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Domestic Electronics Manufacturing: Medical, Military, and Aerospace Equipment and What We Don't Know about High-Tech Productivity

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Beginning in the 1990s, Federal Reserve Board staff paid increasing attention to electronics manufacturing in order to advance its understanding of technological innovation, of the role of the domestic industrial sector in global value chains, and of the sources of labor productivity growth.[1] To date, with respect to final electronics, which excludes intermediate products such as semiconductors, the primary focus of that effort has been general-purpose computing and communications equipment, but the output of these products from U.S. plants has dramatically declined; at the same time, the domestic production of special-purpose electronics--most notably for medical, military, and aerospace applications--has expanded significantly. This note describes the new composition of the domestic electronics sector and considers some implications for the "high-tech" measurement research agenda.

The Shift from General-Purpose to Special-Purpose Equipment

In 1997, computing and communications equipment accounted for two-thirds of U.S. shipments of final electronic equipment (table 1). At that time, domestic plants produced a substantial share of global output of personal computers (PCs), multi-user computers (such as servers and mainframes), cellular phones, and data networking equipment. However, U.S. production of these products has retreated, including a well-known plunge coinciding with the 2001 downturn *and* a less well-appreciated drop during the Great Recession (figure 1). All told, the nominal output of general-purpose electronics declined 60 percent from 1997 to 2012.[2]

Over the same period, the manufacturing of special-purpose electronics *increased* 51 percent and, by 2012, accounted for two-thirds of domestic electronic equipment manufacturing. Special-purpose electronics includes a diverse array of industry-specific equipment falling into three groups of roughly equal size in 2012 (table 2):

- *Medical applications*:[3] Major electro-medical products include ultrasound machines, CT scanners, and MRI machines; the value of domestic production for *each* of these product classes was $2 billion in 2012, roughly equal to the U.S. output of desktop PCs.
- *Military and aerospace applications*: For example, U.S. production of light reconnaissance and surveillance electronic systems and equipment was $8 billion in 2012. The output of electronic warfare countermeasures equipment, a category newly identified in the 2012 Economic Census, was $4 billion.
- *Other applications*: The remaining one-third of special-purpose electronics production consists of a wide variety of industrial, commercial, and residential electronic equipment.

Measuring Special-Purpose Electronics Production

The recent emergence of special-purpose electronics as the dominant component of the electronics sector heightens our uncertainty about both labor productivity and, relatedly, the rate of innovation in the domestic manufacturing sector--topics of considerable interest at the present time. Furthermore, the contribution to productivity from the *use* of special-purpose electronics, particularly in the service sector, is an important open question. For example, accurate measures of electro-medical equipment investment, in combination with the recent improvements to the measurement of health care services introduced by the Bureau of Economic Analysis, may yield estimates of the contribution of capital deepening to health care productivity. Also, the rate of price declines for military and aerospace equipment may shed light on the role of the rise of global military expenditures in driving technical change.

Proper measurement of the production of equipment types that are characterized by rapid innovation depends critically on the deflation of nominal output by price indexes that account for the technical advances embodied in new products. One need only observe the imagery currently available for medical diagnosis or the nature of modern military intelligence to see this is a first-order concern for special-purpose electronics, but there has been little research into measuring technical change for these types of equipment--unlike computing and communications electronics, which have been closely examined by statistical agencies and academic economists.[4] Prices for the types of computing and communications equipment that have been the subject of careful studies typically fall 10-25 percent per year; in stark contrast, prices for special-purpose equipment decline much more slowly or edge up over time (table 3).

The standard matched-model index methods used by the Bureau of Labor Statistics (BLS) to construct producer price indexes (PPIs) are designed to capture quality change, but the relatively slow BLS PPI declines for special-purpose electronics are surprising. Roughly one-quarter of the value of manufactured intermediate inputs for special-purpose electronics production is accounted for by electronic components, such as memory chips and microprocessors, for which prices fall very rapidly (table 3).[5] This share is approximately the

same for computing and communications equipment. It appears that in the case of special-purpose equipment, these falling input costs do not pass through to the price index for the final products.

That being said, prices for special-purpose electronics may behave differently from prices for general-purpose electronics due to differences in market structure. Special-purpose electronics producers have less opportunity to exploit scale economies; only a few thousand MRI machines are sold per year, while the global market for PCs is several hundred million units. In addition, the arcane contracting practices of the health care and government sectors surely affect price trends for special-purpose electronics as well. Supplemental research to corroborate or augment the official price series for these products would be a welcome development.

