Measuring Capital and Technology:
An Expanded Framework

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ABSTRACT

Business outlays on intangible assets are usually expensed in economic and financial accounts. Following Hulten (1979), this paper develops an intertemporal framework for measuring capital in which consumer utility maximization governs the expenditures that are current consumption versus those that are capital investment. This framework suggests that any business outlay that is intended to increase future rather than current consumption should be treated as capital investment. Applying this principle to newly developed estimates of business spending on intangibles, we find that, by about the mid-1990s, business investment in intangible capital was as large as business investment in traditional, tangible capital. Relative to official measures, our framework portrays the U.S. economy as having had higher gross private saving and, under plausible assumptions, fractionally higher average annual rates of change in real output and labor productivity from 1995 to 2002.

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I. INTRODUCTION AND BACKGROUND

The last two hundred years have witnessed dramatic gains in the standard of living in the United States, driven by the technological innovations introduced by the Industrial Revolution and carried forward by the evolution of technology since then.   This evolution is reflected both in the development of new products (electric lighting, automobiles, open-heart surgery) and in the improved efficiency of production processes (the assembly line, just-in-time inventory controls, computer-aided design). Growth economists have undertaken the important task of quantifying these developments and of sorting out the relative importance of the factors that drive sustained increases in real output. This effort has increased in recent years with the debate over the "new economy" and the question of whether living standards will continue to rise at the accelerated pace of the late 1990s.

The "sources of growth" model has been the main empirical tool in tracking and explaining growth trends. This model, developed in the 1950s and 1960s by Solow (1956, 1957, 1960), Kendrick (1961), Denison (1962, 1964), Jorgenson and Griliches (1967, 1972), and others, allocates the growth rate of measured output to the growth rate of labor and capital inputs, each weighted by their share of output, and a residual factor associated with the efficiency with which output is produced from a given set of inputs ("total factor productivity," or TFP). A large academic literature has evolved using this framework, reviewed recently in Hulten (2001), and TFP has become an official statistic produced regularly by the Bureau of Labor Statistics (BLS). An updated version of the BLS decomposition is shown in the upper half of table 1, which indicates that output per hour worked rose about 1-1/4 percentage points per year faster since 1995 than it did during the period of lackluster growth from 1973 until then. These figures have lent support to the "new economy" view about prospective growth trends.

1

Although great progress has been made in applying the sources-of-growth framework to the analysis of economic growth, doubts have nevertheless been raised about our ability to understand and measure fully the fundamental sources of growth. For example, despite several decades of rapid technological advance in information technology, one of the originators of the sources-of-growth model, Robert Solow, famously remarked in 1987 that "you see the computer revolution everywhere except in the productivity data." Alan Greenspan observed about 10 years later that many services industries displayed implausibly negative trends in measured productivity despite being among the top computer-using industries.[1] Also, Nordhaus (1997) concluded from his analysis of the history of lighting that official price and output data "miss the most important technological revolutions in history." The recent debate over the accuracy of the consumer price index has raised similar questions: Studies have shown that the failure to capture the full effect of improvements in product quality and the benefits of new goods and services created an upward bias in the CPI of more than 0.5 percentage point (Lebow, Roberts, and Stockton 1994; Advisory Commission to Study the Consumer Price Index 1996; Shapiro and Wilcox 1996) and implied a corresponding downward bias in the rate of increase in the consumption component of total real output.

Some of the foregoing concerns can be traced to problems inherent in the data used to study economic growth, but many key data concerns have been addressed in relatively recent work at the major statistical agencies. These include, among others, the renewed emphasis on

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[1] Chairman Greenspan's concerns about the measured productivity trends in services industries were first expressed in remarks at an FOMC meeting in late 1996 in regard to a staff analysis of disaggregated productivity trends (Corrado and Slifman 1999). A BLS study reached a similar conclusion (Gulickson and Harper 1999).

The observation that many of the services industries that had negative productivity trends were among the top computer-using industries owes, at least in part, to Triplett (1999); see also Stiroh (1998) and Bosworth and Triplett (2003).

quality change in the measurement of prices at the BLS, the capitalization of software

expenditures by the Bureau of Economic Analysis (BEA), and the expanded coverage of service

industries by the Census Bureau. However, no parallel theoretical advance has emerged, within

or beyond the sources-of-growth framework, to guide further empirical advances and tell us

what we need to know to understand economic growth in the "new economy."

The first goal of this paper is to expand the conceptual framework of the sources-of-

growth model by linking it to a variant of the standard model of intertemporal choice developed

in Hulten (1979). In the expanded framework, the determination of what expenditures are

current consumption and what are capital investment is governed by consumer utility

maximization, and any outlay that is intended to increase future rather than current consumption

is treated as a capital investment. When this deferred-consumption rule is applied to one of the

most important "new economy" questions--whether business intangible outlays and knowledge

input should be expensed or capitalized in national accounting systems--an unambiguous answer

is obtained: There is no basis from the consumers' point of view for treating investments in

intangible capital differently from investments in plant and equipment, or tangible capital.[2]

We then turn to the question of how much difference the theoretically appropriate

treatment of intangible capital might make to the productivity estimates shown in table 1.

Competing approaches have emerged in the current literature on the measurement of intangibles.

One prominent approach uses the value of securities, primarily stocks, to infer the quantity of

intangible capital held by U.S. corporations to help interpret recent changes in productivity (Hall

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[2] The focus of this paper is on the macroeconomic debate over role of intangible capital in the growth
process. There is a parallel debate in the financial accounting literature over the expensing of intangibles
(Lev 2001 and Blair and Wallman 2000). Although the objectives of growth accounting differ from those
of financial accounting, the macroeconomic symmetry principle applies at the firm level as well.

2000, 2001a, 2001b).[3] Our work, however, follows another branch of the literature. Rather than appealing to the stock market, we pull together disparate pieces of spending data and related evidence to gauge the plausible magnitude of the additional business investment (and thus GDP and output per hour) if expenditures on intangibles, or knowledge capital, are treated symmetrically with investments in traditional fixed capital. The estimates we develop build on the studies by Nakamura and others who have examined the undervaluation of measured business investment and capital in the late 1990s (Nakamura 1999, 2001, 2003; Brynjolffson and Yang 1999; Brynjolffson, Hitt, and Yang 2000; McGratten and Prescott 2000), as well as earlier work sponsored by the OECD (OECD Secretariat 1998).[4]

Our effort differs from previous work, however, by applying the theoretical classification and accounting principles that follow from the expanded framework we introduce in the next section. Not only does this framework lead us to cast a wider net to identify the possible components of business investment in intangibles, but it also leads us to distinguish spending flows that generate relatively long lasting revenue streams from those whose returns dissipate too quickly to count the associated asset as fixed capital. The latter consideration has not been an explicit aspect of others' efforts to gauge the plausible undervaluation of business investment. We also are careful to separate assets that are already included in the national accounts from those that are not.

