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1.Introduction

In this paper, we use an evolutionary economic framework on knowledge management to make a first assessment of Swedish production of "embedded software". The assessment starts by reviewing definitions and measurement techniques of software production. The reviews objective is to capture statistically relevant dimensions of software production in different countries to offer a first approximation of Swedish software production. In this paper, we focus on one type of software production, namely "embedded software", and propose to measure it thanks to aspects of knowledge assets in vertically integrated industries. Our suggestion in this paper is to treat Swedish "embedded software production" within a classical product cycle model (Vernon, 1966). From that point of view, one can derive some characteristics relevant to industrial sectors. This paper limits itself to the link between "embedded software" and "industrial sectors" leaving the location dimension of software production for another paper[1]. Here, one considers (1) basic evolutionary economic characteristics on the linkage between vertical integration of the manufacturing industry and the measurement of embedded software, (2) measurement boundaries of software production regarding the existing indicators in the US, OECD and Sweden. (3) descriptive statistics on the Swedish software expenditure per industrial sectors.

[1] One relevant and related question to this vertical integration of the manufacturing industry producing software is the "linkage economies". Those economies are part of firm's control of multiple value chain development activities. "Linkage economies" are particularly relevant to software since they take place in diverse national and international locations.

2. Embedded software, vertical integration of knowledge intensive industries

Recent research in software production (Arora *et al*. 2008) shows that the US are the leading exporters of software, concentrating software patent and inventions, benefiting from a high stock of skilled programmers and benefiting from the agglomeration of competitors and complementors. In Europe, Sweden is second (after UK) in ICT investment (including IT & communication equipment and software) reaching 25% of the share of the total fixed non-residential investment in 2005-7 (OECD, 2009: 48). Sweden exports more software products than it imports (OECD, 2004, table C.1.8). Nevertheless, Sweden spend 1,7 % of its GDP in software. What is less known is that Sweden leads with Canada in the production of in-house software (1 % of its GDP) (Ahmad, 2003). It is not far-fetched to consider that some of its "in-house" software is partly "service" software and partly "embedded in machines" software. Here, we are touching upon Sweden's industrial characteristics where like Japan or South-Korea, it shares similar tradition in electro-mechanics, manufacturing automotive and telecom (PCAST 2007). This differentiates its software toward custom and embedded solutions (Vinnova 2007, Norgren *et al*. 2007).

A review of software production comprises several types of software such as (i) packaged software, (ii) custom software, (iii) embedded software and (iv) games. Software's characteristics are heterogeneous both in types (products as well as process) and across industries. Software embodies knowledge and expertise from several areas (manufacturing, hardware, software, consultancy and services) embodied into complex product or "stacks" made of modules and components designed by different suppliers in different locations (Arora, 2001). For this appraisal, we want to focus on one type of software, namely "embedded software". In this paper, we embrace OECD definition of "embedded software (Lippoldt & Stryszowski, 2009: 40):

> "Embedded software generally resides on a long-term basis in hardware units other than computers, where it is used to control various product components. In contrast to software operating, for example, on a standard desktop computer, such software is almost never directly manipulated by a user, though user input may be required to specify actions or select options among the various functionalities. That is, such software is usually self-contained and not subject to user modification. Consequently, it must be "extremely reliable, very efficient and compact, and precise in its handling of the rapid and unpredictable timing of input and outputs" (Dallas Univ.). Embedded software is on the way to become ubiquitous in modern economies, being found in a very broad range of electronic products and systems. Examples of industries with particularly heavy use of embedded applications include the automobile industry, mobile phones, robotics, telecommunications systems, medical devices and consumer electronics."

According to this definition "embedded software" is ubiquitous and pervasive in many of the hardware produced. Theoretically speaking, one needs to make a series of remarks regarding the link between "embedded software" and the Swedish industry. First, although software can be easily classified as a creative industrial sector in itself, it will not be the main avenue will take to describe Swedish embedded software. Howkins (2001) suggests that dimension characterising "creative industries" should be taken into account. When dealing with software, we should see if there is any "significant copyright, patent, trademark and design activities". Second, if "embedded software" is incorporated within machines, we have to give a particular attention to all relevant industrial sectors developing software. Third, we need to provide a first characterisation of those industrial sectors.