Unfortunately, detailed data appropriate for such analysis is scarce. Because special-purpose electronic equipment is highly customized, is sold in small volumes, is marketed to secretive customers, and is often bundled with other products and services, constructing constant-quality price indexes for this portion of the electronics sector will require a daunting campaign of what Shapiro and Wilcox (1996) called "house-to-house combat."[6]

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1. For the purpose of this note, "electronics" is defined as the output of the Computers and Electronic Product subsector (NAICS 334) excluding Manufacturing and Reproducing Magnetic and Optical Media (NAICS 3346). The focus of this note is final electronics, which excludes electronic components, the output of the Semiconductor and Other Electronic Component Manufacturing industry (NAICS 3344). Return to text

2. This note relies primarily on the detailed product shipments information in the U.S. Census Bureau's quinquennial Economic Census. Return to text

3. Consult note to table 1 for a list of NAICS industries included in each application category. Return to text

4. A 2001 review the literature on quality-adjusted price indexes and found only Trajtenberg's 1990 study of CT scanners (*Economic Analysis of Product Innovation: The Case of CT Scanners*, Harvard University Press.) To the author's knowledge, that remains the only published study of special-purpose electronics prices. (See Berndt, Ernst R., David M. Cutler, Richard Frank, Zvi Griliches, Joseph P. Newhouse, and Jack E. Triplett, 2001, "Price indexes for Medical Care Goods and Services--An Overview of Measurement Issues.") Return to text

5. The BEA's 2007 Commodity Flows tables indicate that for NAICS 3345 (special-purpose electronics), 23.0 percent of manufactured intermediates come from NAICS 3344, and for NAICS 3341 and 3342 combined (computing and communications electronics), this figure is 26.6 percent. Roughly one-half (48.7 percent) of manufactured intermediates for NAICS 3345 come from NAICS 334 and this figure is roughly four-fifths (79.9 percent) for NAICS 3341 and 3342 combined electronics. Return to text

6. Shapiro, M. and D. Wilcox. 1996. "Mismeasurement in the Consumer Price Index: An Evaluation," NBER Macroeconomics Annual. Return to text

Table 1: U.S. Production of Final Electronics

	Value of Production, $ Billion				1997-2012 Growth		Share of Production			
	1997	2002	2007	2012	Total	Per Year	1997	2002	2007	2012
Final Electronics	260.7	188.6	250.2	203.9	-21.8%	-1.6%				
Computing and communications	169.4	92.8	119.5	66.4	-60.8%	-6.1%	65%	49%	48%	33%
Computers and peripherals	91.3	65.7	60.0	29.6	-67.6%	-7.2%	54%	71%	50%	45%
Communications equipment	78.1	42.0	59.5	36.8	-52.9%	-4.9%	46%	45%	50%	55%
Special-purpose	91.3	95.8	130.7	137.6	50.7%	2.8%	35%	51%	52%	67%
Medical	20.0	26.4	44.1	48.6	143.3%	6.1%	22%	28%	34%	35%
Military & aerospace	29.8	30.3	42.8	44.1	48.1%	2.7%	33%	32%	33%	32%
Other special-purpose	41.5	39.2	43.8	44.9	8.2%	0.5%	45%	41%	34%	33%
Memo:										
Computer and Elec. Prod. Mfg. (NAICS 334)	410.4	305.0	372.7	319.5	-22.1%	-1.7%				
Final Electronics	260.7	188.6	250.2	203.9	-21.8%	-1.6%	64%	62%	67%	64%
Electronic Components	138.8	109.0	116.8	112.5	-18.9%	-1.4%	34%	36%	31%	35%
Miscellaneous	11.0	7.3	5.7	3.1	-71.7%	-8.1%	3%	2%	2%	1%

Source: Product shipments from Economic Census, Bureau of Census.

Note: Medical category: Electromedical and electrotherapeutic apparatus manufacturing; analytical laboratory instrument manufacturing; and irradiation apparatus manufacturing.

Military and aerospace category: Search, detection, navigation, guidance, aeronautical, and nautical system and instrument manufacturing.

Other special-purpose category: Automatic environmental control manufacturing for residential, commercial, and appliance use; Instruments and related products manufacturing for measuring, displaying, and controlling industrial process variables; Totalizing fluid meter and counting device manufacturing; Instrument manufacturing for measuring and testing electricity and electrical signals; Other measuring and controlling device manufacturing; and Audio and