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[3] The link between productivity and stock market performance has been examined in earlier literature (e.g., Baily 1981, B. Hall and R. Hall 1993), and financial data have long been used to value R&D and patent assets to construct intangible stocks at the firm level (e.g., Griliches 1981, Cockburn and Griliches 1988, and B. Hall 1993). The recent popularization of this approach is not without its critics, however; see Bond and Cummins (2000).

[4] See also J. Cummins [this volume] for an alternative approach to valuing intangibles based on adjustment costs.

All told, our framework for the economic measurement of capital suggests that, if

business intangibles are fully recognized in national accounting systems, the move will

significantly change measures of economic activity. We estimate that spending on long-lasting

knowledge capital--not just intangibles broadly--grew relative to other major components of

aggregate demand during the 1990s. As a result, our estimates show that, by the end of the

decade, business fixed investment in intangibles was at least as large as business investment in

traditional, tangible capital. When the unrecognized portion of this spending is viewed in

relation to existing measures, our framework portrays the U.S. economy as having had higher

gross private saving and, under plausible assumptions, fractionally higher average annual rates

of change in real output and real output per hour, particularly from 1995 to 2002.

II. THEORY.

II-A. The Production Function Approach to Growth Accounting

Contemporary growth accounting is organized around the concept of the aggregate production

function. Aggregate real output is assumed to be related to inputs of labor and capital via an

aggregate production function, with provision for changes in the productivity of the inputs.

When efficiency change has the Hicks-neutral form, the production function can be expressed

as:

$$(1) \qquad Q_t = A_t F(K_t, L_t),$$

where Q_t denotes real output, K_t and L_t are capital and labor, and A_t is an index of the level of

total factor productivity. In econometric studies of growth, the production function is given a

specific parametric form, and the parameters of $F(\cdot)$ are then estimated using a variety of

techniques. In the index-number (nonparametric) approach of Solow (1957) and Jorgenson and

Griliches (1967), the growth rate of output is equal to the shared-weight growth rates of labor and capital:

$$(2) \quad g_Q = s_K g_K + s_L g_L + g_A.$$

(the g-terms are growth rates, and the s-terms are factor shares). Under constant returns to scale and marginal-cost pricing, Solow showed that the factor shares are equivalent to output elasticities, and the term g_A was associated with a shift in the production function in equation 1 (illustrated as the move from <u>a</u> to <u>c</u> in figure 1), while $s_K g_K + s_L g_L$ was a movement along the function (<u>c</u> to <u>b</u> in the figure). Each item in equation 2 can, in principle, be estimated from national accounting data, except for the growth rate of total factor productivity, g_A, which must be inferred as a residual--Abramovitz's famous "measure of our ignorance."

The sources-of-growth equation is the basis for the estimates in table 1, which are expressed in labor-productivity terms, i.e., $g_Q - g_L = s_{K(g_K - g_L)} + g_A$.[5] The estimates in this table highlight the slowdown in productivity growth in the early 1970s and the pickup in the mid-1990s. The table also reveals the important role played by TFP in these swings in productivity growth. The acceleration in labor productivity since 1995 has generated the "new economy" view that the U.S. economy has entered an era of higher productivity growth. As can be seen in the table, the 1-1/4 percentage point improvement in labor productivity growth after 1995 was driven both by a pickup in TFP and by the increased capital deepening of IT equipment and software.[6]

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[5] This variant follows from equation 2 under constant returns to scale, in which case $s_K + s_L = 1$ and g_L is subtracted from both sides of the equation.

[6] Table 1 shows data on actual productivity growth through 2002. Because the table shows actual data, the averages shown over selected periods reflect changes in factor utilization as well as the underlying trend pace of growth.

The potential importance of investment in intangible assets is borne out by the lower panel of table 1, in which the sources of growth estimates exclude the effect of capitalized software (i.e., they exclude investment in software as a component of both output and capital input). Here the pickup in labor productivity growth is seen to be only about 1 percentage point, about 1/4 percentage point less than when software is included.

These results for software point to the potential importance of capitalizing other intangibles, like R&D. In the treatment shown in the upper panel of table 1 (the part taken from the BLS release), R&D is added as a "memo" item explaining a portion of the residual; it does not play an explicit role as a capital input. Unfortunately, the traditional sources-of-growth framework treats capital and labor inputs as determined outside of the framework and therefore does not provide guidance as to whether to treat R&D as a memo item or as an investment good and thus as part of output. This problem is addressed in the following section by embedding the sources-of-growth framework in a more complete dynamic model in which investment decisions are made explicit. Our extended framework shows that no basis exists for treating intangible capital differently from traditional forms of fixed capital. Indeed, the asymmetrical treatment of the two types of capital could have the effect of suppressing some of the most dynamic factors driving economic growth.[7]

II-B. Capital in a Complete Model of Economic Growth

The sources-of-growth model, derived from the production function as illustrated in figure 1, evolved as a period-by-period analysis of the factors determining output along the growth path

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[7] Our analytical framework also highlights the shortcomings of the prevailing view in the accounting literature. Despite some dissenting views (e.g., Lev 2001), this literature holds that intangible investments should be expensed and not capitalized.

of an economy. This model treats capital as predetermined and cannot fully describe the growth process because saving and investment are choice variables in a complete model of growth. Not only is this choice dimension important because it determines the quantity of capital available at each point in time, but it also determines what should be counted as capital. The answer to the question of whether intangibles should be treated as capital is therefore a matter of embedding the production-function based sources-of-growth analysis in a larger model of economic growth.

