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On Measuring the Productivity and the Standard of Living in Japan, 1955-2006

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Abstract

The paper looks at the contribution of the market sector to changes in Japan's living standards over the years 1955-2006. It considers real income as a measure for living standards and decomposes its growth rate into three components: components due to changes in productivity, in real output prices (including changes in the terms of trade) and in primary input growth. The exact index number approach developed by Diewert and Morrison (1986) and Kohli (1990) (2004) is adapted to this real income context. Finally, the paper switches from a gross output concept to a theoretically preferred net output concept. In the net output context, it turns out that the role of capital deepening as a contributor to higher living standards diminishes and the role of productivity and labour growth becomes more important.

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1. Introduction

The Japanese economy has experienced tremendous growth in the past half century but there has been a pronounced slowdown for more than 10 years after the bubble economy collapsed.[1] This unique experience of the post war Japanese economy has been attracting the interest of a lot of researchers. However, most of these studies have been concerned with the growth of production and productivity of the Japanese economy. These studies quantify the various sources of Japanese economic growth and measure the productive efficiency of the Japanese economy.[2]

In this paper, we are primarily concerned with increases in the standard of living in the post-war Japanese economy. In particular, we focus on the contribution of Japan's market sector to improvements in Japanese living standards over the period 1955-2006. We have excluded the general government sector from our analysis because this sector may provide its outputs without charging for them or it may sell them for prices that are not economically significant. Our analysis will rely on the assumptions of revenue maximizing and cost minimizing behavior, assumptions that are generally not applicable for the government sector. There are other measurement difficulties associated with the government sector. Because it is difficult to measure many outputs in the government sector, the *System of National Accounts 1993*[3] (see the UN (1993)) recommends measuring the value of these difficult to measure outputs of the general government as the cost of producing the outputs and 1993 *SNA* recommends setting the price of these outputs equal to an input cost index. This is not a proper way of measuring output from a theoretical point of view.[4] The household sector is also a producer in the SNA. In particular, this sector produces imputed rent from owner-occupied houses. However, this is a special type of production where productivity improvements cannot take place and so we have decided to exclude this sector from our concept of the market production sector. Therefore, we completely net out the general government and the household sector from our framework in order to avoid the above mentioned difficulties.

Real Gross Domestic Product (GDP) is often used as a proxy for a country's living standard. However, real GDP is a measure of the level of production and it is well known that real GDP can be a very misleading indicator of a country's welfare in the face of changing terms of trade.[5] Real (Gross) Income, which deflates nominal GDP by the price of domestic consumption goods is more appropriate as a measure of economic welfare. Economic welfare comes from consumption. Real income captures how much consumption people can purchase for their income. For example, if the nominal output is constant

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[1] Although Japanese economy is in a period of economic recovery since 2002, its growth is still modest.

[2] See Hayashi and Nomura (2005), Hayashi and Prescott (2002), Jorgenson and Nishimizu (1978), Jorgenson, Kuroda, and Nishimizu (1987), Jorgenson and Nomura (2005), Nishimizu and Hulten (1978) and Nomura (2004).

[3] We call it 1993 SNA hereafter.

[4] There is an additional difficulty with the SNA treatment of input cost in the government sector: the user cost of capital in the government sector is just depreciation with no imputation for the financial cost of capital. Thus if a government building is sold to the private sector, GDP will increase!

[5] Hamada and Iwata (1984) show that real GNP (equivalent to real GDP in our paper) may overestimate national welfare when the terms of trade deteriorate for a country. Kohli (2004) showed that an improvement in the terms of trade can actually lead to a fall in real GDP.

over two consecutive periods, an improvement in the terms of trade should increase economic welfare by enhancing the purchasing power of domestic households. Real Income always increases in this situation. However, the conventional Laspeyres type real GDP may decrease in this case.

We shed the new light on the measurement of the standard of living in Japan for the years 1955-2006 by focusing on the real income generated by the market sector. We attempt to measure the determinants of *real income growth* in Japan. We adapt the analytic framework for productivity measurement that was developed by Diewert and Morrison (1986) and Kohli (1990) (2004) to the real income growth context. Adapting their results, we find that the main determinants of growth in real income generated by the market sector of the economy are:

- Technical progress or improvements in Total Factor Productivity (TFP);
- Growth in nonconsumption real domestic output prices, growth in the real prices of exports and falls in the real prices of imports; and
- Growth in primary inputs.

Using our adapted decomposition formula, all of these three determinants can be calculated using only the observable price and quantity data over the years 1955 to 2006. A difficulty in applying this decomposition formula is uncertainty as to what is the “correct” user cost of capital. In particular, should an exogenous rate of return be used in the formula or should an endogenous balancing rate of return that makes the value of inputs equal to the value of outputs be used. Schreyer (2007) surveys several different procedures for estimating rates of return. We use ex post balancing (real) rates of return. These balancing real rates of return seem to capture business conditions in the post war Japanese economy.

GDP in a closed economy with no government is simply consumption plus gross investment plus changes in inventory. Economists have argued for a long time that Net Domestic Product (NDP), which equals consumption and net investment, is a more appropriate welfare measure than GDP.[6] The problem with the gross concept is that it gives us a measure of output that is not sustainable. In order to move to a more theoretically appropriate NDP concept using our framework for the determinants of real income growth, it is necessary to treat depreciation as an offset to gross investment. Thus we take the depreciation term in the user cost formula out of costs and treat it as a negative output that will act as an offset to gross investment. Our theoretical results, explaining the growth of gross real income generated by the market sector, can still be applied to the net real income concept.

Our dataset of the market sector has been constructed from different data sources. For net output data, we heavily depend on data in Japanese System of National Accounts.[7] For capital stocks and investment, we also made extensive use of the investment and asset data in the KEO database. For labour input, we constructed total hours of works for three different workers; the self-employed, family workers, and employees from the Japanese *Labour Force Survey* and the Japanese national accounts. One limitation of our study must be noted and that is the fact that we have no industry detail in our data base and thus we cannot locate the contributions of TFP growth in individual industries to the aggregate market sector TFP growth.[8]

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[6] See Marshall (1890), Pigou (1924), Samuelson (1961), and Weitzman (1976). More recent papers that argue for the net product framework are Diewert and Fox (2005), Oulton (2004), and Weitzman (2003).

[7] In 1978, the Japanese system of national accounts was revised to comply with the guidelines proposed by the United Nations System of National Accounts (1968 SNA). In 2000, it was revised to comply with the guidelines newly proposed by the United Nations System of National Accounts (1993 SNA).

[8] Moreover, we cannot measure the contributions to aggregate TFP growth of shifts in labour resources from less productive sectors to more productive sectors. It comes from the aggregate nature of our labour data. Since we consider three types of labour such as employees, the self-employed, and family workers, we can

The remainder of this paper is organized as follows. In section 2, we outline a framework for measuring productivity and decomposing real income growth into several explanatory factors. This framework is an adaptation of a methodology introduced by Diewert and Morrison (1987). In section 3, we explain our data construction. The rate of return is endogenously determined from observed data. The procedure for determining the rate of return is explained there. In section 4 of the paper, we present a conventional TFP growth accounting for the market sector of the Japanese economy for the years 1955-2006. There have been several recent studies that do more or less the same thing so one might question the value of yet another study of Japanese TFP growth.[9] However, all of these alternative studies cover a much shorter period (with the exception of Nomura (2004)) and there are other significant differences. In the present study, we consider only the market sector of the Japanese economy where productivity improvements are possible under current national income accounting conventions. Moreover, our focus is not on TFP growth rates per se but rather the contribution of TFP growth to real income growth; i.e., the existing studies do not follow our treatment of changes in the terms of trade. In section 4.2, the gross income methodology developed in section 2 is implemented using our Japanese market sector data base for the years 1955-2006 and the net income methodology is implemented in section 4.3. In section 5, we conclude the paper.

2. The Theoretical Framework

In this section, we present the production theory framework which will be used in the remainder of the paper. The main references are Diewert and Morrison (1986) and Kohli (1990).[10]

Initially, we assume that the market sector of the economy produces quantities of M (net)[11] outputs, $y \equiv [y_1,...,y_M]$, which are sold at the positive producer prices $P \equiv [P_1,...,P_M]$. We further assume that the market sector of the economy uses positive quantities of N (primary)[12] inputs, $x \equiv [x_1,...,x_N]$ which are purchased at the positive primary input prices $W \equiv [W_1,...,W_N]$. In period t, we assume that there is a feasible set of output vectors y that can be produced by the market sector if the vector of primary inputs x is utilized by the market sector of the economy; denote this period t production possibilities set by S^t. We assume that S^t is a closed convex cone that exhibits a free disposal property.[13]

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only capture the contribution of shifts in labour resources within these three types. On the other hand, industry price and quantity data are notoriously unreliable due to the lack of detailed surveys on gross outputs and intermediate inputs, for service industries in particular. A final reason for our use of aggregate market sector data is that reliable breakdowns of exports and imports by industry are not available.