video equipment manufacturing

Table 2: 2012 U.S. Production of Special-Purpose Electronics

Selected Detail, $ Billion

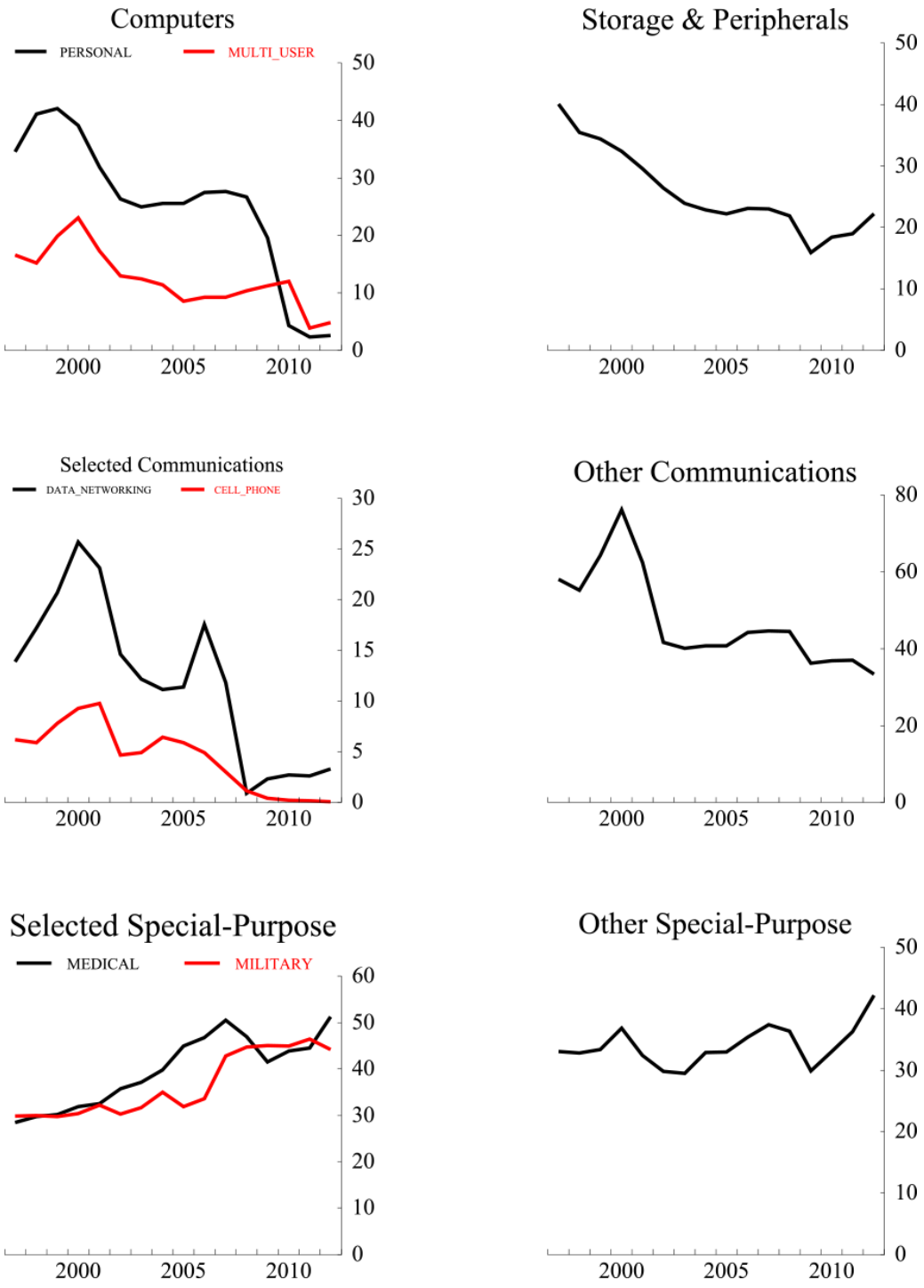
Medical, therapeutic and laboratory applications	48.6
Ultrasound scanning	2.5
Computerized axial tomography (CT or CAT scan)	1.8
Magnetic resonance imaging (MRI)	1.8
Defibrillators	1.3
Digital radiography	1.2
Military and aerospace applications	44.1
Light reconnaissance and surveillance	8.3
Specialized electronic and communications intelligence	5.9
Missile-borne and space vehicle guidance	4.6
Electronic warfare countermeasures (jamming, communications, and radar)	4.3
Search, detection, and acquisition radar, airborne and missile/space	4.2
Other applications	44.9
Measuring and testing electricity and electrical signals	11.1
Industrial process control	10.4
Physical properties and kinematic testing and inspection	3.5
Geophysical, meteorological	3.2
Integrating and totalizing meters for gas and liquids	2.7
Automatic environmental control	2.7
Motor vehicle instruments	2.0

Table 3: Prices for Selected Classes of Electronics

Equipment Type	Average Annual Change, 1997-2012	Source
General-Purpose		
Computers (PCs, workstations, servers, etc.)	-13.0	BLS Producer Price Index
Data Storage	-23.0	Federal Reserve Board
Computer Peripherals	-1.4	BLS Producer Price Index
Wireline Communications	-13.5	Federal Reserve Board
Wireless Communications	-13.8	Federal Reserve Board
Other Communications	0.5	BLS Producer Price Index
Special-Purpose		
Defense & Aerospace		
Search, detection & navigation	1.6	BLS Producer Price Index
Medical & Laboratory		
Electro-medical	-1.6	BLS Producer Price Index
Analytical laboratory	1.2	BLS Producer Price Index
Monitoring, process control, testing		BLS Producer Price Index
Automatic environmental Control	1.3	BLS Producer Price Index

Equipment Type	Average Annual Change, 1997-2012	Source
Industrial process Control	2.2	BLS Producer Price Index
Fluid meter & counting	1.7	BLS Producer Price Index
Electricity measuring & testing	1.1	BLS Producer Price Index
Electronic Components		
Semiconductors		
Microprocessors (MPUs)	-46.1	Federal Reserve Board
Memory	-28.5	Federal Reserve Board
MOS Logic excluding MPUs	-24.2	Federal Reserve Board
Optoelectronics & Discretes	-4.5	Federal Reserve Board
Analog	-3.9	Federal Reserve Board
Circuit Boards	0.4	BLS Producer Price Index

Figure 1: U.S. Shipments for Selected Electronic Equipment



Source. Census Bureau, Federal Reserve Board estimates. $ Billion.

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