Several options are available in this regard: the neoclassical growth model, the endogenous model, and optimal growth theory. The latter is the most suitable because it deals directly with consumer saving behavior. We will therefore work with the variant of this model choice used in Hulten (1979) to endogenize capital in an expanded growth accounting framework. Following standard intertemporal capital theory, we assume that optimal consumption in each period is determined by the maximization of an intertemporal utility function $U(C_1, \dots, C_T)$ subject to: (a) the constraints of the technology represented by the production function in equation (1); (b) the capital accumulation equation expressed in its "perpetual inventory" form as

$$(3) \qquad K_t = I_t + (1-\delta) K_{t-1},$$

where δ is the rate of depreciation; (c) the constraint that the production of consumption goods cannot exceed total output in any period

$$(4) \qquad p^Q_t Q_t = p^C_t C_t + p^I_t I_t = p^L_t L_t + p^K_t K_t$$

(this expression also serves as the annual product and income account of the "economy" portrayed by this model, which for simplicity is assumed closed); (d) the exogenously given initial and terminal quantities of capital, K_0 and K_T; and (e) the initial level and paths of labor input and TFP (and thus g_L and g_A), which are all given. The resulting solution determines the

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path of consumption over time $\{C^*_t\}$, as well and the paths of investment and capital stock.. In

view of equation (4), the optimal path $\{C^*_t\}$ determines how output is divided between the

production of consumption and investment goods and therefore is relevant to how intangibles

ought to be treated.[8]

For purposes of exposition, we can restate the constraints on the optimization in a more

compact form.[9] The production function $C_t + I_t = A_t\, F(K_t, L_t)$, the initial and terminal stocks of

capital K_0 and K_T, the accumulation condition $K_t = I_t + (1\text{-}\delta)K_{t\text{-}1}$, and the paths of A_t and L_t,

can be expressed in equivalent form as

(5) $\Phi(\{C_1, \dots , C_T\}; \{L_1, \dots , L_T\}; \{A_1, \dots , A_T\}; K_0, K_T) = 0.$

This is the intertemporal production possibility frontier, which indicates all combinations of the

consumption vector $\{C_1, \dots , C_T\}$, including the optimal vector, that are possible given the vector

of labor input, technology levels, and the initial and terminal stocks of capital. This form of the

constraint reveals the endogenous role of capital in the growth process. Capital largely

disappears when the constraints are expressed in this form, and it disappears altogether if the

initial and terminal stocks of capital happen to be zero.

The solution to the intertemporal optimization problem is shown graphically in figure 2

for the case of two time periods. The feasibility constraint Φ is represented by the curve AB, and

the intertemporal utility function $U(C_1, \dots , C_T)$ is represented by the curves UU and U'U'. The

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[8] The Solow-Swan neoclassical growth model (Solow 1956; Swan 1956) provides an alternative
description of how output is split between consumption and investment. In that model, investment is
assumed to be a fixed proportion of output ($I_t = s_1 Q_t$). A different growth path emerges when output is
split between consumption and investment according to this rule, but the general conclusion about
intangible capital obtained in this section still holds.

[9] We also ignore the complication of chain weighting to keep the exposition simple.

optimal consumption plan is represented by the point $\underline{a}$, and this point defines the maximum wealth of the economy. The line WW indicates the level of this wealth, and has the form:

$$(6) \qquad W_{0,T} \;=\; \Sigma \, (p^C_t \, C^*_t)/(1+i)^t, \quad t=1,...T.$$

In equation 6, the nominal rate of discount, i, is assumed to be constant over time for simplicity of exposition, and the initial and terminal stocks of capital are set to zero. The optimal point, $\underline{a}$, is an explicit function of labor input and level of technology in each period. Capital is implicit in the optimal solution, because $A-C_1$ units of consumption are foregone in period 1, and the resources freed-up by this abstinence are used to make capital goods, which are then used up in production in period 2. Capital is, in effect, an intermediate intertemporal good.

The relative roles of capital formation and technical change can be explored using the following thought experiment: What would have been the outcome had technology not increased from AB' to AB, with labor held constant? The production possibility frontier in the case of zero technical change is shown as the curve AB', and the optimal solution as b. The effect of capital formation on the optimal consumption plan (in the absence of technical change) is represented by the notional jump from A to b, and the effect of technical change (including the effect of the induced capital accumulation) as the jump from b to a. The latter is the "wealth effect" of technical change much discussed in recent years, but note that it arises only from *unexpected* increases in the level of technology. Expected increases in technology are already embedded in the long-run consumption plan of the optimizer (that is, C_t is invariant to expected technical change).

II-C. Implications of the Intertemporal Framework for Defining and Measuring Capital.

The simple intertemporal framework of figure 2 has an important implication for the treatment

of intangible capital in a set of economic accounts. Figure 2 makes clear that *any* use of

resources that reduces current consumption in order to increase it in the future (for example, the

movement along *AB* from the point *A* on the horizontal axis to the optimal point a̲) qualifies as

an investment. Figure 2 thus argues for symmetric treatment of *all* types of capital, that is, in

national accounting systems, investments in knowledge capital should be placed on the same

footing as that of investments in plant and equipment. This requirement is of rather broad

scope. It includes all investments in human capital (not just outlays by government and not-for-

profit institutions on education), research and development expenditures, and indeed, any

expenditure in which a business devotes resources to projects designed to increase future rather

than current output, whether it is intangible or tangible.

Financial accounting practice continues to ignore this principle, and national income and

wealth accounting is only just beginning to incorporate it into practice. Of course, many

practical difficulties arise in implementing the symmetry principle, and these difficulties are one

reason that financial accountants prefer to expense intangibles. Much intangible capital

investment occurs within the company, household, or government unit that has the intellectual

property right to the capital, and no arm's length valuation of the investment exists. Moreover,

the appropriation of property rights and the spillover of externalities also present problems.

However, practical difficulties do not invalidate the underlying theoretical principle of

symmetry.   From a conceptual standpoint, it does not matter at all whether an asset is

self-constructed or not, nor does the presence of externalities or market pricing power matter in

the theoretical framework of figure 2: the intertemporal utility function is based on the final

result of the production process--consumption. The consumption possibility frontier $\Phi(\bullet)$ incorporates all externality effects, monopolistic market structures, and self-constructed assets. No theoretical basis exists for treating one type of capital differently from another simply because one type is harder to measure accurately.

Some of the practical difficulties will become apparent in Section III of this paper, in which we attempt to estimate the magnitude of some of the main types of business intangible investments. However, before turning to this task, we will review some of the main implications of our theoretical analysis for national economic accounting.

II-D. Implications of Symmetry for Economic Accounting

The symmetry principle implies that the production function, as formulated in equation 1, is an incomplete representation of the production possibilities of an economy and must be expanded to accommodate the input and output of intangibles. Written in implicit form, the expanded production function can be expressed as

$$(7) \qquad F(C_t, I_t, N_t; L_t, K_t, R_t, A^*_t) = 0$$

where investment in intangibles is denoted by N_t; the accumulated stock of intangibles (adjusted for depreciation) is denoted by R_t; and the asterisk on the efficiency term, A^*_t, distinguishes it from the term in 1. The intertemporal production possibility frontier also must be reinterpreted in terms of the expanded concept of capital and correctly specified efficiency term.

