Communications of the Association for Information Systems

Volume 12 Article 31

October 2003

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ECONOMIC AND SYSTEMS ENGINEERING APPROACHES TO IS IDENTITY

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ABSTRACT

This article presents an economic basis for declaring Information Systems and Information Technology to be both cognitively and socio-politically legitimate and to show that learning [Benbasat and Zmud, 2003] has been achieved[1]. The large scale complexity and diversity of today's information systems are discussed within the context of a software engineering (SE) model and the higher-level view of the product that SE provides. The history and scope of investments in computing, and the practices of software engineering demonstrate that we are not a New Collective[2] suffering from an identity crisis. We are a heterogeneous group looking at a wide diversity of Information Systems, some of which challenge the way we think about organizational boundaries and show that artifacts are not adequate to define IT.

Keywords: IS core, systems engineering, economics, IS identity

I. INTRODUCTION

Benbasat and Zmud [2003] propose that IS needs an organizational identity and they proceed to support this assertion with Aldrich's theoretical framework [1999]. In this paper we show that when the issues of legitimacy and learning are examined in terms of economic reality and historical investment, IS and IT do not suffer from either a lack of legitimacy or of learning.

Our results are based on estimates of the United States investment in computers, peripherals, and software (i.e., in information systems (IS)) by the U.S. Department of Commerce, Bureau of Economic Analysis, [2002b]. These data are presented to challenge the issues of cognitive and sociopolitical legitimacy raised by Aldrich [1999] and by Benbasat and Zmud, [2003] and to show that learning was achieved. The reader is left to extrapolate the actual and much larger scope of the total investment in information technology infrastructure and Information Technology (IT)

1 At least by some of the members of the collective.
2 Collective membership as defined by Benbasat and Zmud (2003) includes industries and professional groups.

using an expanded definition of IT from those presented by Evaristo and Munkvold [2003], Champy [2003], and others[3].

Why use the data from the Bureau of Economic Analysis (BEA) at the U.S. Department of Commerce? Because it estimates and tracks the historical-cost investment in private non-residential fixed assets by industry group and legal form of organization [U.S. Department of Commerce, Bureau of Economic Analysis, 2002a]. The BEA also estimates and tracks historical-cost investment in private non-residential fixed assets by category of asset [U.S. Department of Commerce, Bureau of Economic Analysis, 2002b]. The economic analysis and discussion presented here compare two sub-categories of the historical-cost investment in private non-residential fixed assets (Computers and peripheral equipment and Software[4]), with other major (consolidated) BEA categories of fixed asset investment for the years 1959[5] through 2001.

II. THE ECONOMIC DATA SUGGEST LEGITIMACY AND LEARNING OCCURRED

The investment in Computers and peripheral equipment and Software nationwide, a conservative indicator of the investment in IT, rose from a low of less than 1% (31 millions) of the total fixed asset investment in Private, Non-residential Equipment and Software in 1959 to over 30% (254.58 billions) in 2001 (Table 1).

Table 1.Fixed Asset Investment in Private Non-Residential Equipment and Software (in millions)[6]

	1959	1969	1979	1989	1999	2001
Non-residential equipment and software	26372	64398	215262	404020	858999	846859
Computers and Peripherals	20	2441	10018	43092	90415	74172
Software	11	1505	8664	44416	162487	180409
Total (Computers and Peripherals and Software	31	3946	18682	87508	252902	254581
% of Non-residential equipment and software	~.00	0.06	0.09	0.22	0.29	0.30

Source: [U.S. Department of Commerce, Bureau of Economic Analysis, 2002b]

All categories and subcategories of Nonresidential Private Fixed Assets, Equipment and Software are shown in Table 2. The investment in each of these categories and subcategories are shown for the years 1959 and for 2001[7].