For that matter, we found evolutionary economics view of knowledge management particularly relevant. According to Nelson & Winter (1982), Cantwell & Santangelo (1999) and Maskell and Malmberg (1999), knowledge transfer from one activity to another is particularly efficient within the firm. Those "linkage economies" are particularly relevant to vertically integrated industrial sectors where production depends heavily on organization and control. Mudambi's (2008) work on knowledge-intensive industries is particularly relevant for us. He suggests that in industries like the mobile phone industries, one can consider firms to generate significant benefit from (a) vertical integration where their advantage is to control the value chain, (b) "linkage economies" including different levels of vertical integration and (c) comparative advantages of geographic locations with their own resources and competencies.

In this appraisal, we will see how we can capture embedded software for industries who consider their main benefit is in controlling their product's value chain. We start by reviewing the US different statistical bureau, then the OECD and then some characteristics of the Swedish industry to tentatively considering a method for measuring Swedish production of "embedded software".

3. Measurements of software production

In the US, Parker & Grimm (2000) and Grimm *et al*. (2002) confirm that software innovation is taking place beyond the software sector strictly speaking (Lippoldt & Stryszowski, 2009: 55). They show that "in-house" software is a major driver of software development across sector. The exact quantification of such software remains a major challenge. Estimate suggests that 20 to 40 % of the software production may resort from software developed from firm's own needs. Custom software according to the same estimate could present 40 to 5+ % of software produced by software service providers. Let us start by considering (1) the US BEA way of calculating software output, then (2) the OECD to (3) draw some conclusion on the approach we may adopt regarding the study of Swedish software and innovation.

3.1. The BEA on software investment

I will pass on the historical evolution of the BEA ways to calculate software, although it contains valuable information about the way agencies needs to adapt their categories to the change of technology. I will consider software after 2000 (Grimm *et al*. 2005). In the BEA stats, the contribution of IP (information processing) equipment and software investment decline after the beginning of 2000. It suggested to the BEA to rethink their calculation concerning the contribution of IP equipment and software investment in relation to the GDP which became negative all through 2001 (Grimm *et al*. 2005: 366). Beside the problem of measuring real output in the software area, software and information processing have the inconvenience of being constantly evolving products. One way to deal with the problem is to estimate software production from a supply-side approach. It proposed mainly three techniques: (1) the commodity flow method and (2) the demand side approach and (3) software price index.

3.1.1. The commodity flow method:

The commodity flow method is looking at the supply side of software, i.e. tracing the commodities from their production or import to their final purchase (Wasshausen, 2006: 100). It provides details information of the commodity composition of investment. As Grimm et al. (2005) suggest, the strength of the supply approach is that it draws on a detailed commodity classification (covered by census) and the rigor of "input-output" production and commodities usages. The data of the US census allow to have detailed information of the commodity compositions of investment (intermediate, private investment, consumer, exports and government expenditures). But those information on investment are not really industry sensitive since we cannot trace them back to particular industry of class of purchaser. The BEA prefers the commodity flow method because it relies on (1) the strength of domestic and import supply data and (2) additional details on the types of assets (not available in capital expenditure surveys.)

3.1.2. The demand-side approach:

The demand-side approach is essentially assessed with capital expenditures survey. The US ACES (Annual capital expenditure survey) is capturing the capital expenditure by industry but not by type of investment. Survey of expenditure by type of investment are done by a complementary survey ran every 5 years (1998, 2003, 2008 should be the last one). Another survey, the NIPA (National income and product accounts), one can find the supply-side by reported as total investment and investment by type.