The reformulation of the production possibility set has implications for the construction of national accounts and the accounting for economic growth. The GDP identity in equation (4) treats most intangibles as intermediate inputs in which the value of the spending, $p^N_t N_t$, is just matched by the value produced each period (ignoring foreign trade). As a result, the two flows

cancel and aggregate GDP is unaffected by the size and relative growth of $p^N_t N_t$. When an intangible asset is reclassified as fixed capital, the value of the spending is treated as an addition to GDP, and $p^N_t N_t$, is added to the left-hand side of the GDP identity, equation 4.

An adjustment must also be made to the input side of the GDP identity. When intangible capital is treated as a capital input, its user cost value, $p^R_t R_t$, is added to the right-hand side of equation 4. When both the user cost value and the investment value of intangibles are included in GDP, the national accounting identity becomes

$$(8) \quad p^C_t C_t + p^I_t I_t + p^N_t N_t = p^L_t L_t + p^{K^*}_t K_t + p^R_t R_t .$$

For simplicity of exposition, we assume that the $p^I_t I_t$ and $p^{K^*}_t K_t$ refer exclusively to tangible capital, whereas the U.S. national accounts include some intangibles in I_t. The notation $p^{K^*}_t$ denotes the user cost of tangible capital input when intangibles are recognized as in (8). It differs from the corresponding user cost in (4), which may include income from intangible capital. The two user costs are connected by the expression

$$(9) \quad p^K_t K_t = p^{K^*}_t K_t + p^R_t R_t - p^N_t N_t .$$

This expression not only indicates that the conventional measure of capital income has a potential bias, but it also reveals an important feature of the expanded accounts. The symmetry principle indicates that the value of intangible production, $p^N_t N_t$, must be added to the conventional GDP identity in equation (4) to arrive at the correct expression in equation (8); this raises the issue of where this additional value of output should appear on the right hand (income) side of (8).

The treatment of intangibles on the income side of the accounts is subtle because the original estimate of capital income in (4), $p^K_t K_t$, is measured by the sum of all property-type income (interest, dividends, retained earnings, taxes, and depreciation). This list accounts for the

non-labor payments accruing to both tangible *and* intangible capital, i.e., to $p^{K*}_t K_t + p^R_t R_t$.

Where, then, would intangible investment, $p^N_t N_t$, appear on the income side of the accounts? The answer is that intangible investments are reflected as retained earnings that are uncounted in the conventional framework. Specifically, because intangibles are expensed in the conventional framework, they are subtracted from revenue to get earnings. Because intangibles would not be subtracted from revenue in the expanded framework, retained earnings are higher than in the conventional framework.[10] Thus, the symmetry principle is not just about uncounted output, but also about uncounted income accruing to capital.

The expanded framework for growth accounting presents a somewhat different view of the economy than the approach that ignores intangibles. Comparing the GDP identities (4) and (8) reveals that the latter is greater by $p^N_t N_t$. The rate of saving and investment and the relative shares of capital and labor in GDP are also affected. Labor's share in the "old" view is $s_L = (p^L L)/(p^L L + p^K K)$, which becomes $s^*_L = (p^L L)/(p^L L + p^K K + p^N N)$ when intangibles are recognized as asset. (For ease of exposition, time subscripts have been dropped, and the asterisk is used to denote the "true" income share.) The two shares are related by a factor of proportionality

$$(10) \qquad \lambda = (p^C C + p^I I)/(p^C C + p^I I + p^N N).$$

which is less than one. The basic result is that labor's "new" share is smaller, that is, $s^*_L = \lambda s_L$. Since both the old and new shares must sum to one, capital's income share must be larger when intangibles are recognized as being capital. Put differently, the "new" view includes the return to these forms of investment.

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[10] Moulton, Parker, Seskin (1999) describe this accounting for the recognition of software in the NIPAs. See also Fraumeni and Okubo [this volume] and B. Hall [this volume].

A similar analysis applies to the rates of saving and consumption. Consumption's true share is $s^*_C = (p^CC)/(p^CC+p^II+p^NN)$, and the mismeasured share is $s_C = (p^CC)/(p^CC+p^II)$; they are related by the same proportionality factor as above, that is, $s^*_C = \lambda s_C$. Consumption's share is smaller when intangibles are treated as capital, implying that the rate of saving and investment is correspondingly higher. This result is relevant in light of concerns about the low rate of saving in the U.S. economy: Existing measures of saving exclude much of the investment in knowledge capital that defines the modern economy.

III. THE SCALE OF BUSINESS INVESTMENT

In this section, we first identify and group the items commonly thought to represent private business spending on intangibles. We next review the available data sources and develop estimates of outlays on intangibles for three periods chosen to illustrate the growth in intangibles in the 1990s. The intertemporal model is then used to guide the determination of which (or what portion) of the items we have identified as business intangibles should be categorized as business fixed investment in national accounting systems.

III-A. Identifying and Estimating Business Spending on Intangibles.

As illustrated in table 2, we group the various items that constitute the knowledge capital of the firm into three broad categories: computerized information, scientific and creative property, and economic competencies. The table indicates, in general terms, what type of knowledge capital is included in each group and how each type is currently treated in the NIPAs.[11] The major component of computerized information, computer software, already is included as business

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[11] Our classification is similar, but not identical, to groupings developed in studies sponsored by the OECD (see OECD Secretariat 1998 and Khan 2001) and used by Lev 2001.

fixed investment. The other components, which include the knowledge acquired by businesses in their development of new or improved products, processes, or economic competencies, are not generally recognized as assets of the firm in the U.S. NIPAs or in other national accounting systems.

Table 3 presents estimates of the size of outlays by businesses on these broad categories of intangibles. As indicated by the numbered rows of the table, these estimates have been built from *nine* types of intangible assets that have been identified and grouped according to our three basic categories. The table summarizes the availability of data that can be used to measure business spending on each item and then presents our spending estimates for the late 1990s, that is, from 1998 to 2000; spending rates for periods five and ten years earlier also are shown to help illustrate trends by detailed asset type during the decade.[12] In the discussion that follows, we review the data sources for each item and assess how the available information can be used to broaden measures of business investment to more fully encompass each of the categories of knowledge capital shown in table 2.

III-A.1. *Computerized information*. Computerized information reflects knowledge embedded in computer programs and computerized databases. When computer software was recognized in the NIPAs in 1999, the move captured the estimated costs of software created by firms for their own use as well as purchases of prepackaged and custom software. The own-account estimates were developed from detailed occupational data on employment and wages in private industry, in conjunction with an estimate (50 percent) of the average time spent by individuals in the relevant occupations on "software development" (Parker and Grimm 1999).

