private sector data. A number of examples of public-private cooperation, or combination of public and private data, have yielded promising results in improving our information about other high-tech sectors. A parallel initiative may prove promising in medical care as well.

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Table 1

Distribution of Capital Investment to the Health Sector, 1992
BEA Capital Flow Table

(Producer's Prices, in Millions of Dollars)

line no.	I-O commodity group (commodity number in parentheses)	**Health Services, excluding hospitals**		**Hospitals**	
		Amount	Percent of Total	Amount	Percent of Total
Construction		$3500	37.8%	$10408	50.9%
Non-medical Capital Equipment		726	7.8%	1594	7.8%
Medical Capital Equipment		5035	54.4%	8438	41.3%
139	(3821) Laboratory apparatus and furniture	83	0.9%	270	1.3%
140	(3823) Process control instruments	0	a	34	0.2%
141	(3824) Fluid meters and counting devices	0	a	3	a
142	(3825) Instruments to measure electricity	0	a	7	a
143	(3826) Analytical instruments	12	0.1%	49	0.2%
144	(3827) Optical instruments and lenses	4	a	21	0.1%
145	(3829) Measuring and controlling devices, n.e.c.	1	a	6	a
146	(3841) Surgical and medical instruments	2487	26.9%	4043	19.8%
147	(3842) Surgical appliances and supplies	48	0.5%	1498	7.3%
148	(3843) Dental equipment and supplies	585	6.3%	18	0.1%
149	(3844) X-ray apparatus and tubes	1193	12.9%	622	3.0%
150	(3845) Electromedical equipment	622	6.7%	1867	9.1%
Total		9261	100.0%	20440	100.0%

a -less than .1%

Source: Bonds, Belinda and Tim Aylor. "Investment in New Structures and Equipment in 1992 by Using Industries." *Survey of Current Business*. December, 1998: 26-51.

Table 2

New and Old Medical Equipment Industries

SIC 3841 Surgical and Medical Instruments and Apparatus

Minus tranquilizer guns (to NAICS 332994 small arms manufacturing)
Minus Operating Tables (to NAICS 339111 Laboratory Apparatus and Furniture Manufacturing)
Plus Medical Thermometers (from SIC 3829 Measuring and Controlling Instruments, n.e.c.)

= NAICS 339112 Surgical and Medical Instrument Manufacturing

SIC 3844 X-Ray Apparatus and Tubes and Related Irradiation Apparatus

Plus CT scanners (from SIC 3845)

= NAICS 334517 Irradiation Apparatus Manufacturing

SIC 3845 Electromedical and Electrotherapeutic Apparatus

Minus CT Scanners (to NAICS 334517)
Plus Hearing Aids (from SIC 3842, Orthopedic and Surgical Appliances and Supplies)

= NAICS 334510 Electromedical and Electrotherapeutic Apparatus Manufacturing

Table 3

Economic Census, ASM, and CIR Value of Shipments
Electromedical and Irradiation Equipment

(thousands of dollars)

			1997 Value of Shipments	Average Annual Rate of Change 1992-1997	Average Annual Rate of Change 1997-2000
	Electromedical Equipment				
	Economic Census				
	NAICS 334510	Electromedical Equipment	$11,369,974		
	SIC 3845	Electromedical Equipment	10,567,566	8.01%	
	Code 3345101	Electromedical Equipment (excluding ionizing radiation and hearing aids)	10,075,216		
	Code 3345101 (on wherever made basis)	Electromedical Equipment (excluding ionizing radiation and hearing aids)	9,078,746		
	Annual Survey of Manufacturers				
	NAICS 334510	Electromedical Equipment	11,581,624		2.7% A
	Code 3345101 (on wherever made basis)	Electromedical Equipment (excluding ionizing radiation and hearing aids)	9,414,822		5.80 A
	CIR				
1)	Code 3345101	Electromedical Equipment	9,051,100	7.61	6.34
	Irradiation Equipment				
	Economic Census				
	NAICS 334517	Irradiation Equipment	3,797,837		
	NAICS 334517 (on wherever made basis)	Irradiation Equipment	3,284,995		
	SIC 3844	X-ray Apparatus and Tubes	3,942,256	4.03	
	Annual Survey of Manufacturers				
	NAICS 334517	Irradiation Equipment	3,970,454		-.6 A
	Code 3345170 (on wherever made basis)	Irradiation Equipment	3,393,643		3.06 A
	CIR				
	Code 3345170	Irradiation Equipment	3,139,100	6.70	3.90
2)		Non-medical Irradiation Equipment	**766,249**	**-2.96**	**-8.10**
3)		Medical Irradiation Equipment	**2,372,851**	**11.45**	**7.24**
4)	**Electromedical and Medical Irradiation Equipment (Line 1 + Line 3)**		**11,423,951**	**8.34**	**6.53**

Note: Value of shipments for 1997 in ASM (March 2001) reports revised economic census totals for 1997.
Bold: Partly estimated by authors.
A-Average Annual Change from 1995-1999.