In US statistics, a problem of classification of software arises when considering information processing and software from the viewpoint of capital expenditure by industry. Problem of inconsistent estimator may arise since not all business classify software as a capital expenditure[2]. In US statistics, commodity flow method is not related to estimates of software investment. For example, in the investments statistics, "own account software" is measured as the sum of production costs (it includes employee compensation (wage and others) and the costs of intermediate inputs.) The commodity flow method estimates "own account software" based on the number of programmers and computer systems analysts engaged in the production of software. The way to assess the number of embedded and packaged software is assessed from the total number of programmers and computer systems analysts by limiting the maximum shares of employment to a maximum of 0.2 percent of the total employment in the industry.

[2]It results that US statisticians have to take into account understatement in capital expenditures in information technology and software as reported by the US bureau of census' ACES (Annual capital expenditure survey) and the Bureau of economic analysis' NIPA (national income and product accounts). For example, in 1988, this difference registers in information processing equipment and software 363.4 bill$ for NIPA against 183.6 bill. $ for ACES and in prepackaged and custom software, we obtain 92.2 bill. $ with NIPA and 11.8 bill. $ with ACES. (Grimm et al. 2005: 370). For more details issues on obtaining own-account software investment for business and government, see Parker & Grimm (2000) "Recognition of business and government expenditures for software as investment: methodology and quantitative impacts, 1959-98.

In the US software production, this limiting effect[3] touches industrial sectors such as mining, durable and non-durable goods manufacturing, and business services. Within this framework, the US statistical agencies are committed to improve the categories of analysis notably regarding the current dollar estimates of "private fixed investments in IP equipment and software", "prices indexes of own account and custom software"[4].

3.1.3. Price indexes

Price indexes are used to assess current dollar private fixed investments in information processing equipment and software. Quantity and prices are compiled within an index (taking 1996 as a year of reference). For software, the Bureau of Labor Statistics (BLS) established computer price indexes (Wasshausen, 2006). They estimate the investment index for three categories of software with annual and quarterly estimates.

Table 1: Estimating software investments by types

US Software 1999		
Component	Current dollar share	Deflator
Prepackaged	0.340	PPI (producer price index) for prepackaged software applications with a - 3.15 percent per annum bias adjustment
Own-account	0.333	BEA (Bureau of economic analysis) input cost index consisting of compensation cost indexes and an intermediate inputs cost index
Custom	0.327	BEA price/cost index reflecting weighted average of prepackaged and own-account percent changes

Source: Deflators to construct real private fixed investment in software in Grimm *et al*. 2005: 377.

In the US stats, software was considered as a fixed investment until 1999[5]. The BEA developed hedonic price indexes for 2 types of prepackaged software (spreadsheets and word processing). The price index, *P*, can be explained as follow:

$$\text{Ln}\ Pt = \beta 0 + \beta 1\ Qt + \mu$$

where *Q* is the independent variable denotes software quality characteristics in year t, $\beta 1$is the estimated parameter and μ is the common error term.

The BLS and census bureau are working on improving estimates for purchased

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[3]If the number of programmers and computer analysts in those industries goes above the 0.2% prescribed, it is assumed that they are engaged in the production of packaged or embedded software. Those estimates are adjusted with a factor of 0.5 to account for programmers and analysts' time spend on new software investment rather than software revision, upgrades and maintenance. It is also adjusted with national median wage rate of those occupations (see Grimm *et al*. 2005: 374-5 and 387-8).

[4]The BEA creates its price index for custom software from the weighted average of price index for business own-account and prepackaged software. BEA investigates to use the "function points" metrics to estimate prices index of own-account and custom software.

[5]Price index correction method shave been developed. The BLS combines BEA developed hedonic price indexes and the Oliner-Sichel matched-model indexes.

software, own-account software. For example, own-account software is an estimation of cost of production based on wage costs. Before 1992, the BEA did not consider software as investment but as intermediate consumption. In the estimation of purchase of embedded software, the statistics use the original equipment manufacturer (OEM). In this statistics, one find annual detailed company revenue reports and some firms reports information on embedded software in equipments. Other estimates are used to create statistics on own-account software [6] The interesting point of BLS is to count the number of computer system analysts (excluding computer engineers and computer scientists) in order to get a better measure of the number of people who are actually engaged in the creation of own-account software.