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[12] The spending estimates summarized in the table have been developed as consistent, annual time series from 1988 to 2002. In much of the analysis that follows, we focus on the figures for the late 1990s.

This method of estimating investment, though imprecise, is consistent with the framework of figure 2: Some uses of employee time (development) are investments, other uses are inputs to current production. Spending in this category thus reflects the current NIPA computer software estimates (which averaged more than $150 billion during 1998-2000) plus a small figure (about $3 billion) for computerized databases, an item not capitalized in the NIPAs. Spending on computerized databases is estimated from the Census Bureau's *Services Annual Survey* (SAS).

The recognition in the NIPAs of computer software as investment generally has been met with acceptance and praise. During the work leading up to the introduction of software in the accounts in 1999 and in subsequent work by the BEA and others, important lessons have been learned about how to handle the possible double-counting from bundling of assets as well as issues related to own-account production.[13] Because intangibles are often bundled with fixed assets (e.g., Brynjolffson, Hitt, and Yang 2000) or constructed on own-account, the lessons learned from software should be quite valuable as efforts to measure other intangibles move forward.

III-A-2. *Scientific and creative property.* Although the scientific and creative property category of intangibles includes the familiar R&D data as one of its components, it is broader. It reflects not only the scientific knowledge embedded in patents, licenses, and general know-how (not patented) but also the innovative and artistic content in commercial copyrights, licenses, and designs. The category thus encompasses what we term "nonscientific R&D" in addition to the familiar "scientific R&D" component. In contrast to scientific R&D, the magnitude and trajectory of the spending flow on nonscientific R&D is not very well measured. Nonetheless,

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[13] Software is an important tool in R&D, and the conceptual overlap between figures for own-account software and the data on R&D expenditures must be confronted; this point is emphasized in the OECD's work on intangibles.

we estimate that in the 1990s, nonscientific R&D spending was at least as large as scientific

R&D spending. All told, our figures suggest that private businesses spent about $425 billion per

year during 1998-2000 on investments in scientific and creative property.

The industrial R&D data that have been the subject of most of the research in the United

Sates have been collected since the early 1950s by the Census Bureau for the National Science

Foundation (NSF). These data are defined to include expenditures "on the design and

development of new products and processes and on the enhancement of existing products and

processes." The included expenditures are restricted to activities carried on "by persons trained,

either formally or by experience, in the physical sciences, the biological sciences, and

engineering and computer science (but excluding geophysical, geological, artificial intelligence,

and expert systems research)." As is consistent with this restriction, the NSF's industrial R&D

data mainly captures inventive activity by industries that employ these types of workers (high-

tech, pharmaceutical and other manufacturers, software publishers, telecommunications service

providers, and the like), who are estimated to have spent nearly $185 billion annually on R&D in

the 1998-2000 period. Adding an estimate of mining R&D (more than $15 billion), yields a

point estimate for total spending on scientific R&D (items 3 and 4 on the table) of about $200

billion annually during 1998-2000.

Relatively little is known about "nonscientific" R&D spending. Information-sector

industries--book publishers, motion picture producers, sound recording producers, and

broadcasters--as well as financial and other services industries routinely research, develop, and

introduce new products. However, we have no broad survey data on the resources they devote to

these activities. In the table, we identify two types of nonscientific R&D spending (table 3, lines

5 and 6), noting that new product investment by information-sector industries usually leads to an

identifiable asset, such as a copyright or license, whereas the fruits of nonscientific R&D spending elsewhere usually does not.

For the motion picture industry, trade association data suggest that the development costs of new movie releases averaged $25 billion per year during 1998-2000 (table 3, line 5a). This figure includes the *actual* costs incurred by the major motion picture producers and the *estimated* costs for independent producers, with the latter accounting for about half of the total. We have no comparable data for the production costs of new television programs, sound recordings, or books. However, the new film *and new TV program* development costs of four of the seven major U.S. film and TV producers/distributors who identify such costs on a comparable basis in their financial reports was $15 billion per year for the same period, an amount suggesting that the costs of developing new TV programs are nontrivial.[14] As a result, development costs for new products in the broadcasting, sound recording, and book publishing industries (line 5b) are crudely estimated to be twice the new product development costs for motion pictures, a relationship that is roughly the same as that between the revenue of these industries and that of motion pictures as reported in the SAS. A range of plus or minus 50 percent is placed on this point estimate to indicate the high degree of uncertainty about this guess.

Our estimates for other new product development, design, and research costs are also rudimentary guesses, again with a range of plus or minus 50 percent placed on the point estimates. Nakamura (2001) proxies new product development costs in the financial services industries as a proportion (half) of the non-interest expenses of banks and nondepository institutions. We broaden the coverage to include other financial institutions (security and commodity brokers and other financial investments and related activities), and for our proxy we

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[14] The four companies are the Warner Bros unit of Time-Warner, Disney, Fox, and MGM.

use 20 percent of all intermediate purchases reported in the BEA's data on gross output and value added by industry; this spending was about $75 billion annually during 1998-2000. Elsewhere in services, we estimate that spending on *new* architectural and engineering designs was nearly $70 billion during the same period and that R&D in the social sciences and humanities was about $8 billion, twice its purchased component from SAS revenues (to include an own-account portion).

III-A-3. *Economic competencies*. Economic competencies represents the value of brand names and other knowledge embedded in firm-specific human and structural resources; it gathers the expenditures designed to raise productivity and profits (other than the software and R&D expenses classified elsewhere) and labels them "economic competencies."

We include three basic asset types in economic competencies: brand names, firm-specific human capital, and organizational structure. As indicated on lines 7 through 9 of table 3, we suggest that spending on these assets can be captured by measuring the costs of brand development; the costs of workforce training and education; and the costs of organizational change and development. Our raw tally of these flows places the spending on economic competencies at about $640 billion per year in the 1998-2000 period. This large spending category, however, is imprecisely estimated, and we place a wide range around our point estimate.

Spending on brand development is represented by expenditures on advertising and market research (table 3, lines 7a and 7b) and encompasses the costs of launching new products, developing customer lists, and maintaining brand equity. Although advertising and market research are generally aimed at building a firm's market share at the expense of its competitors, such spending is necessary for developing new brands and maintaining the value of existing

20

brands. Data on advertising expenditures are available from Universal-McCann, and revenues of

the industry, market and consumer research services, are available in the SAS. Because we are

unable to gauge the size and prevalence of own-account market and consumer research, the SAS

purchases are simply doubled to obtain an estimate for this item. Our estimate for total spending

on brand equity thus totals about $240 billion annually from 1998 to 2000.