Source: Current Industrial Reports, Electromedical and Irradiation Equipment, Table 1; Annual Survey of Manufactures (Statistics of Industry Groups and Industries, Table 2, and Value of Product Shipments); 1997 Economic Census, Comparative Statistics for United States, 1987 SIC Basis: Manufacturing; and 1997 Economic Census, Electromedical and Electrotherapeutic Apparatus Manufacturing and Irradiation Apparatus Manufacturing, Tables 5 and 6a

Table 4A

CIR Value of Shipments, Electromedical and Medical Irradiation Equipment Classified by Use
(Thousands of Dollars)

	2000	1999	1998	1997	1996	1995
Medical diagnostic equipment	**5,337,549**	**4,821,980**	**4,807,580**	**4,380,167**	4,074,724	3,581,283
Patient monitoring equipment	1,242,651	1,316,394	1,371,354	1,300,999	1,307,411	1,151,086
Medical therapy equipment	4,834,486	**4,776,106**	**4,088,790**	**3,714,595**	**3,162,426**	**2,848,525**
Surgical systems	1,351,673	1,251,750	1,233,583	1,174,447	1,059,085	937,327
Other	1,043,554	957,894	894,219	853,848	866,400	685,196
Total	13,809,913	13,124,124	12,395,526	11,424,056	10,470,046	9,203,417

bold: partly estimated by authors (see footnotes for Table 4B)

Source: Current Industrial Reports, Electromedical and Irradiation Equipment, Table 2, and Author's Estimates

Table 4B
CIR Value of Shipments, Electromedical and Irradiation Equipment
(thousands of dollars)

Product Code		2000	1999	1998	1997	1996	1995	Avg. Ann. Percent Change 1995-2000
	Medical diagnostic equipment:	5,337,549	4,821,980	4,807,580	4,380,167	4,074,724	3,581,283	8.3%
3345170103	Digital radiography equipment...........	101,380	76,265	128,181	147,357	147,883	71,579	7.2
3345170106	Computerized axial tomography (CT or CAT SCAN)	767,983	656,433	542,644	555,574	524,526	**544,076** A	7.1
3345170109	Dental and conventional X-ray	553,411	502,436	621,149	522,837	487,225	447,022	4.4
3345170112	All other medical diagnostic X-ray equipment ……	**554,453** B	**166,040** C	**394,069** D	**367,688** E	299,099	**310,246** A	12.3
3345170115	Nuclear medicine equipment (all equipment used for nuclear in vivo studies)	478,275	482,750	499,557	363,128	307,263	337,244	7.2
3345101106	Ultrasound scanning devices	1,379,635	1,360,741	1,287,895	1,102,906	935,994	781,986	12.0
3345101109	Electrocardiograph (EKG)	183,096	251,243	230,850	204,907	204,281	228,743	-4.4
3345101115	Audiological equipment.	10,687	12,668	7,853	10,288	11,099	11,403	-1.3
3345101121	Respiratory analysis equipment	35,355	**53,343** F	30,444	39,291	48,541	46,009	-5.1
3345101112 + 3345101124	EEG, EMG AND All other medical diagnostic equipment		n/a	n/a	n/a	242,885	156,326	
3345101103 + 345101112	MRI AND EEG, EMG	**1,098,206** G	**1,086,809** H	**877,411** J	849,298	n/a	n/a	
3345101103 + 3345101118	MRI AND Endoscopic Equipment		n/a	n/a	n/a	865,928	646,649	
3345101118 + 3345101124	Endoscopic Equipment and All Other Medical Diagnostic	**175,068** G	**173,252** K	187,527	216,893	n/a	n/a	

Table 4B (continued)
CIR Value of Shipments, Electromedical and Irradiation Equipment
(thousands of dollars)