[9] Some of the recent studies are Hayashi and Nomura (2005), Hayashi and Prescott (2002), Miyagawa, Ito and Harada (2004) and Jorgenson and Nomura (2005).

[10] The theory also draws on Samuelson (1953), Diewert (1974; 133-141) (1980) (1983; 1077-1100), Fox and Kohli (1998), Kohli (1978) (1991) (2003) (2004a) (2004b), Morrison and Diewert (1990), Samuelson (1953) and Sato (1976). This paper is essentially an extended version of Diewert, Mizobuchi and Nomura (2005) using newly available data. The theoretical framework explained in this section was recently used by Diewert and Lawrence (2006).

[11] If the mth commodity is an import (or other produced input) into the market sector of the economy, then the corresponding quantity y_m is indexed with a negative sign. We will follow Kohli (1978) (1991) and Woodland (1982) in assuming that imports flow through the domestic production sector and are "transformed" (perhaps only by adding transportation, wholesaling and retailing margins) by the domestic production sector. The recent textbook by Feenstra (2004; 76) also uses this approach.

[12] Primary inputs only include labour and capital services from reproducible assets, inventories and land. Intermediate inputs fall into the category of (net) outputs.

[13] For a more explanation for the meaning of these properties, see Diewert (1973) (1974; 134), Woodland (1982) or Kohli (1978) (1991). The assumption that S^t is a cone means that the technology is subject to

Given a vector of output prices P and a vector of available inputs x, we define *the period t market sector GDP function*, $g^t(P,x)$, as follows:[14]

(1) $g^t(P,x) \equiv \max_y \{P\cdot y : (y,x) \text{ belongs to } S^t\}$; $t = 0,1,2, \ldots$.

Thus, market sector GDP depends on t (which represents the period t technology set S^t), on the vector of output prices P that the market sector faces and on x, the vector of inputs that is available to the market sector.

If P^t is the period t output price vector and x^t is the vector of inputs used by the market sector during period t and if the GDP function is differentiable with respect to the components of P at the point x^t, then the period t vector of market sector outputs y^t will be equal to the vector of first order partial derivatives of $g^t(P^t,x^t)$ with respect to the components of P; i.e., we will have the following equations for each period t:[15]

(2) $y^t = \nabla_P\, g^t(P^t,x^t)$; $t = 0,1,2, \ldots$.

If the GDP function is differentiable with respect to the components of x at the point P^t, then the period t vector of input prices W^t will be equal to the vector of first order partial derivatives of $g^t(P^t,x^t)$ with respect to the components of x; i.e., we will have the following equations for each period t:[16]

(3) $W^t = \nabla_x\, g^t(P^t,x^t)$; $t = 0,1,2, \ldots$.

The constant return to scale assumption on the technology sets S^t implies that the value of outputs will equal the value of inputs in period t; i.e., we have the following relationships:

(4) $g^t(P^t,x^t) = P^t\cdot y^t = W^t\cdot x^t$; $t = 0,1,2, \ldots$.

The above material will be useful in what follows. However, our focus is not on GDP; instead, our focus is on the income generated by the market sector or more precisely, on *the real income generated by the market sector*. However, since market sector GDP (the value of market sector production) is distributed to the factors of production used by the market sector, nominal market sector GDP will be equal to nominal income of the market sector. As an approximate welfare measure that can be associated with

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constant returns to scale. This is an important assumption since it implies that the value of outputs should equal the value of inputs in equilibrium. In our empirical work, we use an ex post rate of return in our user costs of capital, which forces the value of inputs to equal the value of outputs for each period. The function g^t is known as the *GDP function* or the *national product function* in the international trade literature (see Kohli (1978)(1991), Woodland (1982) and Feenstra (2004; 76). It was introduced into the economics literature by Samuelson (1953). Alternative terms for this function include: (i) the *gross profit function*; see Gorman (1968); (ii) the *restricted profit function*; see Lau (1976) and McFadden (1978); and (iii) the *variable profit function*; see Diewert (1973) (1974) (1993).

[14] The function $g^t(P,x)$ will be linearly homogeneous and convex in the components of P and linearly homogeneous and concave in the components of x; see Diewert (1973) (1974; 136). Notation: $P\cdot y \equiv \sum_{m=1}^{M} P_m y_m$.

[15] These relationships are due to Hotelling (1932; 594). Note that $\nabla_P\, g^t(P^t,x^t) \equiv [\partial g^t(P^t,x^t)/\partial P_1, \ldots, \partial g^t(P^t,x^t)/\partial P_M]$.

[16] These relationships are due to Samuelson (1953) and Diewert (1974; 140). Note that $\nabla_x g^t(P^t,x^t) \equiv [\partial g^t(P^t,x^t)/\partial x_1, \ldots, \partial g^t(P^t,x^t)/\partial x_N]$.

market sector,[17] we will choose to measure the *real income generated by the market sector in period t* in terms of the number of consumption bundles that the nominal income could purchase in period t. Therefore, we define ρ^t as follows:

$$
\begin{aligned}
(5)\ \rho^t &\equiv W^t \cdot x^t / P_C{}^t\ ; && t = 0,1,2, ... \\
&= w^t \cdot x^t \\
&= p^t \cdot y^t \\
&= g^t(p^t,x^t)
\end{aligned}
$$

where $P_C{}^t > 0$ is the *period t consumption expenditures deflator* and the market sector period t *real output price* p^t and *real input price* w^t vectors are defined as the corresponding nominal price vectors deflated by the consumption expenditures price index; i.e., we have the following definitions:[18]

$$(6)\ p^t \equiv P^t/P_C{}^t\ ;\ w^t \equiv W^t/P_C{}^t\ ; \qquad t = 0,1,2, ...$$

The first and last equality in (5) imply that period t real income, ρ^t, is equal to the period t GDP function, evaluated at the period t real output price vector p^t and the period t input vector x^t, $g^t(p^t,x^t)$. Thus *the growth in real income over time can be explained by three main factor; productivity growth, growth in real output prices and the growth of primary inputs.* We will shortly give formal definitions for these three growth factors.

Using the linear homogeneity properties of the GDP functions $g^t(P,x)$ in P and x separately, we can show that the following counterparts to the relations (2) and (3) hold using the deflated prices p and w:[19]

$$(7)\ y^t = \nabla_p\, g^t(p^t,x^t)\ ; \qquad t = 0,1,2, ...$$
$$(8)\ w^t = \nabla_x\, g^t(p^t,x^t)\ ; \qquad t = 0,1,2, ...$$

Now we are ready to define a family of *period t productivity growth factors* $\tau(p,x,t)$:

$$(9)\ \tau(p,x,t) \equiv g^t(p,x)/g^{t-1}(p,x)\ ; \qquad t = 1,2, ...$$

Thus, $\tau(p,x,t)$ measures the proportional change in the real income produced by the market sector that is induced by the technical change going from period t – 1 to t, facing the reference real output prices p and using reference input quantities x. We can choose the reference vectors for the measure of technical progress defined by (9) from the current year or the previous year: a *Laspeyres type measure* $\tau_L{}^t$ that

[17] Since some of the primary inputs used by the market sector can be owned by foreigners, our measure of *domestic* welfare generated by the market sector is only an approximate one. Moreover, our suggested welfare measure is not sensitive to the distribution of the income that is generated by the market sector.

[18] Our approach is similar to the approach advocated by Kohli (2004b; 92), except he essentially deflates nominal GDP by the domestic expenditures deflator rather than just the domestic (household) expenditures deflator; i.e., he deflates by the deflator for C+G+I, whereas we suggest deflating by the deflator for C. Another difference in his approach compared to the present approach is that we restrict our analysis to the market sector GDP, whereas Kohli deflates all of GDP (probably due to data limitations). Our treatment of the balance of trade surplus or deficit is also different.

[19] If producers in the market sector of the economy are solving the profit maximization problem that is associated with $g^t(P,x)$, which uses the original output prices P, then they equivalently solve the profit maximization problem that is associated with $g^t(p,x)$, which uses the normalized output prices $p \equiv P/P_C$; i.e., Therefore, their behaviour can be described by using either $g^t(P,x)$ or $g^t(p,x)$.

chooses the period t−1 reference vectors p^{t-1} and x^{t-1} and a *Paasche type measure* $\tau_P{}^t$ that chooses the period t reference vectors p^t and x^t:

$$(10)\ \tau_L{}^t \equiv \tau(p^{t-1},x^{t-1},t) = g^t(p^{t-1},x^{t-1})/g^{t-1}(p^{t-1},x^{t-1})\ ; \qquad t = 1,2, ... ;$$
$$(11)\ \tau_P{}^t \equiv \tau(p^t,x^t,t) = g^t(p^t,x^t)/g^{t-1}(p^t,x^t)\ ; \qquad t = 1,2, ...$$

Since both measures of technical progress are equally valid, it is natural to average them to obtain an overall measure of productivity growth. If we want to treat the two measures in a symmetric manner and we want the measure to satisfy the time reversal property from index number theory[20] (so that the estimate going backwards is equal to the reciprocal of the estimate going forwards), then the geometric mean will be the best simple average to take.[21] Thus we define the geometric mean of (10) and (11) as follows:[22]

$$(12)\ \tau^t \equiv [\tau_L{}^t\, \tau_P{}^t]^{1/2}\ ; \qquad t = 1,2, ...$$

At this point, it is not clear how we will obtain empirical estimates for the theoretical productivity growth indexes defined by (10)-(12). One obvious way would be to assume a functional form for the GDP function $g^t(p,x)$, collect data on output and input prices and quantities for the market sector for a number of years (and for the consumption expenditures deflator), add error terms to equations (7) and (8) and use econometric techniques to estimate the unknown parameters in the assumed functional form. However, econometric techniques are generally not completely straightforward: different econometricians will make different stochastic specifications and will choose different functional forms.[23] Moreover, as the number of outputs and inputs grows, it will be impossible to estimate a flexible functional form. Thus we will suggest methods for implementing measures like (12) in this paper that are based on exact index number techniques.