The incidence and costs of employer-provided training was measured in special surveys

conducted by the BLS in 1994 and 1995, and the results placed private business spending on

workforce training and education in those years at about a $90 billion annual rate (table 3, lines

8a and 8b). The BLS surveys were designed both to yield unbiased economy-wide estimates of

the costs of employer-provided training and to capture conceptually just what the intertemporal

model wants: The total spending figure includes both direct firm expenses (outlays on

instructors, tuition reimbursements, and the like) and the wage and salary costs of employee time

spent in formal and informal training. The figures for the early and late 1990s shown in the table

are extrapolations using (1) the survey's industry detail on the mid-1990s costs per employee

and (2) trends in aggregate educational costs, industry employment, and industry employment

costs.

Investments in organizational change and development have both own-account and

purchased components. The own-account component is represented by the value of executive

time spent on improving the effectiveness of business organizations, i.e., the time spent on

developing business models and corporate cultures. The purchased component is represented by

management consultant fees. The purchased component is estimated using the SAS annual

revenues from the management consulting services industry, which rose substantially in the

1990s, from $28 billion at the start of the decade to more than $80 billion during 1998-2000 (table 3, line 9a).

The own-account portion is estimated as a proportion of the cost and number of persons employed in executive occupations, which rose very rapidly in the 1990s. Given that executive median pay exceeds the median pay for other employees, the fraction of total private payroll spent on executives and managers is substantial, almost 22 percent in 2000 (Nakamura 2001). Applying the executive and manager payroll share to total private business sector compensation yields an estimate for managerial and executive costs of nearly $900 billion per year in the 1998 to 2000 period.

If just one-fifth of management time is spent on organizational innovation, then businesses devoted more than $200 billion per year to improve the effectiveness of their organizations during 1998-2000 (table 3, line 9b). This figure is highly sensitive, of course, to the admittedly arbitrary choice of one-fifth as the fraction of time managers spend on investing in organizational development and change; as a result, our estimate for this components ranges from $105 billion (based on a one-tenth fraction) to nearly $350 billion (which assumes one-third). Adding in the $80 billion annual expense for management consulting (described above), our point estimate of total spending on organizational change and development is nearly $300 billion per year from 1998 to 2000.[15]

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[15] Consulting expenses and the estimated value of executive time conceptually overlap by a small amount (the value of executive time in the management consulting industry). In addition, some portion of management time arguably overlaps with R&D, so that, for some industries, the line between industry-specific process innovation and organizational change more generally may not be easily drawn. But, whatever uncertainty that amount induces in our estimates, it is dwarfed by the use of an arbitrary fraction for the amount of executive time devoted to organizational change and development.

III-A-4. *Summing up.* As indicated at the bottom of table 3, our best guesses suggest

that business spending on intangibles was about *$1.2 trillion* annually in the late 1990s, more

than 13 percent of GDP. Moreover, we estimate that nominal spending on intangibles grew

relative to the total economy during the second half of the 1990s; the ratio of our estimates to

GDP in the 1998-2000 period was about 2-1/2 percentage points more than it was at the start of

the decade and during 1993-1995. The picture does not change materially when software, which

is already capitalized in the NIPAs, is excluded: Our grand total for 1998-2000 still exceeds

$1 trillion (nearly 11 percent of GDP) and still expands at a much faster rate than it did earlier in

the decade.

Our estimate for business spending on intangibles in the late 1990s shown in table 3 is

nearly 40 percent larger than the spending-based estimate issued by Nakamura (2001, 2003) and

about 20 percent larger than his estimates based on other methods, such as changes in the

occupational structure over time.[16] Although we use many of the same data sources, our

estimates are larger because we introduce some important new sources of information on

spending on intangibles. In particular, the estimates in table 3 incorporate official data on the

revenue of selected services industries (the Census Bureau's annual SAS data) and on businesses

outlays on employer-provided worker training (the BLS's special surveys). Also, our estimates

include an explicit figure, based on data from a trade source, for new product investment in the

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[16] The Nakamura (2001, 2003) spending-based estimate adds together (1) the BEA's estimate of software spending, (2) *double* the NSF's estimate of R&D spending (to capture the nonscientific spending we estimate more explicitly), and (3) the Universal-McCann advertising data. For the 1998 to 2000 period, using figures shown in table 3, these items sum to $759 billion, or 8.2 percent of GDP. Nakamura also uses three other methods, or broad sources of information, to estimate intangibles: labor inputs (the relative increase in employment in "creative" occupations over time), corporate operating margins (the relative increase in "administrative" costs), and models of the ratio of consumption to GDP, a ratio that has risen since the early 1980s. All told, his estimates place business investment in intangibles at about our lower bound for the grand total shown in table 3.

motion picture industry.   Last, as is consistent with the intertemporal model, our estimates

regard spending on each asset type as having an own-account, as well as a purchased,

component. Although our estimates of own-account spending are fairly crude, their inclusion

affects the scale and trajectory of the overall aggregate results.

III-B. Classifying Intangible Spending as Fixed Investment

The intertemporal model and framework of section II would not necessarily classify the grand

total shown at the bottom of table 3 as business investment in long-lasting knowledge capital.

To implement the model's simple rule--investment is deferred consumption--a line must be

drawn to separate the expense of current production from outlays that expand future productive

capacity. National economic accountants typically make this distinction on the basis of the

"durability," or expected service life, of a purchase. In practice, accountants determine

durability by setting a minimum time or "cutoff period" required for an asset to yield services,

(e.g., one year or three years).

If the cutoff period chosen is very short (long), then a larger (smaller) fraction of

business expenditures are classified as fixed investments. As a result, the *scale* of business fixed

investment (and thus GDP) in a particular measurement system depends on the durability cutoff

period that is chosen. Put differently, although the theoretical model views *all* expenditures

aimed at increasing the range of production possibilities in a future period as fixed investment

(recall the discussion of symmetry in section II), the model does not specify the length of time

between the current and "a future" period, even though this definition is needed to determine what becomes *fixed* investment in a particular measurement system.[17]

Of course the NIPAs and the international System of National Accounts 1993 (SNA) currently classify components of intangible spending, either implicitly or explicitly, and the NIPAs are guided by the SNA to some extent. For example, as they do with computer software, the NIPAs treat mineral exploration as fixed investment, and they treat scientific R&D as intermediate consumption, all of which is consistent with the SNA.[18] But no single recent statement conveys the NIPAs "choice" of a durability cutoff for determining what is business fixed investment. BEA's practice would appear to approximate a system in which business fixed assets are inputs with a useful service life of at least three years, although a dated study defines business equipment as having an average service life of more than one year.[19]

In the remainder of this section, we review the available evidence and confront the difficult task of determining which items in table 3 are fixed investment. Although we faced

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[17] But, note that because what becomes fixed investment depends on the durability cutoff period chosen, what becomes inventory investment also depends on this cutoff period. Any input that is not used up in current period and is intended to be used to increase future consumption is still "capital" in the sense of figure 2, even if it is not classified as *fixed* capital. Such an input would simply be an *inventory* carried over for future use. An examination of the implications of the intertemporal framework for identifying and valuing intermediates as inventory investment is beyond the scope of this paper.