To improve the price index for own-account and custom software, the BEA is considering to refine the software input cost. In the case of custom software which is a mix of new software and existing programs and modules, the price index is the weighted average of the price index of business own-account and prepackaged software. This is in line with 1993 EC commission on system of national accounts.

The preliminary remarks one may reach regarding the American experience are: In general, "prepackaged" and "custom" software productions have the main revenue share of the US software industry. For our own interest in Swedish software production, we look at: 1- The commodity-side approach is using instruments that include production, import and purchase. One tool worth using in the perspective of vertically integrated industries is firm's investment in software types (originally based on the commodity types of investments). The survey on investment is delivered by type of industry (and not by type of investment). The commodity-side approach privileges the number of programmers and system analysts involved in the production of "own-account software". This approach is compatible with the evolutionary economic approach of knowledge management. Consequently, those are elements we will be using ti identify Swedish embedded software production.

2- In the demand-side approach, the US statistics consider "information processing and software" as a capital expenditure. There is problem of consistency in the data regarding software since not all industries count software as capital expenditure. In the Swedish data, this variable is not available as such. 3- The US statistics' assessment of "own-account" software is calculated essentially indirectly through an index of input cost[7]. Both "compensation rates for computer programmers and systems analysts" and a definition of "intermediate inputs" of their work could be part of the definition of firm's specific knowledge. Those aspects seem valid for "own account software" as well as "embedded systems" or "embedded software". Let us turn now toward the OECD studies on software accounts in national accounts.

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[6]See Grimm *et al.* (2005: 388). Other decisions to specify this estimate are: 3 digits of employees creating software (rather than sold software and sold goods with software bundled.) The BLS also estimates the means wage of the computer programmers and computer system analysts by industry. The census bureau publishes total costs and wage costs for custom and prepackaged software industries. New treatment of "own account" software is to consider software produced as a fixed asset with a expected life service. Copies are also an asset. It demands to measure 2 assets: the original software and the copies. Both are registered under investment in 1993 Systems of National Accounts.

[7]The index is calculated from a "weighted average of the percentage changes in the compensation rates for computer programmers and system analysts and in the intermediate inputs associated with their work".(Moylan, 1991: 5)

3.2. The OECD and software

The OECD has been concerned to deal with software accountancy for national accounts in the perspective of international comparisons (Pilat, 2004, 2006). We review OECD main characteristics in measurements, i.e. (a) software in industrial classification, (b) intangible investment, (c) product and process innovation, (d) acquisition of machinery and (e) software and R&D.

3.2.1. Software in standard industrial classification

Software is both a product of the computer services industry and a process for those companies which acquire and use it. * Software products reported by the United Nation (UN, 1990) It included updated version of software product and distinguished between package software, custom software, application software and systems, and user software. * Software consultancy and supply industry is identified in a subgroup 722 of the division 72 "computer and related activities" of ISIC Rev. 3 (NACE Rev. 1). The other components are hardware consultancy, data processing, database activities and other computer-related activities (UN: 1990).

3.2.2. Software as intangible investment

According to the System of National Accounts (SNA) computer software (computer programs, program descriptions and supporting materials both systems and applications software) that an enterprise expects to use in production for more than one year is treated as an intangible fixed asset. Such software may be purchased on the market or produced for own use. The acquisition of this software is treated as gross fixed capital formation. The SNA gross fixed capital formation also includes the purchase or development of large data bases the firm will use in production over a period of more than a year.