We turn now to the problem of defining theoretical indexes for the effects on real income due to changes in real output prices. Define a family of *period t real output price growth factors* $\alpha(p^{t-1},p^t,x,s)$:[24]

$$(13)\ \alpha(p^{t-1},p^t,x,s) \equiv g^s(p^t,x)/g^s(p^{t-1},x)\ ; \qquad s = 1,2, ...$$

Thus $\alpha(p^{t-1},p^t,x,s)$ measures the proportional change in the real income produced by the market sector that is induced by the change in real output prices going from period t−1 to t, using the reference technology that is available during period s and using the reference input quantities x. Thus, each choice of the reference period for technology s and the reference input vector x will generate a possibly

[20] See Fisher (1922; 64).

[21] See the discussion in Diewert (1997) on choosing the "best" symmetric average of Laspeyres and Paasche indexes that will lead to the satisfaction of the time reversal test by the resulting average index.

[22] The theoretical productivity change indexes defined by (10)-(12) were first defined by Diewert and Morrison (1986; 662-663). See Diewert (1993) for properties of symmetric means.

[23] "The estimation of GDP functions such as (19) can be controversial, however, since it raises issues such as estimation technique and stochastic specification. ... We therefore prefer to opt for a more straightforward index number approach." Ulrich Kohli (2004a; 344).

[24] This measure of real output price change was essentially defined by Fisher and Shell (1972; 56-58), Samuelson and Swamy (1974; 588-592), Archibald (1977; 60-61), Diewert (1980; 460-461) (1983; 1055) and Balk (1998; 83-89). Readers who are familiar with the theory of the true cost of living index will note that the real output price index defined by (13) is analogous to the Konüs (1924) *true cost of living index* which is a ratio of cost functions, say $C(u,p^t)/C(u,p^{t-1})$ where u is a reference utility level: g^s replaces C and the reference utility level u is replaced by the vector of reference variables x.

different measure of the effect on real income of a change in real output prices going from period t−1 to period t.

Again, we can choose the reference vectors for the measure of output price change defined by (13) from the current year or the previous year: a *Laspeyres type measure* $\alpha_L{}^t$ that chooses the period t−1 reference technology and reference input vector x^{t-1} and a *Paasche type measure* $\alpha_P{}^t$ that chooses the period t reference technology and reference input vector x^t:

(14) $\alpha_L{}^t \equiv \alpha(p^{t-1},p^t,x^{t-1},t-1) = g^{t-1}(p^t,x^{t-1})/g^{t-1}(p^{t-1},x^{t-1})$; $t = 1,2, \ldots$;
(15) $\alpha_P{}^t \equiv \alpha(p^{t-1},p^t,x^t,t) \quad = g^t(p^t,x^t)/g^t(p^{t-1},x^t)$; $t = 1,2, \ldots$.

Since both measures of real output price change are equally valid, it is natural to average them to obtain an overall measure of the effects on real income of the change in real output prices:[25] The simple geometric mean is justified from the same reason as that for the technical progress shift function.

(16) $\alpha^t \equiv [\alpha_L{}^t \alpha_P{}^t]^{1/2}$; $t = 1,2, \ldots$.

Finally, we look at the problem of defining theoretical indexes for the effects on real income due to changes in real output prices. Define a family of *period t real input quantity growth factors* $\beta(x^{t-1},x^t,p,s)$:[26]

(17) $\beta(x^{t-1},x^t,p,s) \equiv g^s(p,x^t)/g^s(p,x^{t-1})$; $s = 1,2, \ldots$.

Thus $\beta(x^{t-1},x^t,p,s)$ measures the proportional change in the real income produced by the market sector that is induced by the change in input quantities going from period t−1 to t, using the technology that is available during period s and facing the reference real output prices p. Thus, each choice of the reference period for technology s and the reference real output price vector p will generate a possibly different measure of the effect on real income of a change in input quantities going from period t−1 to period t.

Again, We can choose the reference vectors for the measure of input quantity change defined by (13) from the current year or the previous year: a *Laspeyres type measure* $\beta_L{}^t$ that chooses the period t−1 reference technology and reference real output price vector p^{t-1} and a *Paasche type measure* $\beta_P{}^t$ that chooses the period t reference technology and reference real output price vector p^t:

(18) $\beta_L{}^t \equiv \beta(x^{t-1},x^t,p^{t-1},t-1) = g^{t-1}(p^{t-1},x^t)/g^{t-1}(p^{t-1},x^{t-1})$; $t = 1,2, \ldots$;
(19) $\beta_P{}^t \equiv \beta(x^{t-1},x^t,p^t,t) \quad = g^t(p^t,x^t)/g^t(p^t,x^{t-1})$; $t = 1,2, \ldots$.

Since both measures of real input growth are equally valid, it is natural to average them to obtain an overall measure of the effects of input growth on real income:[27] The simple geometric mean is justified from the same reason as that for the technical progress shift function.

(20) $\beta^t \equiv [\beta_L{}^t \beta_P{}^t]^{1/2}$; $t = 1,2, \ldots$.

[25] The indexes defined by (13)-(16) were defined by Diewert and Morrison (1986; 664) in the nominal GDP function context.
[26] This type of index was defined as a true index of value added by Sato (1976; 438) and as a real input index by Diewert (1980; 456).
[27] The theoretical indexes defined by (17)-(20) were defined in Diewert and Morrison (1986; 665) in the nominal GDP context.

We provide all the theoretically motivated measures such as τ_L^t, α_L^t, β_L^t, τ_P^t, α_P^t, and β_P^t. Now, we consider how to calculate these measures from the observed data. On the first sight, the effort is hopeless. Under the constant returns to scale assumption on the technology set S^t, we have

(21) $p^t y^t = g^t(p^t,x^t)$

It means that we observe values for the denominator of Laspeyres type measure such as τ_L^t, α_L^t, β_L^t and for the numerator of Paasche type measure such as τ_P^t, α_P^t, β_P^t. However, since we only know the denominator or the numerator of indicators, we cannot calculate even any indicators of τ_L^t, α_L^t, β_L^t, τ_P^t, α_P^t, and β_P^t.

For example, the numerator of Laspeyres type measure technical progress $g^t(p^{t-1},x^{t-1})$ is the hypothetical revenue that would result from using the period t technology with the period t−1 input quantities and real output prices. Fortunately, these hypothetical revenues can be inferred from observed data if the period t revenue function follows the Translog functional form. The following Translog functional form is known as the flexible functional form which approximates the arbitrary revenue function by the second order:[28]

$$(22)\ \ln g^t(p,x) \equiv a_0^t + \sum_{m=1}^{M} a_m^t \ln p_m^t + (1/2) \sum_{m=1}^{M}\sum_{k=1}^{M} a_{mk} \ln p_m^t \ln p_k^t$$
$$+ \sum_{n=1}^{N} b_n^t \ln x_n^t + (1/2)\sum_{n=1}^{N}\sum_{j=1}^{N} b_{nj} \ln x_n^t \ln x_j^t + \sum_{m=1}^{M}\sum_{n=1}^{M} c_{mn} \ln p_m^t \ln x_n^t\ ; \quad t = 1,2, \ldots .$$

Note that the coefficients for the quadratic terms are assumed to be constant over time. The coefficients must satisfy the following restrictions in order for g^t to satisfy the linear homogeneity properties that we have assumed in section 2 above:[29]

(23) $\sum_{m=1}^{M} a_m^t = 1$ for $t = 0,1,2, \ldots$;
(24) $\sum_{n=1}^{N} b_n^t = 1$ for $t = 0,1,2, \ldots$;
(25) $a_{mk} = a_{km}$ for all k,m ;
(26) $b_{nj} = b_{jn}$ for all n,j ;
(27) $\sum_{k=1}^{M} a_{mk} = 0$ for $m = 1,\ldots,M$;
(28) $\sum_{j=1}^{N} b_{nj} = 0$ for $n = 1,\ldots,N$;
(29) $\sum_{n=1}^{N} c_{mn} = 0$ for $m = 1,\ldots,M$;
(30) $\sum_{m=1}^{M} c_{mn} = 0$ for $n = 1,\ldots,N$.