[18] However, the SNA advises national accountants to treat the costs of developing an "artistic or entertainment original" (one of our nonscientific R&D asset types) as investment, a practice not followed in the NIPAs.

[19] Moreover, different sectors in the NIPAs apply different accounting periods for capital. According to a more than 20-year-old study, business and government equipment is defined as durable goods having an average service life of more than one year whereas, for households, equipment (consumer durables) is defined as durable goods having an average service life at least three years (Young and Musgrave 1980). In practice, the available source data introduce additional twists in BEA practices: For example, the Census of Governments uses five years as a cutoff to determine whether a purchase is equipment. But for the business sector, in which the flows are built using data by asset type according to the commodity-flow method (see Grimm, Moulton, and Wasshausen [this volume]), the NIPAs currently do not recognize any assets having a service life of less than three years. (The authors thank Brent Moulton, Associate Director of National Economic Accounts at the BEA, for the information in this footnote.)

many hurdles in assembling the data in table 3, we were on a path that others (the OECD, Nakamura, Lev) have followed. At this juncture, however, we are on our own in applying the full logic of the intertemporal model to the development of measures for business fixed investment that include intangibles. Not surprisingly, the challenges we now confront exceed those we faced in the construction of table 3.

Table 4 works with five sub-aggregates of the detailed items reported in table 3 and summarizes our results. The first three columns report the table 3 figures for *total* spending, and the last three columns show our corresponding estimates for *capital* spending. Because the capital spending estimates were derived by considering whether some, rather than all, of total spending should be classified as investment in long-lasting knowledge capital, *the capital spending estimates for some items are lower than the total spending estimates*. Also, because we don't know whether to apply a service life cutoff of one year or three years, ranges are shown when the available evidence suggests that this choice may make a difference.

The capital spending columns of table 4 were developed in four steps: First, if economic research has clearly demonstrated that a given type of spending is fixed investment in the sense of our model, then we categorize 100 percent of the total spending as capital spending. For example, scientific R&D (line 2a) is unequivocally a long-lived investment; so is employer-provided training (a component of line 3b).[20] Second, if economic research suggests that only a portion of the spending on an intangible pays off in a future year (or years), we apply these findings. For example, although the marketing literature finds that the effects of advertising are generally to be short-lived, some advertising--apparently, more than half--has a

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[20] The very high rates of return to R&D investments found in microeconomic studies are summarized in National Science Board, 2000, p. 7-18; see also Griliches 1984. Studies that document the returns to employer-provided training include, among others, Bartel (1991, 1994) and Black and Lynch (1996).

service life of at least one year; a smaller fraction--perhaps one-third--makes a cutoff of three years (Landes and Rosenfield 1994).[21] As a result, the estimates for capital spending on brand equity (line 3a) are noticeably smaller than the corresponding total spending figures.

Our third and fourth steps are less precise: When we have a strong suspicion that the lifetime of a type of intangible may not be at least three years, we discount the item by 20 percent (an arbitrary amount) and show a range for our estimate for capital spending for the item. The lower bound of this "lifetime ignorance" range is the discounted figure and the upper bound is the total spending figure. For example, BEA's assumptions of a three-year service life for all pre-packaged software and a five-year service life for custom and own-account software are based on indirect and anecdotal evidence (Parker and Grimm 1999). Because many businesses expense recurring software fees and routine purchases of upgrades,[22] and because very little is known about the age-efficiency and retirement patterns of software assets, we apply the discount; the software capital spending estimate (line 1) thus shows a range to capture the uncertainty about software lifetimes. Also, the spending for some new products in the entertainment industry--a new television series or a new copyright film--are investments that generate, on average, relatively long-lasting revenue streams; but other spending on new product

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[21] Specifically, of the 20 two-digit SIC industries examined by Landes and Rosenfield, the implied annual geometric rate of decay of advertising was about 55 percent or less for seven industries (furniture; paper; chemicals; fabricated metals; transportation equipment; instruments; and building materials, hardware, and garden supplies) and about 65 percent to 70 percent for seven more (food, rubber and plastics, industrial machinery, electrical machinery, miscellaneous manufacturing, apparel retailers, and business services). For the remaining six industries (wholesale distributors of durable goods, general merchandisers, eating and drinking places, miscellaneous retailing, investment offices, and hotels), the effects of advertising dissipated within one year.

[22] Businesses reported to the Census Bureau that they spent about $12 billion on separately purchased, capitalized software in 1998, compared with BEA's estimates for business purchases of prepackaged and custom software that were *each* 3-1/2 times larger that year. The Census figure is from table 8 in the 1998 issue of *Annual Capital Expenditures.*

development pays off very quickly, while still other costs are "paid for" by advertising (Caves 2000). All told, to indicate our ignorance about the service lives of assets in this category, we apply the discount and show a lower bound for nonscientific R&D spending (line 2b) as well.

Fourth, when we have a strong suspicion that a portion of the spending in table 3 may be for routine tasks or represent current consumption, we discount the point estimate 20 percent. For example, we know very little about the composition of purchased management expertise; but we guess that a portion of these costs are current expenses, so we deduct the arbitrary discount before carrying this item over to the capital spending column. The total on line 3b includes our point estimate for the costs of organizational development and change on own-account that, although highly imprecise, was developed by explicitly considering what was investment.

Putting the pieces together, our table 4 estimates place business fixed investment in intangibles at nearly $1 trillion in the 1998-2000 periods, or about 10-11 percent of existing GDP. Moreover, as indicated on the table, only a portion of this spending (about 2 percent of existing GDP) is currently included in the NIPAs. Indeed, when viewed in relation to NIPA business spending on tangible capital, that is, spending on durable equipment and structures, we find that businesses invested in intangibles at roughly the same rate at which they invested in tangibles.