Product Code		2000	1999	1998	1997	1996	1995	Avg. Ann. Percent Change 1995-2000
	Patient monitoring equipment:	1,242,651	1,316,394	1,371,354	1,300,999	1,307,411	1,151,086	1.5%
3345101227	Intensive care/coronary care units, including component modules such as temperature, blood pressure, and pulse................	518,659	530,477	617,833	594,256	597,819	535,595	-0.6
3345101233	Prenatal and Respiratory Monitoring ……………	87,782	87,778	86,274	88,046	100,688	101,637	-2.9
3345101237	All other patient monitoring	636,210	698,139	667,247	618,697	608,904	513,854	4.4
	Medical therapy equipment:	4,834,486	4,776,106	4,088,790	3,714,595	3,162,426	2,848,525	11.2
3345101241	Ultrasound therapy ..…	20,911	18,330	13,437	12,096	11,387	8,528	19.6
3345101244	Pacemakers	**1,151,468** L	**1,142,877** M	869,747	803,335	636,018	639,343	12.5
3345101247	Defibrillators	884,815	804,973	746,185	578,780	528,073	440,238	15.0
3345101251	Dialyzers, including machines and equipment	518,316	503,484	493,039	458,290	385,735	301,749	11.4
3345101254	Medical laser equipment	546,008	675,058	617,381	623,934	559,526	455,058	3.7
3345170118	Radiation therapy (linear accelerators, X-ray, cobalt 60, brachetherapy)	**470,944** L	**470,573** N	**446,099** D	**416,234** O	**385,218** P	**368,410** Q	5.0
3345101257	All other medical therapy equipment	1,242,024	1,160,811	902,902	821,926	656,469	635,199	14.4
	Surgical systems:	1,351,673	1,251,750	1,233,583	1,174,447	1,059,085	937,327	7.6
3345101361	Electrosurgical equipment	420,103	351,108	335,762	340,908	339,205	327,144	5.1
3345101364 + 3345101367	Heart-Lung machines, excluding iron lungs AND Blood Flow Systems …	535,160	542,606	563,894	547,534	320,307	291,729	12.9
3345101371	All other surgical support systems .…	396,410	358,036	333,927	286,005	399,573	318,454	4.5
	Other:	1,043,554	957,894	894,219	853,848	866,400	685,196	8.78
3345101374	Other electromedical equipment (except diagnostic and therapeutic) n.e.c. …	234,701	164,075	135,577	106,820	81,469	35,202	46.1
3345101477	Electromedical parts and accessories, including diagnostic and therapeutic n.e.c.	808,853	793,819	758,642	747,028	784,931	649,994	4.5

Entries in bold: values estimated by the authors or unrevised value of shipments data.
Source: Current Industrial Reports, Electromedical and Irradiation Equipment, Table 2, 1996-2000

Footnotes

A- From the 1996 CIR, the sum of CT scan and all other medical diagnostic X-ray equipment is 854,323 in 1995. Assume the ratio of these products is constant between 1995 and 1996 and split the sum between the products in 1995.

B- Estimated all other non-medical irradiation equipment in 2000 (not shown in table) by taking the average annual growth from 1997 to 1999 and assuming the same growth rate from 1999-2000. After this estimate, the only x-ray and irradiation product neither reported nor estimated in 2000 is all other medical diagnostic x-ray equipment. Estimated all other medical diagnostic x-ray equipment by controlling for the sum between it and the remaining x-ray and irradiation products.

C- In 1999, x-ray tubes (sold separately) and all other medical diagnostic x-ray equipment are the only two products for which neither revised nor unrevised data is available. Controlling for the total 1999 revised v.o.s., the sum of the two products is 491,484. Took ratio of x-ray tubes to the three other non-medical products in 1998 to estimate the 1999 v.o.s. for x-ray tubes. Controlled for the sum to estimate all other medical diagnostic x-ray equipment in 1999

D- From the 1999 CIR, the sum of all other medical diagnostic x-ray equipment and radiation therapy is 840,166 in 1998 (these were the only two products not reported by themselves or grouped with another product). The individual v.o.s. for these products is reported in 1997. Assume ratio of these products is constant between 1997 and 1998, and split the sum between the two products in 1998.

E- Unrevised v.o.s. from the 1997 CIR. In the 1998 CIR, there is a disclosure problem for the 1997 v.o.s.

F- Unrevised v.o.s. from the 1999 CIR. In the 2000 CIR, there is a disclosure problem for the 1999 v.o.s.

G- EEG and EMG, MRI, endoscopic equipment, and all other medical diagnostic equipment are the remaining products left unreported and not estimated in 2000. Assume ratio of the 1999 groupings of these products is constant between 1999 and 2000, and split the sum between the two groupings in 2000.

H- Unrevised v.o.s. from the 1999 CIR. In the 2000 CIR, there is a disclosure problem for the 1999 v.o.s.

J- In 1997, the MRI v.o.s. is 741,003 and the EEG ad EMG v.o.s. is 108,295. 1997 is the only year these products are individually reported, so they are grouped together in the table for time series comparison.