Theorem 1: Adaptation of Diewert and Morrison (1986)[30]: If g^{t-1} and g^t are defined by (22)-(30) above and there is competitive profit maximizing behaviour on the part of all market sector producers for all period t, we have

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[28] This functional form was first suggested by Diewert (1974; 139) as a generalization of the translog functional form introduced by Christensen, Jorgenson and Lau (1971). Diewert (1974; 139) indicated that this functional form was flexible.

[29] There are additional restrictions on the parameters which are necessary to ensure that $g^t(p,x)$ is convex in p and concave in x.

[30] Diewert and Morrison (1986) established their proof using the nominal GDP function $g^t(P,x)$. However, it is easy to rework their proof using the deflated GDP function $g^t(p,x)$ using the fact that $g^t(p,x) = g^t(P/P_C,x) = g^t(P,x)/P_C$ using the linear homogeneity property of $g^t(P,x)$ in P. This argument is also true for theorem 2 and 3.

(31) $\tau^t = p^t y^t/(\alpha^t\, \beta^t\, p^{t-1}y^{t-1})$; $t = 1,2, ...$

where

(32) $\ln\alpha^t = \Sigma_{m=1}(1/2)[(p_m^{t-1}y_m^{t-1}/p^{t-1}\cdot y^{t-1}) + (p_m^t y_m^t/p^t\cdot y^t)]\ \ln(p_m^t/p_m^{t-1})$;

(33) $\ln\beta^t = \Sigma_{n=1}(1/2)[(w_n^{t-1}x_n^{t-1}/w^{t-1}\cdot x^{t-1}) + (w_n^t x_n^t/w^t\cdot x^t)]\ \ln(x_n^t/x_n^{t-1})$;

The above theorem shows how we can calculate the theoretically motivated measures such as τ^t, α^t, and β^t from observed data. Another contribution of the theorem is to show that the real income growth can be exactly decomposed into the three explanatory factors: productivity growth, real output price change, and input quantity change.

For some purposes, it is convenient to decompose the aggregate period t contribution to real income growth due to changes in all real output prices α^t into separate effects for the change in each real output price. Similarly, it can sometimes be useful to decompose the aggregate period t contribution to real income growth due to changes in all input quantities β^t into separate effects for the change in each input quantity. We indicate how this can be done, making the same assumptions on the technology that we have made so far.

We first model the effect of the change in the real output price of output m, say p_m, going from period t−1 to t. Counterparts to the theoretical Laspeyres and Paasche type price indexes defined by (14) and (15) above for all the outputs are the following *Laspeyres type measure* α_{Lm}^t that chooses the period t−1 reference technology, holds constant other real output prices at their period t−1 levels, and holds input quantities constant at their period t−1 levels and a *Paasche type measure* α_{Pm}^t that chooses the period t reference technology, holds constant other real output prices at their period t levels, and holds input quantities constant at their period t levels;

(34) $\alpha_{Lm}^t \equiv g^{t-1}(p_1^{t-1},...,p_{m-1}^{t-1},p_m^t,p_{m+1}^{t-1},..., p_M^{t-1},x^{t-1})/g^{t-1}(p^{t-1},x^{t-1})$; $m = 1,...,M;\ t = 1,2, ...$;

(35) $\alpha_{Pm}^t \equiv g^t(p^t,x^t)/g^t(p_1^t,...,p_{m-1}^t,p_m^{t-1},p_{m+1}^t,..., p_M^t,x^t)$; $m = 1,...,M;\ t = 1,2, ...$.

Since both measures of real output price change are equally valid, it is natural to average them to obtain an *overall measure of the effects on real income of the change in the real price of output m*:[31]

(36) $\alpha_m^t \equiv [\alpha_{Lm}^t\,\alpha_{Pm}^t]^{1/2}$; $m = 1,...,M ; t = 1,2, ...$.

Under the assumption that the deflated GDP functions $g^t(p,x)$ have the translog functional forms as defined by (22)-(30), the arguments of Diewert and Morrison (1986; 666) provide the following exact decomposition of the period t aggregate real output price contribution factor α^t into a product of separate price contribution factors α_m^t:

Theorem 2: Adaptation of Diewert and Morrison (1986): If g^{t-1} and g^t are defined by (22)-(33) above and there is competitive profit maximizing behaviour on the part of all market sector producers for all periods t, then we have

(37) $\alpha^t = \alpha_1^t\alpha_2^t ... \alpha_M^t$; $t = 1,2, ...$.

where

[31] The indexes defined by (34)-(36) were defined by Diewert and Morrison (1986; 666) in the nominal GDP function context.

$$(38)\ \ln\alpha_m{}^t = (1/2)[(p_m{}^{t-1}y_m{}^{t-1}/p^{t-1}\cdot y^{t-1}) + (p_m{}^t y_m{}^t/p^t\cdot y^t)]\ \ln(p_m{}^t/p_m{}^{t-1})\ ; \qquad m = 1,\ldots,M.$$

For example, we consider the case where there are four net outputs:

- 1: Domestic sales;
- 2: Investment;
- 3: Exports and;
- 4: Imports.

Since commodities 1, 2, and 3 are outputs, y_1, y_2, and y_3 will be positive but since commodity 4 is an input into the market sector, y_3 will be negative. Hence an increase in the real price of exports will *increase* real income but an increase in the real price of imports will *decrease* the real income generated by the market sector, as is evident by looking at the contribution terms defined by (38) for m = 3(where $y_m{}^t > 0$) and for m = 4(where $y_m{}^t < 0$). The above decomposition (38) is useful for analyzing the impacts that the changes in the real price of exports (i.e., a change in the price of exports relative to the price of domestic consumption) and in the real price of imports make on the real income generated by the market sector.

We now model the effects of the change in the quantity of input n, say x_n, going from period t−1 to t. Individual counterparts to the overall theoretical Laspeyres and Paasche type quantity indexes defined by (18) and (19) above for all the inputs are the following *Laspeyres type measures* for input n $\beta_{Ln}{}^t$ that chooses the period t−1 reference technology and holds constant real output prices at their period t−1 levels and holds other input quantities (other than input n) constant at their period t−1 levels and the *Paasche type measures* for input n $\beta_{Pn}{}^t$ that chooses the period t reference technology and hold constant real output prices at their period t levels and hold other input quantities constant at their period t levels;

$$(39)\ \beta_{Ln}{}^t \equiv g^{t-1}(p^{t-1},x_1{}^{t-1},\ldots,x_{n-1}{}^{t-1},x_n{}^t,x_{n+1}{}^{t-1},\ldots, x_N{}^{t-1})/g^{t-1}(p^{t-1},x^{t-1})\ ; \qquad n = 1,\ldots,N;\ t = 1,2, \ldots ;$$
$$(40)\ \beta_{Pn}{}^t \equiv g^t(p^t,x^t)/g^t(p^t,x_1{}^t,\ldots,x_{n-1}{}^t,x_n{}^{t-1},x_{n+1}{}^t,\ldots, x_N{}^t)\ ; \qquad n = 1,\ldots,N;\ t = 1,2, \ldots .$$

Since both measures of input change are equally valid, as usual, we average them to obtain *an overall measure of the effects on real income of the change in the quantity of input n*:[32]

$$(41)\ \beta_n{}^t \equiv [\beta_{Ln}{}^t\beta_{Pn}{}^t]^{1/2}\ ; \qquad n = 1,\ldots,N\ ;\ t = 1,2, \ldots .$$

Under the assumption that the deflated GDP functions $g^t(p,x)$ have the Translog functional forms as defined by (22)-(30), the arguments of Diewert and Morrison (1986; 666) can be adapted to provide the following exact decomposition of the period t aggregate input growth contribution factor β^t into a product of separate input contribution factors $\beta_n{}^t$:

Theorem 3: Adaptation of Diewert and Morrison (1986): If g^{t-1} and g^t are defined by (22)-(30) above and there is competitive profit maximizing behaviour on the part of all market sector producers for all periods t, then we have

$$(42)\ \beta^t = \beta_1{}^t\beta_2{}^t\ldots\ \beta_N{}^t\ ; \qquad t = 1,2, \ldots .$$

where

[32] The indexes defined by (33)-(41) were defined by Diewert and Morrison (1986; 667) in the nominal GDP function context.

(43) $\ln\beta_n^t = (1/2)[(w_n^{t-1}x_n^{t-1}/w^{t-1}\cdot x^{t-1}) + (w_n^t x_n^t/w^t\cdot x^t)] \ln(x_n^t/x_n^{t-1})$;   n = 1,...,N.

Substituting the results in Theorems 2 and 3 into the decomposition in Theorem 1 and rearranging the terms, we obtain the following formula;

(44) $\rho^t/\rho^{t-1} = \tau^t\prod_{m=1}^M \alpha_m^t \prod_{n=1}^N \beta_n^t$;   t = 1,2, ...