3.2.3. Software and innovation

The OECD is basically treating software along the line of technological innovation. It comprises new products and processes and significant technological changes of existing product and processes. An innovation has been implemented if it has been introduced on the market (product innovations) or used within a production process (process innovation). Innovations therefore involve a series of scientific, technological, organizational, financial and commercial activities (OECD, 1992). On the product side, the OECD distinguishes between the major, incremental innovation and product differentiation. On the process side, OECD distinguishes between the acquisition and the introduction of software which is new (to the firm, industry or country) and that which is not significantly different from that already in use[8]. The OSLO manual (vs. 2005: 48-9, § 156 & 163) give some additional indication on the treatment of software: * Software considered as an auxiliary to product innovation: product innovation is the introduction of good or service, new or significantly improved with respect to its characteristics or intended uses. it includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. * Software as an auxiliary to process innovation: process innovation is the implementation of a new or significantly improved production or delivery method. It

[8]Not all intangible investment in software counts as an innovation, notably the purchase of copies of programs in use or minor upgrade.

includes significant changes in techniques, equipment and/or software. Production and delivery methods, creation and provision of services, support activities (purchasing, accounting, computing, maintenance) includes or are assisted by software.

3.2.4. Acquisition of machinery, equipment and other capital goods:

Capital goods for innovations (OECD 2005: 93, §327 & 330) are composed of acquisition of land and buildings, of machinery, instruments and equipment and, in line with the revised System of National Accounts (SNA) of computer software, which is a component of intangible investment and considered as capital formation. Computer software (in line with the revised SNA) includes computer software, programme descriptions and supporting materials for both systems and applications software for use in product and process innovation activities of the firm. It also includes the acquisition, development or extension of computer databases expected to be used for more than one year in product and process innovation activities of the firm.

The development and use of software in innovation activities:

The development, acquisition, adaptation and use of software pervade innovation activities (2005: 97, § 350). Developing new or substantially improved software, either as a commercial product or for use as an in-house process (an innovation of its own right), involves research and experimental development and a range of post-R&D activities. In addition, all types of innovations may involve the acquisition and adaptation of software; the software is not an innovation in itself. But it is required for the development and implementation of innovations.

3.2.5. Software in R&D:

Software development (OECD, Oslo 2005: 92, § 319) is classified as R&D if it involves making a scientific or technological advance and/or resolving scientific/technological uncertainty on a systematic basis. Services development is classified as R&D if its results in new knowledge or involves the use of new knowledge to devise new applications. The OECD has a classification of R&D that includes more systematically services R&D (Young, 1996: 9). According to an 1995 OECD survey, it looks at how to report software in the R&D expenses. In 1995, Sweden was a low spender of R&D in services (under 10% of the whole BERD (Business Entreprise R&D) spending, see table 2 below).

Table 2: OECD impact of survey coverage on the level of services R&D in business enterprises

Level of spending on Services R&D	High services R&D spender: over 15% of BERD	Medium R&D spender: about 10% of BERD	Low services R&D spenders: under 10% of BERD
Countries	UK, Denmark, Spain, Portugal, Greece, Iceland, US,	Ireland, Italy, Netherland, Finland	Germany, France, Belgium, **Sweden,** Switzerland, Japan.

Source: Young (1996: 10) "Measuring R&D in the services", simplified version.

In the 1997-2006 period, Statistics Sweden shows that R&D in private manufacturing still dominate (even if we do not count the service R&D done within those manufacturers). In the table 3 below, reporting data from 1995, the largest share of R&D spending (92,1 percent) in the private enterprises is in the manufacturing sector (see table 3 below). In 2009, Statistics Sweden reports that Business sector R&D totaled SEK 78.6

billion. Those R&D spending are highly concentrated in the pharmaceutical industry, industrial electricity, computing and optical equipment and the vehicle manufacturing industry. They represent 53 percent of all R & D expenditures, sharing the highest R&D intensity together with dedicated R&D firms in relation to net sales.

Table 3: R&D in the business enterprise sector

Main industry group in 1993	agriculture	mining	manufacturing	utilities	construction	services
Industrial value added as % of the total industry	2.9	0.4	25.7	4.2	8.1	58.7
R&D in the BERD sector	1.1	0.3	92.1	1.3	..	4.4

Source: OECD, National accounts database, February 1996 (for industrial value added). OECD, DIRDE database, February 1996; DSTI/EAS Division (for R&D in BERD) in Young (1996: 34-5).