K- Unrevised v.o.s. from the 1999 CIR. In the 2000 CIR, there is a disclosure problem for the 1999 v.o.s

L- The 1999 v.o.s. for each medical therapy product is known (some data from the unrevised 1999 CIR and some data from the revised 2000 CIR). Also, the v.o.s. for all medical therapy equipment in 2000 is 4,834,486, and the sum of pacemakers and radiation therapy is 1,622,412 in 2000. Held pacemaker's percentage of 1999 medical therapy equipment constant and controlled for total with radiation therapy in 2000, and held radiation therapy's 1999 percentage of medical therapy equipment constant and controlled for total with pacemakers in 2000. The 2000 v.o.s. estimates for pacemakers and radiation therapy are the average of those two estimates.

M- Unrevised v.o.s. from the 1999 CIR. In the 2000 CIR, there is a disclosure problem for the 1999 v.o.s.

N- The 1999 CIR reports that the v.o.s. for pacemakers is 1,142,877 in 1999, and the 2000 CIR reports the sum of the v.o.s. for pacemakers and radiation therapy is 1,613,450 in 1999. The 1999 radiation therapy estimate equals the difference between the sum of pacemakers and radiation therapy (revised 1999 sum) and pacemakers (unrevised 1999 v.o.s.)

O- The 1998 CIR reports the sum of all other medical diagnostic x-ray equipment and radiation therapy in 1997, and the 1997 CIR reports the v.o.s. for all other medical diagnostic x-ray equipment in 1997. The 1997 estimate for radiation therapy equals the difference between the sum of all other medical diagnostic and radiation therapy (revised 1997 sum) and all other medical diagnostic x-ray equipment (unrevised 1997 v.o.s.).

P- From the 1997 CIR, the sum of radiation therapy and parts and accessories for x-ray equipment is 520,332 in 1996. Took ratio of parts and accessories for x-ray equipment to the three other non-medical products in 1997 to estimate the 1996 v.o.s. for parts and accessories. Controlled for the sum to estimate radiation therapy in 1996.

Q- From the 1996 CIR, the sum of radiation therapy and parts and accessories for x-ray equipment is 480,074 in 1995. Took ratio of parts and accessories for x-ray equipment to the three other non-medical products in 1997 to estimate the 1995 v.o.s. for parts and accessories. Controlled for the sum to estimate radiation therapy in 1995.

Table 5A

Annual Growth Rates, Producer Price Indexes

CIR Product Code		Average Annual Growth Rate 1995-2000	Annual Percent Changes 2000	1999	1998	1997	1996
Medical Diagnostic Equipment							
Medical and Dental Diagnostic Irradiation Equipment		0.22	-0.1	-0.7	0.5	1.5	-0.1
Diagnostic Electomedical Equipment		-2.31	-6.6	-2.4	-1	-1.1	-0.3
3345101106	Ultrasound scanning devices	-1.52 A	n/a	-3.4	1.2	-2.6	-1.2
3345101109	Electrocardiograph (EKG)	-4.48	-0.3	-3.3	-15.4	-1.6	-0.9
Several	All other medical diagnostic (including MRI 1998-2000)	0.72	0.8	-0.2	1.5	0.7	0.8
3345101103	MRI		n/a	n/a	n/a	-0.1	-0.5
Patient Monitoring Equipment		-5.38	-6.3	-5.9	-0.1	-8.7	-5.7
3345101227	Intensive care/coronary care units, including component modules such as temperature, blood pressure, and pulse…………….	-3.05	-0.6	0	-1.5	-4.7	-8.2
Several	Prenatal, Respiratory, and All other patient monitoring	-8.33	-13.5	-12.8	1.4	-13.2	-2.5
Therapeutic equipment							
Electromedical Therapy Equipment		-3.00	-2.3	-2.7	-2.7	-4	-3.3
Several	Ultrasound therapy, Dialyzers, and All other medical therapy equipment	-0.73 B	0	-0.9	-1.3	n/a	n/a
3345101244	Pacemakers	-3.32 A		-5.2	-4.4	-3.3	-0.3
3345101247	Defibrillators …………	-5.20 B	-5.1	-5.8	-4.7	n/a	n/a
3345101254	Medical laser equipment /1		**-1.93**	**-1.93**	**-1.93**	n/a	n/a
Radiation Therapy		N/a					
Surgical Systems		0.17	0	-0.3	0.8	n/a	n/a
3345101361	Electrosurgical equipment	N/a					
Several	Heart Lung Machines, Blood Flow Systems, and All Other Surgical Support Systems	0.26 B	-0.2	-0.6	1.6	n/a	n/a
Parts, accessories, and all other electromedical equipment		-1.81	0.5	-2	-3.8	-2.5	-1.2

n/a- PPI not available.

A-Average annual growth rate 1995-99.
B- Average annual growth rate, 1997-2000.