Thus *the growth in real income over time can be explained by three main factors: productivity growth, the growth of real output prices, and the growth of input quantities.*

Rather than look at explanatory factors for the growth in real income, it is sometimes convenient to express the level of real income in period t in terms of cumulated period to period growth factors. Thus (45) below defines a period t index of *the technology level* or of Total Factor Productivity in period t relative to period 0, T^t; (46) defines a period t cumulated index of the level of real output m price change since period 0, A_m^t; and (47) defines a period t cumulated index of the growth of input n since period 0:

(45) $T^0 \equiv 1$; $T^t \equiv T^{t-1}\tau^t$;   t = 1,2,…,;
(46) $A_m^0 \equiv 1$; $A_m^t \equiv A_m^{t-1}\alpha_m^t$;   m = 1,2,…,M and t = 1,2,…,;
(47) $B_n^0 \equiv 1$; $B_n^{t-1} \equiv B_n^0\beta_n^t$;   n = 1,2,…,N and t = 1,2,…,;

Using the appropriate equalities (44) for the chain links that appear in (45)-(47), we can establish the following exact relationship for the level of real income in period t, ρ^t, relative to its counterpart in period 0, ρ^0, and the cumulated growth factors defined by (45)-(47):

(48) $\rho^t/\rho^0 = T^t\prod_{m=1}^M A_m^t \prod_{n=1}^N B_n^t$;   t = 1,2, ...

3. Data Construction

3.1 The Definition of the Market Sector

In this paper, we focus on the production of the market sector within the whole economy. This is the sector which plays the critical role for economic growth. Following the *1993 SNA*, we classify the producers for the whole economy into the following five mutually exclusive institutional sectors;

- IU1; Non-financial corporations;
- IU2; Financial corporations;
- IU3; General government;
- IU4; Households[33];
- IU5; Non-profit institutions serving households.

In our definition, the market sector consists of IU1, IU2, and IU5. Thus, we subtract the government's and the households' outputs and inputs from aggregate output, capital services and labour input in order to perform the growth accounting exercise explained in the previous section. There are two types of transactions between the market sector and general government sector; (1) the sales of goods and services of the general government sector to the market sector and (2) the purchases of intermediate inputs by the general government sector from the market sector. Note that the sales of goods and services by the general government sector are considered as inputs for the market sector while the purchases of intermediate inputs by the general government sector are regarded as outputs by the market

[33] According to UN (1993), the unincorporated enterprises are parts of the household sectors. However, we added the unincorporated enterprises to IU1 or IU2 based on the characteristics of the enterprise. Therefore, in our classification, households only includes household own-account producers.

sector. Thus, the difference between (1) and (2) is the net output by the market sector which has been purchased by the general government sector. In the Japanese national accounts, the imputed rent of the owner-occupied dwellings is the major output by the household sector.[34] The households sector produces imputed rent by making use of capital services from the stock of owner-occupied houses. Therefore, we need to subtract the imputed rent from the consumption output and the stock of owner-occupied houses from the total stock of residential buildings.[35]

3.2 The Database for Inputs and Outputs

Our final data set consists of price and quantity series for the variables listed below. They are the inputs and outputs for the market sector. We also followed the conventions introduced by Jorgenson and Griliches on the treatment of indirect taxes; i.e., we adjusted prices for tax wedges whenever possible so that the adjusted prices reflect the prices that producers face.[36] We also included the services of inventories and land (utilized by the market sector) as capital inputs.

The net outputs in our most disaggregated data base are as follows:

- C; Domestic final consumption expenditure of households (excluding the imputed rent of owner-occupied dwellings);
- N; Final consumption expenditure of private non-profit institutions serving households;
- G; Net purchases of goods and services by the general government from the market sector;
- X; Exports of goods and services (including direct purchases in the domestic market by non-resident households since this is a source of revenue to the market sector);
- M; Imports of goods and services (excluding direct purchases abroad by resident households since this is not a source of revenue to the Japanese market sector);
- I1 to I95; Gross investments for 95 asset categories;
- IV1 to IV4; Change in inventories for 4 types of inventory asset.

The primary inputs in our most disaggregated data base are as follows:

- K1 to K95; Capital services from 95 classes of fixed asssets;
- KIV1 to KIV4; Inventory services for 4 classes of inventory asset;
- LD1 to LD4; Market sector land services and
- LB1 to LB3; Labour input for 3 types of labour.

Dividing the prices of inputs and outputs by the price of domestic final consumption expenditure of households P_C, we constructed the corresponding real input and output prices. The net outputs C, N, G, X, and M have been constructed as aggregates of the net output components listed above and are essentially based on the data of the Japanese national accounts. Since the Japanese national accounts experienced several revisions, there are different data series even for the same variable. We chose the reference data series from the most recent publication and extended these series by using the growth

[34] We ignore other own-account production by households.

[35] The household sector purchases goods and services for the maintenance of owner-occupied houses. The expenses on these goods and services are produced by the market sector and thus are part of our market sector output.

[36] Thus our suggested treatment of indirect commodity taxes in an accounting framework that is suitable for productivity analysis follows the example set by Jorgenson and Griliches who advocated the following treatment of indirect taxes: "In our original estimates, we used gross product at market prices; we now employ gross product from the producers' point of view, which includes indirect taxes levied on factor outlay, but excludes indirect taxes levied on output." Jorgenson and Griliches (1972; 85).

rates of other data series from earlier publications.[37] A more detailed explanation of our data construction methods is provided in appendix.

Table 1: List of Capital Services, Inventory Services, and Land Services

Name			
K1	Trees (growth)	K53	Other ships
K2	Livestock (growth)	K54	Railway vehicles
K3	Textile products	K55	Aircraft
K4	Wooded products	K56	Bicycles
K5	Wooden furniture and fixtures	K57	Transport equipment for industrial use
K6	Metallic furniture and fixtures	K58	Other transport equipment
K7	Nuclear fuel rods	K59	Camera
K8	Metallic products	K60	Other photographic and optical instruments
K9	Boilers and turbines	K61	Watches and clocks
K0	Engines	K62	Physics and chemistry instruments
K11	Conveyors	K63	Analytical and measuring instruments and testing machines
K12	Refrigerators and air conditioning apparatus	K64	Medical instruments
K13	Pumps and compressors	K65	Miscellaneous manufacturing products
K14	Sewing machines	K66	Residential construction (wooden)
K15	Other general industrial machinery and equipment	K67	Residential construction (non-wooden)
K16	Mining, civil engineering and construction machinery	K68	Non-residential construction (wooden)
K17	Chemical machinery	K69	Non-residential construction (non-wooden)
K18	Industrial robots	K70	Road construction
K19	Metal machine tools	K71	Street construction
K20	Metal processing machinery	K72	Bridge construction
K21	Agricultural machinery	K73	Toll road construction
K22	Textile machinery	K74	River improvement
K23	Food processing machinery	K75	Erosion control
K24	Sawmill, wood working, veneer and plywood machinery	K76	Seashore improvement
K25	Pulp equipment and paper machinery	K77	Park construction
K26	Printing, bookbinding and paper processing machinery	K78	Sewer construction
K27	Casting equipment	K79	Sewage disposal facilities
K28	Plastic processing machinery	K80	Waste disposal facilities
K29	Other special industrial machinery, nec	K81	Harbor construction
K30	Other general machines and parts	K82	Fishing port construction
K31	Office machines	K83	Airport construction
K32	Vending, amusement and other service machinery	K84	Agricultural construction
K33	Electric audio equipment	K85	Forest road construction
K34	Radio and television sets	K86	Forestry protection
K35	Video recording and playback equipment	K87	Railway construction
K36	Household electric appliance	K88	Electric power facilities
K37	Electronic computer and peripheral equipment	K89	Telecommunication facilities
K38	Wired communication equipment	K90	Other civil engineering and construction
K39	Radio communication equipment	K91	Plant engineering
K40	Other communication equipment	K92	Mineral exploration
K41	Applied electronic equipment	K93	Custom software
K42	Electric measuring instruments	K94	Pre-packaged software
K43	Generators	K95	Own-account software
K44	Electric motors	KIV1	Finished-goods inventory
K45	Relay switches and switchboards	KIV2	Work-in-process inventory
K46	Other industrial heavy electrical equipment	KIV3	Work-in-process inventory for cultivated assets
K47	Electric lighting fixtures and apparatus	KIV4	Material inventory
K48	Passenger motor vehicles	LD1	Land for agricultural use
K49	Trucks, buses and other vehicles	LD2	Land for industrial use
K50	Two-wheel motor vehicles	LD3	Land for commercial use
K51	Motor vehicle parts	LD4	Land for residential use
K52	Steel ships		

[37] The data from the Japanese national accounts are taken from publications such as the *Annual Report on National Income Statistics 1975*, *Report on National Accounts from 1955 to 1998*, *Annual Report on National Accounts of 2000*, and *Annual Report on National Accounts of 2004-2008*. See appendix for the further explanation.