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[3] Evaristo and Munkvold [2003] define IT Infrastructure as hardware, software, data and telecommunications networks. Champy [2003] adds components such as help desks, data centers, networks, and security systems to the definition of IT infrastructure.
[4] I wanted to examine the investment in Information Technology (IT) for the U.S. economy; however, I was informed that the BEA does not track investment in IT because "There is no agreement among researchers regarding what should be included under 'Information Technology'" R. Matsunaga (BEA). The closest categories are Computers and peripheral equipment and Software even though these values constitute a subset of the total investment in IT. We know the total investment is greater because some portion of Communications equipment (another BEA fixed asset category) is used to support networked systems.
[5] The investment in Computers and peripheral equipment and Software before 1959 is effectively zero.
[6] For all years see Appendix 1.
[7] Only the first year and last year of asset tracking are shown here. Detailed categories and subcategories can be obtained at http://www.bea.gov/bea/dn/faweb/FATableView.asp?SelectedTable=54& FirstYear=1996 &LastYear=2001&Freq=Year)

Table 2. Private Fixed Assets, Equipment and Software Categories for 1959 and 2001 (in millions)

Year	1959	2001
Nonresidential equipment and software	26372	846859
Information processing equipment and software	**4021**	**403096**
Computers and peripheral equipment	20	74172
Software [8]	11	180409
Communication equipment	1766	90631
Instruments	661	43535
Photocopy and related equipment	247	7932
Office and accounting equipment	1316	6417
Industrial equipment	**8410**	**156902**
Fabricated metal products	950	13700
Engines and turbines	579	9332
Steam engines	441	7251
Internal combustion engines	138	2081
Metalworking machinery	1440	31290
Special industry machinery, n.e.c.	1794	40306
General industrial, including materials handling, equipment	1771	32980
Electrical transmission, distribution, and industrial apparatus	1877	29294
Transportation equipment	**6300**	**139555**
Trucks, buses, and truck trailers	2549	88382
Autos	1728	9595
Aircraft	872	33909
Ships and boats	495	3076
Railroad equipment	655	4593
Other equipment	**7641**	**147306**
Furniture and fixtures	1342	35436
Household furniture	136	1711
Other furniture	1206	33725
Tractors	1055	14036
Farm tractors	815	11099
Construction tractors	240	2937
Agricultural machinery, except tractors	1229	10773
Construction machinery, except tractors	1007	18927
Mining and oilfield machinery	502	5764
Service industry machinery	1304	16082
Electrical equipment, n.e.c.	262	17957
Household appliances	115	625
Other	147	17332
Other nonresidential equipment	940	28331

Source: [U.S. Department of Commerce, Bureau of Economic Analysis, 2002b]

The investment in Computers and peripheral equipment and Software overtook and surpassed private, non-residential investments in the major (consolidated) asset tracking categories of

[8] Excludes software that is “embedded" or bundled in computers and other equipment.

Industrial Equipment, Transportation Equipment, and Other Equipment in 1991 and this trend continues (Table 3)[9]. Since 1991 investment in Computers and peripherals and Software dominates the fixed asset investments in Private Non-residential Equipment and Software.

Table 3.[10] Investments in Other Private, Non-residential Equipment Compared to Computers and Software 1992-2001(in millions)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Total (Computers and Peripherals and Software	104374	116545	126745	148110	166000	196079	224206	252902	272695	254581
Industrial Equipment	91598	100827	112202	127343	135044	139525	145778	148762	163040	156902
Transportation Equipment	78955	86481	104609	111358	120884	128292	139788	166297	162858	139555
Other Equipment	78973	90191	98474	106386	114009	127644	140629	142661	150291	147306

Source: [U.S. Department of Commerce, Bureau of Economic Analysis, 2002b]

Corporate investment in Computers and peripheral equipment and Software shows a steady upward trend from 1959 through 2001 (Tables A1 through A4 in Appendix I) with the exception of 2000 when a small downtick back to the spending levels of 1998 occurred. Spending levels returned to previous growth rates again in 2001. These numbers exclude the 90.63 billions spent in the U.S. in 2001 on Communications equipment [U.S. Department of Commerce, Bureau of Economic Analysis, 2002b] much of which was used to support computer networks. Also excluded are embedded systems which penetrate all parts of American culture and living.