/1 Percent changes assumes average annual PPI growth is constant between 1997 and 2000. The PPI only reports data for those two years.

Source: Producer Price Index.

Table 5B

Annual Growth Rates of CIR Value of Shipments, Constant Prices

CIR Product Code		Average Annual Growth Rate 1995-2000	Annual Percent Changes 2000	1999	1998	1997	1996
Medical Diagnostic Equipment							
	Medical and Dental Diagnostic Irradiation Equipment	7.27	30.5	-13.2	11.1	9.2	3.4
	Diagnostic Electomedical Equipment	11.60	5.0	14.8	9.3	6.1	23.8
3345101106	Ultrasound scanning devices	16.62 A	n/a	9.4	15.4	21.0	21.1
3345101109	Electrocardiograph (EKG)	0.13	-26.9	12.5	33.2	1.9	-9.9
Several	All other medical diagnostic (including MRI) /1	8.15	-1.3	20.4	-2.6	-5.2	34.7
Patient Monitoring Equipment		7.32	0.7	2.0	5.5	9.0	20.4
3345101227	Intensive care/coronary care units, including component modules such as temperature, blood pressure, and pulse............…	2.48	-1.6	-14.1	5.6	4.3	21.6
Several	Prenatal, Respiratory, and All other patient monitoring	12.69	6.5	19.6	5.1	14.7	18.2
Therapeutic Equipment							
	Electromedical Therapy Equipment	15.43	3.7	21.5	13.5	23.7	15.8
Several	Ultrasound therapy, Dialyzers, and All other medical therapy equipment	12.11 B	5.9	20.5	10.5	n/a	n/a
3345101244	Pacemakers	19.60 A	N/a	38.6	13.3	30.6	-0.2
3345101247	Defibrillators ....…	21.52 B	15.8	14.5	35.3	n/a	n/a
3345101254	Medical laser equipment /2	-2.46 B	-17.5	11.5	0.9	n/a	n/a
	Radiation Therapy	n/a					
Surgical Systems		4.62 B	8.0	1.8	4.2	n/a	n/a
3345101361	Electrosurgical equipment	N/a					
Several	Heart Lung Machines, Blood Flow Systems, and All Other Surgical Support Systems	3.50 B	3.6	0.9	6.0	n/a	n/a
Parts, accessories, and all other electromedical equipment		10.78	8.4	9.3	8.9	1.1	28.0

1/ For 1996 and 1997, BLS publishes a PPI for MRI. However, we group MRI with all other medical diagnostic equipment in each year, and use the PPI for all other electromedical diagnostic equipment to deflate this v.o.s. and calculate the constant dollar annual growth rate.
2/ Percent changes assumes average annual PPI growth is constant between 1997 and 2000. The PPI only reports data for those two years

A-Average annual growth rate 1995-99.

B- Average annual growth rate, 1997-2000.

Source: Current Industrial Reports, Electromedical and Irradiation Equipment, Table 2, and Producer Price Index

Table 6

Summary of PPI and CIR Growth Rates

CIR Product Code		PPI	Constant Price CIR	Current Price CIR
		Average Annual Percent Change 1995-2000		
Medical diagnostic equipment				8.3
Medical and Dental Diagnostic Irradiation Equipment		.22	7.27	7.5
3345170103	Digital radiography equipment............	X	X	7.2
3345170106	Computerized axial tomography (CT or CAT SCAN)	X	X	7.1
3345170109	Dental and conventional X-ray	X	X	4.4
3345170112	All other medical diagnostic X-ray equipment ……	X	X	12.3
3345170115	Nuclear medicine equipment (all equipment used for nuclear in vivo studies)	X	X	7.2
Electromedical Diagnostic Equipment		-2.31	11.60	9.02
3345101106	Ultrasound scanning devices	-1.52 A	16.62 A	12.0
3345101109	Electrocardiograph (EKG)	-4.48	.13	-4.4
3345101115	Audiological equipment.	.72 /1	8.15 /1	-1.3
3345101121	Respiratory analysis equipment			-5.1
3345101112 + 3345101124	EEG, EMG AND All other medical diagnostic equipment			
3345101103 + 345101112	MRI AND EEG, EMG			8.9 B
3345101103 + 3345101118	MRI AND Endoscpic Equipment			
3345101118 + 3345101124	Endoscopic Equipment and All Other Medical Diagnostic			-6.9 B

Table 6 (Continued)