Quantities of capital services, inventory services, and land services are proportional to capital stocks of fixed assets, inventories, and land at the beginning of the year. Capital stocks have been constructed by applying the perpetual inventory method using the gross investment data (I1 to I95) to the initial stocks of 1955, using asset specific depreciation rates suggested by Nomura (2004). Changes in Inventories IV1-IV4 are calculated by using the difference between the inventory stock in the current period and the inventory stock in the previous period. The initial stocks for fixed assets, inventory stocks and land and the price and quantity series for investments have been taken from KEO database. This is a comprehensive productivity database for the Japanese economy constructed by the Keio Economic Observatory (KEO) at Keio University.[38] The detailed procedures used to construct prices and quantities for capital stocks and services are explained in Nomura (2004). For residential structures and residential land, we use other data sources in order to net out the stocks held by the household sector, which corresponds to the stocks of residential land and structures used by owner-occupier households. Our procedures will be explained in the following subsection. Prices of capital services for the 95 types of reproducible capital services K1-K95, for the 4 types of inventory services KIV1-KIV4 and the four types of land services LD1-LD4 are calculated by applying a user cost formula which we will explain in the next section.

Estimates of the quantities of labour services LB1-LB4 are based on hours of work. There are three different types of workers; the self-employed, family workers, and employees. After we calculate the average labour income and the hours of works for each type of worker, we aggregate these three types of labour into a labour aggregate using a superlative index number formula. We explain how we calculate the average labour income for three types of workers in the data appendix. Investments I1-I95 correspond to the capital services K1-K95. Changes in inventories IV1-IV4 correspond to the inventory stocks KIV1-KIV4. The Table 1 lists the names of all capital stocks, inventory stocks and land stocks.

The following subsection explains how we constructed the price, quantity and value series for the capital inputs. The details on how our labour inputs were constructed may be found in Appendix A.

3.3 User Costs and Real Rates of Return

Prices of capital services, inventory services and land services are estimated as user costs of capital. User costs are constructed for each of our capital stock components. The general formula for a user cost for a capital stock component in year t, u^t, is as follows:

$$(49)\quad u^t = P_K{}^t - (1-\delta)P_K{}^t(1+i^t)/(1+r^t)$$

where $P_K{}^t$ is the beginning of year t asset price for the capital stock component, δ is the geometric depreciation rate that applies to the asset,[39] i^t is the amount of asset specific price change that is expected to occur over the course of year t and r^t is the nominal rate of return (or opportunity cost of capital) that producers face at the beginning of year t. Thus the user cost of a durable input is equal to its purchase cost or opportunity cost at the beginning of the year, $P_K{}^t$, less the discounted expected value of the depreciated asset at the end of the year.[40] The nominal rate of return r^t can be decomposed into a real rate of return component r^{t*} and an expected general inflation component, i^{t*}, by using the following formula:

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[38] This database also includes labour inputs. Kuroda, Shimpo, Nomura, and Kobayashi (1997) explains the data construction of labour inputs in detail. In this paper, we use only their relative wages for employees, the self-employed and family workers from KEO database.

[39] We assume that the depreciation rates for the inventory stocks and land components are 0.

[40] We have temporarily neglected tax factors for simplicity.

(50) $1+r^t = (1+r^{t*})(1+ i^{t*})$.

The practical problem for the economic statistician with a user cost formulae of the type defined by (49) and (50) is that there is *uncertainty* about how exactly to estimate the depreciation rate δ, the relevant real rate of return r^{t*} and the two anticipated inflation rates, ρ^t (general inflation rate) and i^t (asset specific inflation rate). If we estimate i^{t*} and i^t as actual ex post inflation rates, we will almost certainly generate user costs u^t which are negative for some years, which is not sensible in our context since we want our user costs to closely approximate market rental rates for the assets and these rates would not be negative. Even if we estimate i^{t*} and i^t by smoothing the ex post values for these variables or using a forecasting model, with Japanese data, we will inevitably generate some negative user costs for land components, due to the very rapid land price inflation that occurred in Japan during the 1980's. We decided to avoid these negative user cost problems by assuming that producers expect the asset specific inflation rate i^t to equal the general inflation rate i^{t*}; i.e., we make the following assumption:

(51) $i^t = i^{t*}$.

If we substitute (50) and (51) into (49), we find that our user cost formula simplifies as follows:[41]

(52) $u^t = P_K{}^t - (1-\delta)P_K{}^t/(1+r^{t*}) = [r^{t*} + \delta]P_K{}^t /(1+r^{t*})$.

We approximate the beginning of the year asset price $P_K{}^t$ by the corresponding year t investment price $P_I{}^t$. Thus our final user cost formula has the following generic form where τ^t is the business tax rate:[42]

(53) $u^t \equiv [r^{t*} + \tau^t + \delta]P_I{}^t /(1+r^{t*})$.

There remains the problem of finding a suitable real interest rate series, r^{t*}, which will be discussed below. Once r^{t*} has been determined, the user cost defined by (53) can be calculated for each of our 95 types of capital services, 4 types of inventory services, and 4 types of land services. The corresponding beginning of year capital stocks have already been described and tabled. We normalize the resulting user costs so that they are 1 in 1955 and offsetting normalizations are made to our capital quantity series. The resulting input prices are $W_{K1}{}^t$-$W_{K95}{}^t$, $W_{KIV1}{}^t$-$W_{KIV4}{}^t$, and $W_{LD1}{}^t$-$W_{LD4}{}^t$ and the resulting quantities are $x_{K1}{}^t$-$x_{K95}{}^t$, $x_{KIV1}{}^t$-$x_{KIV4}{}^t$, and $x_{LD1}{}^t$-$x_{LD4}{}^t$. The price series and the quantity series for 13 aggregated inputs and outputs are listed in Appendix B.[43]

Finally, we discuss how we obtained a suitable real interest rate series r^{t*}. The rate we chose is an economy wide ex post real rate of return. If we use the user cost formula (53) in order to form prices for capital services, then we can rearrange the value of outputs equals the value of primary inputs equation into a single (linear) equation involving an unknown real rate of return. The solutions to these equations (one for each year) are the series of ex post real interest rates, r^{t*}, listed below in Figure 1.

The average rate for the years 1955-2006 is 3.25%. It is consistent with "the long run observed economy wide real rates of return for most OECD countries which fall in the 3 to 5 per cent rage" (Diewert (2004)). The performance of the Japanese economy over the years 1955-2006 can be divided into 5 periods:

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[41] For discussions about alternative assumptions for user cost formulae, see Schreyer (2001) (2007) (2008) and Diewert (1980) (2004) (2005b).

[42] For business structures and land, we need to add the appropriate specific property tax rates to the general tax rate τ^t.

[43] More detailed data will be provided to the interested reader.

- Period 1: 1955-1973: Rapid economic growth;
- Period 2: 1974-1979: Stagnation between oil shocks;
- Period 3: 1980-1990: Stable economic growth;
- Period 4: 1991-2001: Long recession and stagnation;
- Period 5: 2002-2006: Modest economic recovery.

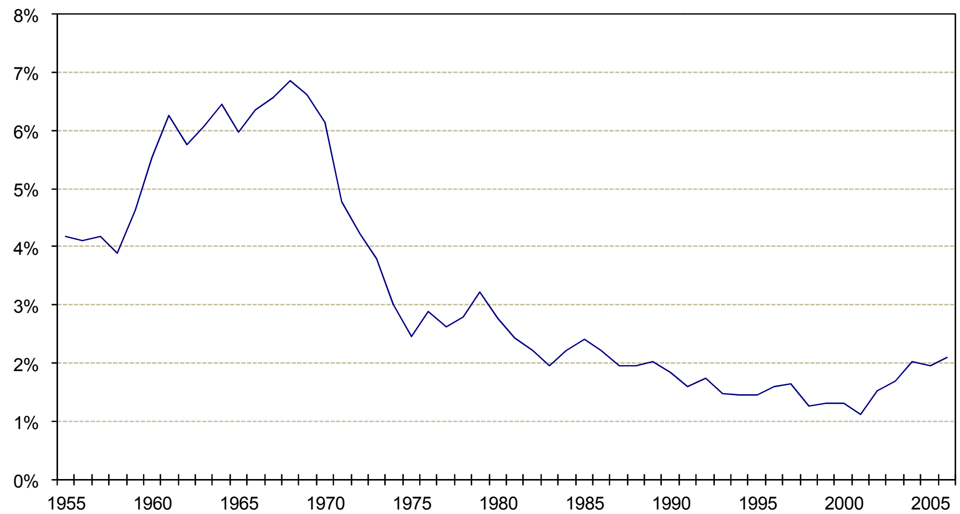

Figure 1: The Real Rate of Return for the Years 1955-2006

The average real rates of return for the above periods are 5.390% (Period 1), 2.841% (Period 2), 2.196% (Period 3), 1.467% (Period 4) and 1.876% (Period 5). Even though currently, the Japanese economy is in a period of economic recovery, its average real rate of return is still significantly smaller than the average real rate of return of the period of rapid economic growth (Period 1).