The investment in Computers and peripherals and Software speak to both Cognitive and Sociopolitical legitimacy by demonstrating a high degree of acceptance, at least for some of the members of the collective. The steadily growing investment in Computers and peripherals and Software from 1959 through 2001 coupled with the history of over 40 years of computing in business shows a reliance on and integration of computing into industry.

Across industries management continues to invest heavily in computers to increase productivity, shorten supply chains, and improve processes. Clearly the business world views Computers and peripherals and Software as legitimate and learned how to use them productively [Roach, 1992].

III. SOFTWARE ENGINEERING, ARTIFACTS AND THE LARGE COMPLEX SYSTEMS OF TODAY

To Benbasat and Zmud [2003] an artifact

"is the application of IT to enable or support some task(s) embedded within a structure that itself is embedded within some context(s)."

Benbasat and Zmud further define an artifact by decomposing the artifact into its parts which are the Information Technology, Task, Task structure, and Task context. These categories are inadequate to describe the highly complex, interdependent, globally distributed systems of today.

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[9] Refer to Table 1 for a list of all equipment categories contained in Equipment and software.
[10] For all years since 1959 see Appendix 1.

Given the nature of Information Systems; the functions they serve; and the diversity of the population which uses, studies, builds and supports these systems, the systems definition used by the IEEE provides a better framework within which to understand Information Systems.

The IEEE defines any system as

"a collection of components organized to accomplish a specific function or set of functions [IEEE Standard 6110.12-1990]." [Christensen and Thayer, 2001].

The world of IS where software is developed and implemented to perform a single function (e.g. billing or inventory) is past for large firms and perhaps even for small ones. Today information systems are interdependent, networked systems with a multiplicity of interfaces (e.g., Intranet, Extranet, Internet) that may well serve an entire organization, its vendors, and customers through EDI and Web access to back end systems for ordering and information tracking.

Since 1959, information systems have grown in complexity. For every 25% increase in problem complexity the software solution grows by 100 percent in complexity [Christensen and Thayer, 2001; Glass, 2002]. Information systems became larger and more complex as hardware grew in capacity and the physical and logical boundaries of systems transcend what were previously crisp edges or sharp organizational boundaries.

Even though the systems engineering definition relies on functionality and components, the systems engineering model underscores the importance of stakeholders as a part of any Information System. A Systems Engineering process begins with the production of a Concept of Operations (ConOps) document [IEEE Std 1362-1998, 1999]. The fundamental purpose of the ConOps document is to "provide a mechanism for users to describe, in non-technical terms, their view and expectation of the system and its required features and functionality." [Christensen and Thayer, 2001]. Benbasat and Zmud's [2003] model does not place adequate emphasis on the importance of the users or stakeholders. The software engineering model, on the other hand, places the users first and considers them as an important component of the system.

We also know that systems are not static but are configured dynamically after installation and are structured adaptively [Poole and DeSanctis, 1992] by the people who use them. Organizational boundaries and Information Systems undergo dynamic restructuring both by the user or customer and type of use as these individuals move, virtually speaking, in and out of the organization on an ad hoc basis via the IS (e.g., customers tracking packages on the Web or shopping at Amazon.com). Information Systems configurations change dynamically as each customer accesses the IS through his or her own equipment and adaptively structures [Poole and DeSanctis, 1992] the IS to his or her own needs. Software Engineers must design and implement Information Systems to accommodate and support the dynamic restructuring of both organization boundaries and the IS brought about by differences in client equipment, communications links, and human differences and preferences.

For example, FEDEX operates more than 75,000 networked computers which support tens of thousands of hand-held, wireless computers used by their field service staff to record and track shipments. The FEDEX data center processes more than 20 million-information management system transactions daily, more than any other US company in history. FEDEX also offers Web-based interfaces which enable customers to access corporate databases [FEDEX, 2003].

The FEDEX integrated systems are highly interdependent and transcend traditional boundaries making the application of artifacts and nomological nets virtually useless. This highly interdependent, complex, networked system eliminates barriers to information access by using the Web and wireless devices supported by a host of computers to "push" information out to the FEDEX employees and customers who may or may not be moving around.