To conclude on OECD's statistics about software:
1- Software is rightly distinguished between product or process, but made difficult to distinguish in practice due to a lack of correlation with industrial sectors. Software is considered as a firm's activity rather than a sector output. For example, in the BERD, statisticians include software in firms' R&D with those that are principally engaged in computer services. Regarding the firm in other industries, their software R&D is indistinguishably reported in the global R&D of the industry concerned.
2- We suggest that counting software in total R&D spending introduces a statistical bias in the accountability of the total software production. The classification under the overall R&D spending is omitting two dynamic characteristics of software: (a) software as a knowledge asset differentiated by types of scientific or technological services. (b) Software as firm specific making it belongs to sector vertically integrated industries (Lööf & Hesmati, 2002).

4. Embedded software in Europe

A consulting firm (PAC- Pierre Audoin Consultants) reported in their study of "the European Software Industry" (2009: 171) that software intensive systems are the invisible part of the industry. This study defines "software intensive systems" very much in the same terms than OECD researchers Lippoldt and Stryszowski (2009) cited above. It considers software intensive system to be "any product or services whose functionalities are dependent[9] upon software or even defined by it." Example of those systems are numerous: electronic control units in car and trucks, operating systems and API in mobile phone, process software in digital TV. Those software define the attributes and functionalities of many of our products and services today. The value of software intensive systems is therefore not accounted within the software industry but generally reported in the activities of the vertical industries. Software intensive systems are mostly used internally to a process (like robotics) or bundled within products (mobile phones).

[9]"Dependent" means that the product will not function without the software or in a very different way.

Table 4: Estimates for 2007 of Software R&D effort worldwide (PAC 2009: 172-3) - manufacturing

2007	worldwide market size in € billion	R&D level (share of revenues)	Software R&D expenses as a percentage of total R&D	Software intensity (€ billion)
Aerospace	350	6%	39%	8.2
Automotive	1550	5%	27%	20.9
Consumer electronics	195	7%	50%	6.3
Medical Equipment	193	11%	28%	5.6
Telecom equipment	247	13,5%	57%	19
Total of expenses	40	4%	12%	0.2
	1575			60.3

Source: IDATE based on extirpates form ASD, Eucomed, BERR (ex-DTI), DataMonitor, AIA, ACEA, European Commission for market size and R&D level in vertical industries, and also R&D spending and revenues from top 5 players of each industry.

Table 5: Estimates for 2007 of Software R&D effort worldwide (PAC 2009: 172-3) - services

2007	worldwide market size (billion of EURO)	R&D lelve (share of revenues)	Software R&D expenses as a percentage of total R&D expenses	Software intensity in Billion of EURO
Licenses	187	14,5%	82%	22.2
IT services	400	5%	60%	10.8
Paid Web based	16.3	15%	90%	2.2
Advertising	17.9	12%	90%	1.9
Total	621.2			37.2

Source: IDATE based on estimates form BERR (ex-DTI), PAC, European Commission for market size and R&D level in vertical industries, and also R&D spending and revenues from top 5 players of each industry.

Total software R&D effort (developed internally, contracted or bought) in the 6 manufacturing sectors is almost 3 times larger (€60.3 billions) than software packaged intensity (through licensing) (€22.2 billion). In Europe, manufacturing produced software in the world is 60% more than all software and software based services (including IT services software, paid web-based services and advertising). ICT sectors has stronger share of software intensity than sectors that are not classified under ICT (notably the manufacturing domain automotive, aerospace and medical equipment). The manufacturing sectors are software intensive since many attributes and functionalities of its products and processes depend on software. It is also a tool of differentiation and innovation.

Table 6: Forecast for 2012

2012	worldwide market size in € billion	R&D level - share of revenues	Software R&D expenses as a percentage of total R&D expenses	Software intensity in € billion
Aerospace	375	6.5%	42%	10.2
Automotive	1600	6%	31%	29.8
Consumer electronics	200	7%	55%	7.7
Medical equipment	350	11%	31%	11.9
Telecom equipment	260	13.5%	62%	21.8
Automation	50	4%	13%	0.3
Total	2835			81.6

Source: IDATE (as reported by PAC 2009: 175)

They are substantial differences between Europe level data on software intensive systems. Those differences re-enforce our view about the need to study software embedded systems in direct relation to Swedish industry characteristics (as suggested by the investment data show earlier). The Swedish service and financial sector is certainly important to investigate. This sector will gain at being study with data on spending and investment in software which would characterize "custom software". In the same line of thought, those dimensions could help specify what is meant by "software intensive systems" or "embedded software" in the Swedish industry especially regarding manufacturing and the telecommunication sector.