Summary of PPI and CIR Growth Rates

CIR Product Code		Average Annual Percent Change 1995-2000 PPI		Constant Price CIR		Current Price CIR
Patient monitoring equipment		-5..38		7.32		1.5
3345101227	Intensive care/coronary care units, including component modules such as temperature, blood pressure, and pulse................	-3.05		2.48		-0.6
3345101233	Prenatal and Respiratory Monitoring	-8.33		12.69		-2.9
3345101237	All other patient monitoring					4.4
Medical therapy equipment						11.2
Electromedical Therapy		-3.00		15.43		11.96
3345101244	Pacemakers	-3.32	A	19.60	A	12.5
3345101247	Defibrillators	-5.20	B	21.52	B	15.0
3345101254	Medical laser equipment /2	-1.93	B	-2.46	B	3.7
3345101241	Ultrasound therapy	-.73	B	12.11	B	19.6
3345101251	Dialyzers, including machines and equipment					11.4
3345101257	All other medical therapy equipment					14.4
Radiation therapy		X		X		5.0
Surgical systems		.17	B	4.62	B	7.6
3345101361	Electrosurgical equipment	X		X		5.1
3345101364 + 3345101367	Heart-Lung machines, excluding iron lungs AND Blood Flow Systems …	.26	B	3.50	B	12.9
3345101371	All other surgical support systems					4.5
Other		-1.81		10.78		
3345101374	Other electromedical equipment (except diagnostic and therapeutic) n.e.c. …	X		X		46.1
3345101477	Electromedical parts and accessories, including diagnostic and therapeutic n.e.c.	X		X		4.5

Shaded Areas: The average annual change in the PPI and constant price CIR applies to all products in the shaded area. Shaded area used when PPI aggregates a subset of products from a particular use category, but CIR reports product detail.
X-PPI not available.
A-Average annual growth rate 1995-99.
B-Average Annual Growth Rate 1997-2000.
/1 For 1996 and 1997, BLS publishes a PPI for MRI. However, we group MRI with all other medical diagnostic equipment in each year, and use the PPI for all other electromedical diagnostic equipment to deflate this v.o.s. and calculate the constant dollar annual growth rate.
/2 Percent changes assumes average annual growth constant between 1997 and 2000. The PPI only reports data for those two years.
Source: Current Industrial Reports Electromedical and Irradiation Equipment, Table 2, and Producer Price Index.

Table 7

Materials Consumed by Kind, Electromedical and Irradiation Equipment, 1997

	Delivered Cost (Thousands of Dollars)	**Percent of Total Materials Consumed**
Electromedical Equipment		
Total material consumed	$3,377,133	
Resistors, Capacitors, transformers, electron tubes, semiconductors, and other electronic components	1,088,403	32.2%
Irradiation Equipment		
Total Material Consumed	1,503,813 /1	
Purchased electronic computing and peripheral equipment for incorporation into complete finished products	390,806	26
Electronic Components and Accessories	119,430	7.9
Semiconductors, including transistors, diodes, rectifiers, and integrated circuits for electronic circuitry	26,499	1.8
Capacitors for electronic circuitry	6,847	.4
Resistors for electronic circuitry	9,077	.6
Connectors for electronic circuitry	5,261	.3
Other Electronic Components and accessories	71,746	4.8

/1 The total does not include the delivered cost and forgings and transmittal, industrial, and special-purpose electron tubes, except x-ray. The census bureau withheld these delivered costs because of disclosure problems.

Source: 1997 Economic Census, Electromedical and Electrotherapeutic Apparatus Manufacturing and Irradiation Apparatus Manufacturing, Table 7

Annex 1

Description of Medical Technologies
(from Medtronic 2001 Annual Report)