Today, customer service representatives in centralized call centers may be just as easily physically located in India as in Omaha as a result of the reach and scope of IS. Service representatives, truck drivers, store operators, vendors and customers all can access FEDEX systems from remote locations or mobile devices resulting in improved customer satisfaction and control, and increased employee productivity. FEDEX is only one example of a company using IS to redefine its processes and de-structure its organization.

New ways of doing business such as outsourcing [Lee, J. et al., 2003] and partnerships also transform IS boundaries. Companies such as American Airlines [Hopper, 1993] and Allegis [Konsynski and McFarlan, 1990] created information partnerships to share Information Systems and routinely cooperate for financial advantage [Konsynski and McFarlan, 1990]. The large complex Information Systems of today's world which include the users can rarely can be shoehorned into the narrowly defined concept of an artifact.

IV. LAYING CLAIM TO SYSTEMS IN ORGANIZATIONS

Laying claim to systems in organizations [Alter, 2003] also implies containment of systems by organizational boundaries although to a lesser degree than does the artifact. The concept of systems in organizations does not address the complexities of organizations that share Information Systems or use highly interdependent networked IS in collaboration with customers and partners. These organizations have fluid, permeable, virtual boundaries and many are, in fact, made boundaryless by the use of wireless technologies. Any claim laying should be to Information Systems that serve organizations rather than to "systems in organizations" [Alter, 2003]. Information systems may, in fact, exist completely outside of the organization (e.g. Web based information systems only require Web access and a browser on the user's computer). The complex, highly integrated, information systems of today which may no longer be surrounded by easily defined physical boundaries or may even serve organizations without boundaries are redefining what we understand as an organization.

V. CONCLUSION

Building a theoretical meta-model within which to examine Information Systems is a challenge because of the diversity of IS and the heterogeneity of individuals designing, building, using, and studying these systems. However, this very diversity is also a strength which facilitates the rapid changes in and growth of IS. The innovative, large scale, complex systems of today are also the result of the diversity of the collective and the evolving role of the user as defined by software engineers.

Can we even be considered a new collective? The velocity of change, acceptance, and adoption of IS and IT belie their rather short historical time frame. The chronological age of computing can hide the real speed of development and depth of IS penetration and acceptance in our society. The 40 or more years of IS/IT history does not communicate with any degree of accuracy the degree of integration of computing into the way we think and live. The diversity of the people who design, build, and study IS helps foster the innovative and novel ways Information Systems are constructed and used.

Based on the massive investment by the private sector both Information Systems and Information technology can be viewed as cognitively and socio-politically legitimate. The private sector has also learned how to manage and apply technology innovatively. By taking a broad systems engineering approach, by disseminating the many results of the research we already completed, and by undertaking new research to increase the economic value of our work, we can as academics contribute to the future growth of the Information Systems field.

Editor's Note: This article is the first in the series titled *The IS Core*. At the time of publication, the papers in this CAIS series included Articles 31 through 41 and the editorial in Article 42. These articles were motivated by Benbasat and Zmud [2003] in the MIS Quarterly and by Article 30 [Alter 2003] in this journal. The article was received on September 18, 2003 and was published on November 24, 2003.

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U.S. Department of Commerce, Bureau of Economic Analysis (Sept. 2002b), Table 2.7. Historical-Cost Investment in Private Fixed Assets; Equipment, Software, and Structures; by Type. http://www.bea.gov/bea/dn/faweb/FATableView.asp?SelectedTable=54&FirstYear=1996&LastYear=2001&Freq=Year)(Current November 6, 2002).