We recognize, of course, that the figures in tables 3 and 4 are imprecise and that, in putting them together, we raised many issues that we were unable to resolve: Recall that software is a major tool in R&D (and thus the own-account software estimates and the scientific R&D figures likely overlap), that remarkably little is known about innovative activity outside of the industries that employ scientists and engineers, and that quantifying the scale and service lives of business outlays geared to the acquisition of economic competency is very difficult. All

28

in all, though, one cannot escape the conclusion that business capital spending on intangibles was a very substantial and growing component of the economy in the 1990s--and that a serious attempt to fully account for these intangibles significantly alters one's view of the scale and composition of business fixed investment.

IV. REAL OUTPUT AND PRODUCTIVITY INCLUDING BUSINESS KNOWLEDGE CAPITAL: A FIRST STEP

Given the magnitude and trajectory of our estimates of business investment in knowledge capital, the full recognition of intangible assets in national economic accounting would be expected to have implications for measured changes in real output, output per hour, and total factor productivity. As a first step in answering how much of an effect those changes might be, we adjusted the value of nonfarm business output (the nominal output metric used in most productivity calculations) to include unrecognized intangible investments, and we experimented with how to express the resulting adjusted output series in real terms.

Alternative values of nonfarm business output adjusted to include unrecognized investment in intangibles are shown in table 5. The alternatives use the table 4 capital spending estimates corresponding to a one-year versus a three-year service life cutoff; as may be seen in table 5, the value of output including the unrecognized investment corresponding to a one-year service life cutoff exceeds that using the investment series corresponding to a three-year cutoff. The ratio of the published value of nonfarm business output to our alternative adjusted values (the λ defined in equation 10) also is shown in table 5. The published-to-adjusted ratio is lower for the output figures that incorporate the unrecognized investment corresponding to a one-year cutoff. This implies that economic accounts that include intangibles and adopt a one-year cutoff

would show a higher saving rate and a lower labor share than would accounts that adopt a three-year cutoff. However, because the published-to-adjusted ratio for *each* alternative is noticeably below one, the inclusion of unrecognized investment in intangibles would imply an economy with a higher saving rate and a lower labor share than implied by the existing published figures, whatever choice is made about the service life cutoff.

The conversion of our estimates to real terms is especially difficult because intangibles often are owner-constructed, or are "difficult-to-measure" services (Griliches 1994), with no available (or reliable) price deflator. As a result, we use two surrogates, one based on the price of output for the overall nonfarm business sector, the other based on employment costs in the sector. The rationale for using the overall output price as a surrogate is that intangible investments are firm-specific and occur broadly across industries; the rationale for using employment costs is that the construction of intangibles is a labor-intensive process with little growth in productivity.[23]

Our estimates of real output using the two deflators are applied to the adjusted output series corresponding to the one-year service life cutoff and shown in table 6. In this table we present annualized results for periods that correspond to the final two columns in table 1. When the nonfarm business output price is used to deflate the unrecognized business investment, the rates of change in the adjusted real output measure exceed the existing measures of change, suggesting that a move to fully recognize intangibles *could* raise the growth rate of real output, on average, by a noticeable amount. However, if employment costs are used to deflate the

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[23] Under constant returns to scale, the rate of change in the intangible output price is connected via the factor price frontier to the rate of change in the prices of inputs used in the production of the output, less the rate of change in the efficiency, or productivity, of the process. If the rate of productivity change is close to zero, and labor's share is close to one, employment costs are a good proxy for the output price.

unrecognized investment flows, the resulting rates of change in real output are little different than the published measures of change.

The figures shown in table 6 thus frame the answer to the question posed at the outset of this paper: How much difference does the theoretically appropriate treatment of knowledge capital make to the productivity estimates shown in table 1? The adjustments to real output shown in table 6 imply corresponding percentage point adjustments to the rate of change in measured output per hour shown in line 1. All told, therefore, the change to measured productivity that would result from the *full* recognition of intangibles *could* be as large as that which occurred with the move to include software in business investment--about 1/4 percentage point per year in recent years.

The potentially striking nature of these results underscores both the importance of further work on measuring business investment in intangibles in real terms and the need to obtain additional information on historical investment flows and service lives for the many and varied types of intangible assets described in the previous section. We have made no estimate of the aggregate real stock of knowledge capital, nor of its impact on TFP, but our results and our framework suggest that intangible investments need to be included in the empirical accounting of factors determining economic growth.

V. CONCLUSION

The remarkable performance of the U.S. economy in the second half of the 1990s has refocused attention on identifying the underlying sources of economic growth. In the introduction to this paper, we discussed some of the strands of literature that have, in different ways, started to stir the pot of growth analysis and measurement. Because we, too, share the general sense that the

31

conventional framework and current data are not telling us all that we need to know about the role of knowledge capital in economic growth, we set out in this paper a broader framework for the economic measurement of capital.

On the theory side, we described a growth framework that adds an explicitly intertemporal dimension to the standard Solow growth-accounting framework. One important way in which the extended framework is useful is that it provides guidance on the "boundary" question of what should be included in investment and therefore what measure of capital should be entered into the production function. The conventional framework provides little guidance on this point, while the extended framework yields the concept necessary to define investment: Any use of resources that reduces current consumption in order to increase consumption in the future qualifies as investment. Thus, spending on a host of intangibles--including R&D, copyrights, films, computerized databases, improved organizational structures, brand equity, etc.--should, in principle, be counted as investment.

In terms of practice, we assembled data on spending on intangibles (using the types of definitions that national economic accountant might use) to gauge their possible magnitude via the application of our model. The estimates suggested that business fixed investment in intangibles may have been large as the spending on tangible capital--as much as $1 trillion in recent years--and that a significant portion of this amount is excluded from the existing investment figures in the NIPAs. Although we regard our numbers on intangible investment as illustrative, not definitive, the inclusion of heretofore unrecognized business intangible capital in the NIPAs implies that the move could alter the average rate of growth of real output and labor productivity in the late 1990s.

We believe that the statistical agencies and the broader research community should construct satellite accounts for as many of the categories of intangible investment as possible. Satellite accounts would illuminate the data hurdles and information needs and position researchers to suggest improved techniques and data sources. At the same time, the use of satellite accounts would insulate the headline accounts from the spotty data that invariably would be used in the satellites. One noteworthy effort in the development of satellite accounts is the work of Fraumeni and Okubo [this volume], who take a first look at an accounting of GDP that includes scientific R&D.

As indicated, we regard this paper, along with other papers in this volume, as one step in a long process. Despite the challenges ahead, we believe that useful progress is being made on measuring and understanding the role of business intangibles in the economy and that substantial further progress is both possible and necessary.

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