5. Software and Swedish vertically integrated industries

One way to solve the dilemma of software production from the supply-side is to consider software production according to the Swedish industrial system. Accordingly, one can approach embedded software production by looking at vertically integrated industries. It will lead us to consider how significant is the investment in software by sectors in relation to knowledge intensive industries.

5.1. Innovation in services and manufacturing sectors

According to the IT investment in software in Sweden, two major sectors are implicated: (1) manufacturing and telecommunication and (2) services. In the Swedish industry, software intensive systems are more important than the software industry of products. This is the main structural difference between the US and the Swedish industry. "Software intensive system" is a product or a service which functions depends upon the software. It corresponds broadly to the definition of "embedded system" we provided at the beginning of the paper. We find those software in systems functionalities, system cost, development risk, and system development time (Vinnova, 2007). Those systems are presents in the key industries constituting the backbone of Swedish traditional manufacturing. Notably, pharmaceutics, telecommunication networks, materials and analysis control (automotive and medical machinery). Those systems are defined by standard and their development and other technological opportunities are defined by them. There is also a strong indication that firms are conducting innovation through their suppliers and customers. Those are often the main partners of the firms (Edquist *et al.* 2000). ⅔ of the large firms cooperate for innovation and ⅓ of SMEs do so especially in knowledge intensive business services.

5.2. The Swedish software expenditure by sectors

There are a domination in Sweden of large firms in the performance of the innovation system. In this regard it is interesting to notice that Sweden do not under-perform on the innovation output regarding the turnover due to products "new-to-the-firm". Bitard *et al.* (2005) suggests that if those new- to- the-firm products represent a large percentage of the firms' turnover, then those products may account for large volume of sales. It is either a product that is known largely to the consumers (such a consumers' products - mobile phones and related products) or it is an added dimension to a existing product that does not count as hardware (namely "embedded software").

According to Swedsoft, an industrial interest group[10], if we take 12 most R&D intensive Swedish corporation, 60% of their budget of R&D is dedicated to software development. They estimate that 60 billion of SEK is spend in software R&D per year in Sweden and 75 000 people are working with software and R&D in Sweden. We consider those indicators are strong estimates of the important of embedded software in the Swedish national innovation system. Nevertheless, from the statistical point of view, they are not workable data on which one may built research hypothesis and support research questions on software in Sweden. Let us start with some statistical information regarding the investment structure in software of the Swedish industry.

[10]http://www.swedsoft.se/

Table 7: Expenditure for the purchase of software (investment) in M of SEK, by sector, year.

Software	2007
10-14 Mining industry	..
15-37 Manufacturing	1217
40+41 Electricity, gas-, heat and watersupply	184
45 Construction	59
50-52 Wholesale and retail trade, repair of motor vehicles, household and personal items	824
55 Hotel and restaurant	..
60-64 Transport-, warehousing and communication	1273
65-67 Finance sector	1166
71-74 Rentals- and service to the firm	1616
90+92-93 Cleaning; entertainment, culture and sport; other services to firms	160

Source: SCB 2007.

We see that the main account regarding investment alone in 2007 shows that the service sector is the main investor in software (1616 M SEK), followed logistics, transportation and communication (1273 M SEK) and closely followed by manufacturing (1217 M SEK). It is interesting to notice that investment in software is not necessarily reflecting activities of development with software. For that matter, one better approximation of the issue is reflected in the statistics regarding expenditure of software reported as cost accounting which reflects the allocated budget and actual cost of operations, processes, departments or products.

Table 8: Expenditure for the purchase of software in the form of cost accounting expenses excluding rent and leases, in M of SEK by type of asset, industry and time.