APPENDIX I. HISTORICAL DATA

Table A-1. Historical-Cost Investment in Private Fixed Assets; Equipment, Software, and Structures; by Type

[Millions of dollars] 1959-1969

Year	**1959**	**1960**	**1961**	**1962**	**1963**	**1964**	**1965**	**1966**	**1967**	**1968**	**1969**
Industrial Equipment	8410	9290	8726	9184	9937	11335	13591	16038	16835	17198	18935
Transportation	6300	6474	5838	7565	7012	8473	10768	11338	11361	15323	16246
Other Equipment	7641	7184	7199	7701	8972	10111	11385	13100	12651	13447	14841
Information processing equipment and software[11]	4021	4854	5217	5639	6401	7203	8361	10408	10998	11699	14376
Computers and Peripherals	20	192	261	347	735	928	1164	1698	1868	1924	2441
Software	11	104	137	180	347	433	541	813	953	1094	1505

Source: U.S. Department of Commerce, Bureau of Economic Analysis (Sept. 2002b), Table 2.7.

[11] The major category of Information processing equipment also includes communications equipment, instruments, photocopy and related equipment, office and accounting equipment.

Table A-2. Historical-Cost Investment in Private Fixed Assets; Equipment, Software, and Structures; by Type [Millions of dollars] 1970-1980

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Industrial Equipment	20196	19294	21284	25905	30575	31245	34052	39395	47509	55916	60487
Transportation	13017	15343	19264	23681	23339	22158	26323	35408	43252	48612	42277
Other Equipment	16054	16576	19367	23686	26719	29070	31795	38666	46423	52608	52243
Information processing equipment and software	16347	17095	19246	22945	26730	28156	32330	38491	47805	58125	69059
Computers and Peripherals	2722	2774	3435	3504	3836	3563	4374	5624	7291	10018	12404
Software	2004	2199	2778	3220	3912	4780	5204	5476	6570	8664	10658

Source: U.S. Department of Commerce, Bureau of Economic Analysis (Sept. 2002b), Table 2.7.

Table A-3. Historical-Cost Investment in Private Fixed Assets; Equipment, Software, and Structures; by Type [Millions of dollars] 1981-1991

Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Industrial Equipment	65203	62268	58649	68028	72267	75345	76093	83472	93013	91808	89037
Transportation	44216	39399	46463	53812	58543	60649	55642	61163	54492	59037	74840
Other Equipment	59332	53902	52624	61267	62898	63806	68092	73537	84743	86137	77303
Information processing equipment and software	81708	88584	100395	121166	130314	136998	140932	154747	171772	174920	180186
Computers and Peripherals	16928	18871	23891	31609	33734	33410	35762	37957	43092	38644	37704
Software	12931	15417	17976	22051	25625	27755	31373	36745	44416	50153	56589

Source: U.S. Department of Commerce, Bureau of Economic Analysis (Sept. 2002b), Table 2.7.

Table A-4. Historical-Cost Investment in Private Fixed Assets; Equipment, Software, and Structures; by Type [Millions of dollars] 1992-2001

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Industrial Equipment	91598	100827	112202	127343	135044	139525	145778	148762	163040	156902
Transportation	78955	86481	104609	111358	120884	128292	139788	166297	162858	139555
Other Equipment	78973	90191	98474	106386	114009	127644	140629	142661	150291	147306
Information processing equipment and software	196910	214390	233025	261184	286420	324290	362339	401279	445674	403096
Computers and Peripherals	43580	47153	51274	64567	70860	79625	84156	90415	93333	74172
Software	60794	69392	75471	83543	95140	116454	140050	162487	179362	180409

Source: U.S. Department of Commerce, Bureau of Economic Analysis (Sept. 2002b), Table 2.7.

ABOUT THE AUTHOR

Donna Dufner is associate professor in the Department of Information Systems in the College of Information Science and Technology at the University of Nebraska at Omaha (UNO). She received her Ph.D. from Rutgers University in management (computer and information science) in 1995. Her over 12 years of industry experience in telecommunications, and information systems design, development and implementation included working for corporations such as AT&T, Chemical Bank Corp., Ardis (a joint venture of IBM and Motorola), and Bell Atlantic Nynex. Dr. Dufner's research is published in such journals as the *Journal of Group Decision and Negotiation*, the *Journal Of Organizational Computing*, *Communications Of AIS*, And *Public Productivity And Management Review*.

Communications of the Association for Information Systems

ISSN: 1529-3181