Disorder	Description	Medtronic Therapies or Products
Cardiovascular		
Bradyarrhythmia	Heart rates that are too slow	Pacing systems of pacemakers, pacing leads, programmers and software
Tachyarrhythmia	Heart rates that are too fast or irregular Tachyarrhythmia can lead to sudden cardiac arrest.	Implantable defibrillators and tachyarrhythmia leads, programmers, software and external defibrillators Ablation and mapping systems and catheters*
Atrial Arrhythmias	Irregular heartbeat where the upper chambers of the heart, the atria, beats rapidly and inconsistently, affecting the flow of blood through the heart.	Implantable atrial arrhythmia management systems and preventative pacing systems Ablation and mapping systems and catheters*
Unexplained Syncope (fainting)	Temporary loss of consciousness	Insertable loop recorders to diagnose the cause of syncope
Heart Failure	The heart pumps inefficiently, limiting the blood supply to meet the body's needs	Cardiac resychronization systems including biventricular pacemakers, biventricular pacemaker defibrillators, data management systems, and defibrillation, pacing and monitoring electrodes*
Heart Valve Disease	Disease of the heart valves that limits the heart's ability to pump blood, including stenosis, or narrowing of valve opening, and regurgitation, when the valve may not close completely	Aortic bioprosthesis, aortic and mitral tissue and mechanical valves, and flexible annuloplasty rings*
Coronary Vascular Disease	Deposits of cholesterol and other fatty materials on the walls of the coronary arteries, causing narrowing or blockage of the coronary arteries or veins used to bypass earlier arterial blockages, reducing the blood supply to the heart	*Interventional Cardiology* Coronary stent delivery systems, balloon angioplasty catheters, guiding catheters, guidewires, diagnostic catheter products and distal embolic protection systems *Cardiac Surgery* Perfusion systems for arrested heart surgery, beating heart surgery devices, autotransfusion systems, and diagnostic equipment
Peripheral Vascular Disease	Narrowing or blockage of arteries or veins outside the heart Abdominal Aortic Aneurysm (AAA)—a weakening and ballooning of the aortic artery	Renal (kidney) stent systems*, iliac (pelvic/femoral) stent systems, biliary (liver) stent systems*, endovascular stent grafts, and distal embolic protection systems*
Neurological		
Chronic Debilitating Pain	Chronic pain (lasting 6 months or more) or pain caused by cancer or cancer treatment Chronic back or leg pain and complex regional pain syndrome	Programmable, fixed-rate drug infusion systems and neurostimulation systems

Spasticity	Extreme muscle stiffness caused by involuntary muscle contractions	Intrathecal baclofen therapy
Movement Disorders	Involuntary shaking of the limbs such as in Essential Tremor Rigidity, bradykinesia/akinesia, tremor or postural instability in Parkinson's Disease	Tremor control therapy and Parkinson's control therapy*
Hydrocephalus	Excess cerebrospinal fluid (CSF) in the ventricles of the brain Increased intracranial pressure (ICP).	Shunts, valves, and catheters, and flexible neuroendoscopes.
Urology and Gastroenterology Disorders	Dysfunction of the gastrointestinal tract, the urological tract, and neuro physiological activity	Continence control therapies Diagnostic and monitoring systems for use in treating gastroenterologic, urologic, and neurologic disorders
Spinal, Ear, Nose, and Throat		
Spinal Disorders	Herniated disc, congenital spine disorders, degenerative disk diseases,tumor, trauma/fracture and stenosis.	Cervical, thoracolumbar and/or lumbar systems such as threaded spinal fusion devices Bone morphogenetic protein*
Ear, Nose and Throat Diseases and Disorders	Diseases and conditions affecting the ear, nose and throat, and eye	Powered tissue removal systems, nerve monitors, instruments, implants and image-guided surgery systems

* Includes some products not yet cleared for marketing in the United States.

Source: Medtronic 2001 Annual Report
http://www.medtronic.com/annual01/MDT2001AR.pdf

Annex 2
Distribution of Capital Investment to the Health Sector
Non-Medical and Medical Equipment

(Producer's Prices, in Millions of Dollars)

line no.	I-O commodity group (commodity number in parentheses)	Health Services, Excluding Hospitals		Hospitals	
		Amount	Percent of Total	Amount	Percent of Total
6, 8, 9, 12, 18, 33	**Construction**	$3500	37.8%	$10408	50.9%
	Non-Medical Capital Equipment	726	7.8%	1594	7.8%
31, 40-46	Furniture	198	2.1%	515	2.5%
49, 54-56, 58-60	Rubber, Plastic, and Fabricated Metal Products	5	0.1%	25	0.1%
63-64	Farm and Garden Machinery	7	0.1%	11	0.1%
68, 70, 74, 83,-85, 88, 89	Industrial Machinery	7	0.1%	29	0.1%
90-95	Computing and Office Equipment	158	1.7%	482	2.4%
97-100, 102, 106-108, 110, 113, 118	Laundry and Refrigeration Equipment, Motors and Generators, and Other Operations Equipment	108	1.2%	199	1.0%
119-121, 125	Audio, Video, and Other Communications Equipment	32	0.3%	63	0.3%
126-129	Vehicle and Aircraft	156	1.7%	124	0.6%
1, 151, 155	Uranium-radium-vanadium Ores, Photographic Equipment, Manufacturing Industries, n.e.c.	55	0.6%	146	0.7%
	Medical Equipment	5035	54.4%	8438	41.3%
139	(3821) Laboratory apparatus and furniture	83	0.9%	270	1.3%
140	(3823) Process control instruments	0	a	34	0.2%
141	(3824) Fluid meters and counting devices	0	a	3	a