4. Results

4.1 Japanese Productivity Growth: A Conventional Approach

In this section, we measure the productivity growth of the market sector of the Japanese economy using a conventional chained Fisher index number approach. Depending on whether inventory stock services or land services are included in the list of primary inputs, we can consider three different cases:

- Case 1: inventory stock services and land stock services are in the list of capital inputs;
- Case 2: land stock services are not in the list of capital services and
- Case 3: inventory stock services and land stock services are both excluded from the list of capital services.

Since we endogenously determine the real rate of return from the zero profit condition, the composition of capital inputs affects the real rate of return. Basically, the conventional measure of productivity growth is set equal to a chained Fisher output quantity index divided by a chained Fisher input quantity index. Thus, the composition of capital inputs also affects the productivity growth. Thus in Table 2, under the above three assumptions, we list three sets of the Fisher year to year output and input growth factors, y^t/y^{t-1}, x^t/x^{t-1} respectively along with their ratios, $\tau^t \equiv [y^t/y^{t-1}]/[x^t/x^{t-1}]$ and the balancing year t real interest rates r^t.

Table 2: Chained Fisher Indexes of Output, Input and Productivity Growth and the Balancing Real Rate of Return in the Japanese Economy, 1956-2006.

	Case 1				Case 2				Case 3			
	y^t/y^{t-1}	x^t/x^{t-1}	τ^t	r^r	y^t/y^{t-1}	x^t/x^{t-1}	τ^t	r^r	y^t/y^{t-1}	x^t/x^{t-1}	τ^t	r^r
1955	1.00000	1.00000	1.00000	0.04185	1.00000	1.00000	1.00000	0.10316	1.00000	1.00000	1.00000	0.13416
1956	1.11124	1.04610	1.06227	0.04113	1.11130	1.05022	1.05815	0.10607	1.11130	1.04597	1.06246	0.13968
1957	1.09559	1.04682	1.04659	0.04191	1.09565	1.05394	1.03958	0.11287	1.09565	1.04981	1.04366	0.15407
1958	1.05114	1.03596	1.01466	0.03895	1.05135	1.04498	1.00610	0.11166	1.05135	1.04277	1.00823	0.15524
1959	1.13732	1.03339	1.10057	0.04634	1.13733	1.03941	1.09421	0.14247	1.13733	1.04126	1.09227	0.20034
1960	1.17782	1.04740	1.12451	0.05541	1.17783	1.06035	1.11080	0.18635	1.17783	1.05895	1.11226	0.26734
1961	1.15667	1.04836	1.10331	0.06245	1.15657	1.06483	1.08615	0.20896	1.15657	1.06574	1.08523	0.30273
1962	1.07165	1.06156	1.00951	0.05757	1.07167	1.08373	0.98886	0.19339	1.07167	1.08211	0.99035	0.27666
1963	1.10261	1.04220	1.05797	0.06069	1.10258	1.05851	1.04164	0.20584	1.10258	1.06324	1.03700	0.29124
1964	1.13972	1.04801	1.08751	0.06437	1.13972	1.06512	1.07005	0.22015	1.13972	1.06736	1.06780	0.30887
1965	1.05337	1.05221	1.00111	0.05974	1.05338	1.06825	0.98608	0.20023	1.05338	1.07038	0.98412	0.27536
1966	1.13090	1.06057	1.06632	0.06356	1.13091	1.06334	1.06354	0.21867	1.13091	1.06611	1.06078	0.30131
1967	1.13551	1.05551	1.07579	0.06561	1.13552	1.06091	1.07032	0.23952	1.13552	1.06330	1.06792	0.33237
1968	1.13640	1.04439	1.08810	0.06852	1.13642	1.06495	1.06711	0.25843	1.13642	1.06534	1.06672	0.36136
1969	1.14133	1.05594	1.08087	0.06616	1.14127	1.06967	1.06693	0.26230	1.14127	1.07146	1.06515	0.36531
1970	1.10251	1.05403	1.04599	0.06137	1.10246	1.07718	1.02347	0.24610	1.10246	1.07962	1.02116	0.33527
1971	1.03639	1.04886	0.98811	0.04789	1.03592	1.07088	0.96735	0.19470	1.03592	1.07382	0.96470	0.25787
1972	1.08462	1.03837	1.04454	0.04236	1.08456	1.05163	1.03132	0.18697	1.08456	1.05745	1.02564	0.24317
1973	1.10733	1.05482	1.04978	0.03814	1.10783	1.05967	1.04545	0.17522	1.10783	1.06510	1.04012	0.22558
1974	0.98945	1.02222	0.96794	0.03011	0.98892	1.03299	0.95734	0.12219	0.98892	1.03418	0.95624	0.15367
1975	1.00794	1.00880	0.99915	0.02464	1.00775	1.01492	0.99294	0.09464	1.00775	1.01513	0.99273	0.11782
1976	1.06272	1.04474	1.01721	0.02903	1.06273	1.04880	1.01328	0.10402	1.06273	1.05224	1.00997	0.12747
1977	1.03519	1.03236	1.00274	0.02641	1.03508	1.03479	1.00028	0.09619	1.03508	1.03623	0.99889	0.11632
1978	1.05398	1.02279	1.03049	0.02801	1.05394	1.02585	1.02738	0.10390	1.05394	1.02809	1.02514	0.12382
1979	1.08746	1.02771	1.05814	0.03224	1.08740	1.03194	1.05374	0.11336	1.08740	1.03448	1.05115	0.13340
1980	1.02811	1.03101	0.99718	0.02780	1.02829	1.03745	0.99117	0.09847	1.02829	1.03631	0.99226	0.11589
1981	1.02026	1.02825	0.99223	0.02442	1.02022	1.03467	0.98604	0.08944	1.02022	1.03448	0.98621	0.10488
1982	1.02889	1.02405	1.00473	0.02243	1.02889	1.02817	1.00070	0.08430	1.02889	1.02911	0.99979	0.09816
1983	1.01990	1.03435	0.98602	0.01973	1.01990	1.03807	0.98250	0.07751	1.01990	1.03902	0.98159	0.08963
1984	1.04942	1.01687	1.03201	0.02235	1.04940	1.02095	1.02787	0.08606	1.04940	1.02240	1.02641	0.09863
1985	1.05245	1.03023	1.02157	0.02414	1.05234	1.03604	1.01573	0.09115	1.05234	1.03707	1.01472	0.10343
1986	1.02548	1.02565	0.99984	0.02239	1.02588	1.03198	0.99409	0.08901	1.02588	1.03278	0.99331	0.10000
1987	1.04535	1.02964	1.01526	0.01975	1.04535	1.03580	1.00922	0.08651	1.04535	1.03752	1.00755	0.09610
1988	1.06680	1.03325	1.03247	0.01966	1.06678	1.03803	1.02770	0.09017	1.06678	1.03883	1.02691	0.09974
1989	1.06722	1.03108	1.03506	0.02039	1.06723	1.03660	1.02955	0.09459	1.06723	1.03733	1.02883	0.10403
1990	1.05501	1.02910	1.02518	0.01847	1.05505	1.03561	1.01876	0.08950	1.05505	1.03572	1.01866	0.09820
1991	1.03178	1.02860	1.00309	0.01620	1.03175	1.03597	0.99593	0.07716	1.03175	1.03644	0.99548	0.08413
1992	1.01006	1.01805	0.99215	0.01765	1.01007	1.02275	0.98760	0.07061	1.01007	1.02328	0.98709	0.07626
1993	0.99101	1.01110	0.98013	0.01487	0.99101	1.01388	0.97744	0.05821	0.99101	1.01438	0.97696	0.06253
1994	1.01093	1.00958	1.00133	0.01463	1.01093	1.01093	1.00000	0.05499	1.01093	1.01154	0.99940	0.05896
1995	1.01713	1.01180	1.00527	0.01457	1.01716	1.01321	1.00389	0.05324	1.01716	1.01370	1.00341	0.05680
1996	1.02595	1.01054	1.01525	0.01620	1.02596	1.01162	1.01417	0.05542	1.02596	1.01156	1.01423	0.05914
1997	1.01392	1.00811	1.00576	0.01651	1.01389	1.00925	1.00459	0.05262	1.01389	1.00908	1.00476	0.05614
1998	0.97028	1.00631	0.96419	0.01273	0.97030	1.00707	0.96349	0.04135	0.97030	1.00694	0.96361	0.04415
1999	0.99586	1.00156	0.99432	0.01328	0.99592	1.00231	0.99362	0.04065	0.99592	1.00244	0.99349	0.04339
2000	1.02453	1.01694	1.00746	0.01337	1.02452	1.01671	1.00768	0.04116	1.02452	1.01732	1.00708	0.04381
2001	0.99262	0.99708	0.99553	0.01136	0.99263	0.99741	0.99521	0.03602	0.99263	0.99744	0.99517	0.03821
2002	1.00694	0.99907	1.00788	0.01536	1.00693	0.99938	1.00755	0.04076	1.00693	0.99978	1.00715	0.04299
2003	1.00865	1.00271	1.00593	0.01710	1.00868	1.00235	1.00631	0.04244	1.00868	1.00258	1.00608	0.04472
2004	1.03540	1.00794	1.02725	0.02048	1.03538	1.00847	1.02668	0.04759	1.03538	1.00881	1.02633	0.05013
2005	1.03493	1.00521	1.02957	0.01970	1.03491	1.00565	1.02909	0.04674	1.03491	1.00600	1.02873	0.04924
2006	1.03959	1.01539	1.02383	0.02115	1.03949	1.01556	1.02356	0.04821	1.03949	1.01503	1.02409	0.05093
Average	y^t/y^{t-1}	x^t/x^{t-1}	τ^t	r^r	y^t/y^{t-1}	x^t/x^{t-1}	τ^t	r^r	y^t/y^{t-1}	x^t/x^{t-1}	τ^t	r^r
1955-2006	1.05533	1.02878	1.02546	0.03252	1.05533	1.03544	1.01889	0.11522	1.05533	1.03629	1.01806	0.14751
1955-1973	1.10380	1.04603	1.05513	0.05390	1.10380	1.05829	1.04301	0.18806	1.10380	1.05946	1.04187	0.25936
1974-1979	1.03946	1.02644	1.01261	0.02841	1.03930	1.03155	1.00749	0.10572	1.03930	1.03339	1.00569	0.12875
1980-1990	1.04172	1.02850	1.01287	0.02196	1.04176	1.03394	1.00758	0.08879	1.04176	1.03460	1.00693	0.10079
1991-2001	1.00764	1.01088	0.99677	0.01467	1.00765	1.01283	0.99487	0.05286	1.00765	1.01310	0.99461	0.05668
2002-2006	1.02510	1.00606	1.01889	0.01876	1.02508	1.00628	1.01864	0.04515	1.02508	1.00644	1.01848	0.04760