Software	2007
10-14 Mining industry	..
15-37 Manufacturing	3532
40+41 Electricty, gas-, heat and water supply	335
45 Construction	281
50-52 Wholesale and retail trade, repair of motor vehicles, household and personal items	1133
55 Hotel and restaurant	..
60-64 Transport-, warehousing and communication	762
65-67 Finance sector	6068
71-74 Rentals and service to the firm	2792
90+92-93 Cleaning; entertainment, culture and sport; other service to the firm	191

Source: SCB 2007

For 2007, three industrial sectors in Sweden are clearly spending in one form or the other substantial resources in software: (1) the financial sector with 6068 M SEK; (2) manufacturing with 3532 M SEK and (3) service to the firm with 2792 M SEK. There is some indication that software is part of the "servicification" of the manufacturing industry in Sweden (Kommerskollegium, 2010). During the period 1991-2001, "computer and related activities" increased by 192% and represented a relative total share of value-added of 1,65% in the whole Swedish economy. Compare to 1993-2001 period, "the computer and related activities" sector represented the most dramatic growth in value added. It has also the strongest growth in R&D expenditures (index 20 in 1995 to index 120 in 2001). This trend seems to carry on, where during the period 2003-2006, "computer and related activities" represent successively of 3.6% (2003) 6.1% (2004) 7.9% (2005) 6.6% (2006) of all Swedish manufacturing services sales. If one speculates that part of servicing is software based, one would also assume that its development is made in the R&D tradition of manufacturing. It would suggests that products/services range are incremental (and rather imitative) rather than seeking disruption in the market. It also suggests that, manufacturing is dominated by large Swedish firms[11], those firms are working at maintaining their dominance in well established line of product. Those firms work for capitalizing on existing networks of customers.

6. Conclusion: Some suggestions to approach "embedded software" in the Swedish industry

Part of the existing economic tools measuring software show enduring trouble over dimension of product or or process innovation in this sector (Arora *et al*. 2008 & Raduchel, 2006). One solution to this problem is to consider software carefully by types. In this study, we focus on "embedded software" we consider as an intellectual asset in a vertically integrated industries. This allows to link Swedish software production with its relevant industrial sectors. We have learned from spending and investment in software was a reliable evaluation of software, assuming that one has access to such data. Statistics Sweden provides expenditures by sectors.

In line with the evolutionary economics approach of traditional product cycle, one need to draw attention to the basic requirement of software development work, i.e. the source of knowledge and skills starting with the provision of software engineers as programmers or system analysts (nbr. of employees developing software). Since we focus our appraisal on "embedded software" type, one needs to address adjustment variable in line with the industrial sector in consideration. If one concentrate on manufacturing, we suggest to take elements of Swedish manufacturing innovation into account such as firm's characteristics (size and turnover) and innovation effort (in terms of types of cooperation: B2B, business to customers, business to suppliers, business to universities). One of the dimension that needs to be more carefully considered is what Mudambi has called "linkage economies" which we could address tentatively here by looking at product market segment (determined by their location - Sweden, US world). The production function of "embedded software"(es) indicated by spending, S, on software can be explained as follow:

[11]The organization and financing of R&D is dominated by private sector. The large firms of 500 employees or more accounts for 83 % of R&D.

$$S^{es} = \beta 0 + \beta 1 Fm + \beta 2 K + \beta 3 I + \beta 4 M + \mu$$

where *F* is the independent variable of firms' characteristics (size and turnover) in the manufacturing sector m, *K* is the independent variable for knowledge assets (in terms of % of people developing software), *I* is the independent variable for innovation effort (4 types of types of cooperation: B2B, B2C, B2Supp. and B2Univ.) and M is the independent variable for market segments (Sweden, US, the world).

This basic model should be improved by taking in our investigation of "embedded software production" aspects of international production locations (Melchior 2011). This is in line with Vernon's basic product cycle notion (1979) and developed into Mudambi (2008) "linkage economies" revealing significant correlation with world-wide sites of productions.

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