142	(3825) Instruments to measure electricity	0	a	7	a
143	(3826) Analytical instruments	12	a	49	0.2%
144	(3827) Optical instruments and lenses	4	a	21	0.1%
145	(3829) Measuring and controlling devices, n.e.c.	1	a	6	a
146	(3841) Surgical and medical instruments	2487	26.9%	4043	19.8%
147	(3842) Surgical appliances and supplies	48	0.5%	1498	7.3%
148	(3843) Dental equipment and supplies	585	6.3%	18	0.1%
149	(3844) X-ray apparatus and tubes	1193	12.9%	622	3.0%
150	(3845) Electromedical equipment	622	6.7%	1867	9.1%
Total		9261	100.0%	20440	100.0%

a- less than .1%

Source: Bonds, Belinda and Tim Aylor. "Investment in New Structures and Equipment in 1992 by Using Industries." *Survey of Current Business*. December, 1998: 26-51.

Annex 3

Product Lists for Electromedical Equipment and Irradiation Equipment

NAICS 334510   Electromedical and electrotherapeutic Manufacturing

Arc lamp units, electrotherapeutic (except infrared, ultraviolet), manufacturing
Audiological equipment, electromedical, manufacturing
Automated blood and body fluid analyzers (except laboratory) manufacturing
Bronchoscopes, electromedical, manufacturing
Carbon arc lamp units, electrotherapeutic (except infrared and ultraviolet), manufacturing
Cardiodynameter manufacturing
Cardiographs manufacturing
Cardiophone, electric, manufacturing
Cardioscope manufacturing
Cardiotachometer manufacturing
Colonscopes, electromedical, manufacturing
Cystoscopes, electromedical, manufacturing
Defibrilators manufacturing
Diagnostic equipment, electromedical, manufacturing
Diagnostic equipment, MRI (magnetic resonance imaging), manufacturing
Dialysis equipment, electromedical, manufacturing
Diathermy apparatus, electromedical, manufacturing
Diathermy units manufacturing
Electrocardiographs manufacturing
Electroencephalographs manufacturing
Electrogastrograph manufacturing
Electromedical diagnostic equipment manufacturing
Electromedical equipment manufacturing
Electromedical therapy equipment manufacturing
Electromyographs manufacturing
Electrotherapeutic apparatus manufacturing
Electrotherapy units manufacturing
Endoscopic equipment, electromedical (e.g., bronchoscopes, colonoscopes, cystoscopes), manufactu
Gastroscopes, electromedical, manufacturing
Hearing aids, electronic, manufacturing
Heart-lung machine, manufacturing
Laser equipment, electromedical, manufacturing
Laser systems and equipment, medical, manufacturing
Lithotripters manufacturing
Magnetic resonance imaging (MRI) medical diagnostic equipment manufacturing
Medical cleaning equipment, ultrasonic, manufacturing
Medical ultrasound equipment manufacturing
MRI (magnetic resonance imaging) medical diagnostic equipment manufacturing
Otoscopes, electromedical, manufacturing
Pacemakers manufacturing
Patient monitoring equipment (e.g., intensive care, coronary care unit) manufacturing
PET (positron emission tomography) scanners manufacturing
Phonocardiographs manufacturing
Position emission tomography (PET) scanners manufacturing
Probes, electric medical, manufacturing
Respiratory analysis equipment, electromedical, manufacturing
Retinoscopes, electromedical, manufacturing
Sentinel, cardiac, manufacturing
Surgical support systems (e.g., heart-lung machines) (except iron lungs) manufacturing
TENS (transcutaneous electrical nerve stimulator) manufacturing
Transcutaneous electrical nerve stimulators (TENS) manufacturing

Ultrasonic medical equipment manufacturing
Ultrasonic scanning devices, medical, manufacturing

NAICS 334517 Irradiation Apparatus Manufacturing

Beta-ray irradiation equipment manufacturing
Computerized axial tomography (CT/CAT) scanners manufacturing
CT/CAT (computerized axial tomography) scanners manufacturing
Fluoroscopes manufacturing
Fluoroscopic X-ray apparatus and tubes manufacturing
Gamma ray irradiation equipment manufacturing
Generators, X-ray, manufacturing
Irradiation apparatus and tubes (e.g., industrial, medical diagnostic, medical therapeutic, rese
Irradiation equipment manufacturing
Lamps, X-ray, manufacturing
Medical radiation therapy equipment manufacturing
Nuclear irradiation equipment manufacturing
Radium equipment manufacturing
Therapeutic X-ray apparatus and tubes (e.g., medical, industrial, research) manufacturing
Tubes, X-ray, manufacturing
X-ray apparatus and tubes (e.g., control, industrial, medical, research) manufacturing
X-ray generators manufacturing
X-ray irradiation equipment manufacturing
X-ray tubes manufacturing