Table 2 shows that it is extremely important to include land and inventory services in the list of capital services. If these primary inputs are omitted from a productivity analysis, the results will be distorted. The growth rates for primary inputs will be too high and thus productivity growth will be underestimated. The exclusion of business land services from the primary inputs significantly changes our estimate. This exclusion bias becomes more serious during periods when the price of land is very high. Thus, productivity growth when land is included (Case 1) is almost 50% greater compared to when it is excluded during the years 1980-1990 (Cases 2 and 3). This period includes the bubble era at the end of the 1980's.

Now, we turn to the theoretical framework presented in section 2 and determine the factors that explain real income growth in the Japanese economy using a traditional value added framework as opposed to the net framework which will be discussed later in section 4.3.

4.2 The Decomposition of Deflated GDP Growth

We implement the translog approach using our Japanese database. The chain link information on period by period changes in real income that corresponds to (44) is listed in Table 3.

Table 3: The Decomposition of Market Sector Real Income Growth into Translog Productivity, Real Output Price Change and Input Quantity Contribution Factors

	ρ^t	τ^t	$\alpha_C{}^t$	$\alpha_N{}^t$	$\alpha_G{}^t$	$\alpha_X{}^t$	$\alpha_M{}^t$	$\alpha_I{}^t$	$\alpha_{IV}{}^t$	$\beta_K{}^t$	$\beta_{KIV}{}^t$	$\beta_{LD}{}^t$	$\beta_{LB}{}^t$
1956	1.13349	1.06216	1.00000	1.00065	1.00110	1.00404	0.99244	1.01873	1.00309	1.00105	1.00232	1.00037	1.04230
1957	1.09829	1.04657	1.00000	1.00033	1.00032	0.99667	0.99924	1.00742	0.99853	1.00900	1.00280	1.00086	1.03372
1958	1.05396	1.01464	1.00000	1.00004	0.99874	0.99183	1.02114	0.99164	0.99958	1.01510	1.00245	1.00105	1.01702
1959	1.12932	1.10058	1.00000	1.00006	0.99919	0.99872	1.00485	0.99045	0.99973	1.01405	1.00074	1.00179	1.01650
1960	1.17609	1.12451	1.00000	1.00024	0.99918	0.99979	1.00329	0.99757	0.99847	1.01590	1.00249	1.00130	1.02712
1961	1.15450	1.10335	1.00000	1.00011	0.99889	0.99297	1.00584	1.00429	0.99608	1.02539	1.00288	1.00514	1.01422
1962	1.04941	1.00952	1.00000	1.00000	0.99811	0.99005	1.00977	0.98409	0.99725	1.03128	1.00432	1.00516	1.01966
1963	1.07386	1.05800	1.00000	0.99995	0.99764	0.99478	1.00610	0.97719	0.99821	1.02888	1.00170	1.00496	1.00620
1964	1.13395	1.08753	1.00000	1.00052	0.99889	0.99828	1.00149	0.99622	0.99954	1.02679	1.00238	1.00522	1.01294
1965	1.03110	1.00112	1.00000	0.99985	0.99816	0.99082	1.00920	0.98204	0.99881	1.02823	1.00242	1.00701	1.01372
1966	1.12652	1.06631	1.00000	1.00024	0.99941	0.99500	1.00369	0.99855	0.99925	1.02269	1.00161	1.01543	1.01964
1967	1.13975	1.07579	1.00000	1.00031	0.99990	0.99643	1.00537	1.00280	0.99893	1.02419	1.00189	1.01508	1.01336
1968	1.12644	1.08812	1.00000	1.00009	0.99905	0.99443	1.00567	0.99305	0.99897	1.02844	1.00300	1.00629	1.00613
1969	1.14055	1.08089	1.00000	1.00031	0.99920	0.99730	1.00066	1.00166	1.00019	1.03113	1.00278	1.01532	1.00579
1970	1.09177	1.04602	1.00000	1.00058	0.99883	0.99558	1.00529	0.99146	0.99856	1.03250	1.00256	1.00761	1.01052
1971	1.02189	0.98812	1.00000	1.00042	0.99810	0.99451	1.01105	0.98340	0.99910	1.03312	1.00200	1.00624	1.00692
1972	1.08106	1.04458	1.00000	1.00052	0.99821	0.99212	1.01061	0.99523	1.00020	1.02580	1.00033	1.00664	1.00521
1973	1.11654	1.04973	1.00000	1.00039	0.99937	0.99809	0.99228	1.01663	1.00128	1.02342	1.00021	1.01345	1.01684
1974	0.95963	0.96785	1.00000	1.00021	1.00525	1.00805	0.96430	0.99443	0.99792	1.02384	1.00127	1.00826	0.98909
1975	0.96594	0.99917	1.00000	0.99999	0.99241	0.99079	1.00263	0.97304	0.99944	1.01697	1.00107	1.00647	0.98451
1976	1.03629	1.01721	1.00000	1.00012	0.99908	0.98907	1.00535	0.98143	1.00000	1.01332	0.99973	1.00373	1.02745
1977	1.02215	1.00274	1.00000	1.00006	0.99884	0.98364	1.01502	0.99028	0.99992	1.01237	1.00030	1.00572	1.01364
1978	1.05758	1.03049	1.00000	0.99996	0.99813	0.98503	1.02459	0.99612	1.00012	1.01230	0.99988	1.00385	1.00661
1979	1.07995	1.05812	1.00000	1.00022	1.00047	1.00610	0.97331	1.01299	1.00035	1.01477	0.99979	1.00323	1.00973
1980	0.99400	0.99718	1.00000	0.99997	1.00187	1.00201	0.96453	0.99932	0.99909	1.01498	1.00116	1.00346	1.01113
1981	1.01436	0.99223	1.00000	0.99983	1.00031	0.99792	1.00624	0.99041	0.99965	1.01419	1.00071	1.00177	1.01135
1982	1.02273	1.00473	1.00000	0.99999	0.99900	1.00205	0.99970	0.99334	0.99998	1.01317	1.00020	1.00242	1.00810
1983	1.01495	0.98602	1.00000	0.99995	0.99958	0.99164	1.01139	0.99268	1.00005	1.01180	1.00012	1.00201	1.02012
1984	1.04747	1.03202	1.00000	1.00000	0.99933	0.99876	1.00703	0.99313	0.99997	1.01107	0.99984	1.00049	1.00540
1985	1.04710	1.02151	1.00000	1.00003	1.00130	0.99178	1.01037	0.99195	0.99970	1.01903	1.00022	1.00295	1.00785
1986	1.03404	0.99985	1.00000	1.00004	0.99747	0.97995	1.03974	0.99217	1.00001	1.01696	1.00015	1.00052	1.00786
1987	1.04380	1.01525	1.00000	1.00004	0.99866	0.99459	1.00739	0.99790	0.99999	1.01836	0.99986	1.00181	1.00940
1988	1.06827	1.03248	1.00000	1.00005	0.99896	0.99760	1.00282	1.00197	1.00001	1.01615	1.00009	1.00224	1.01447
1989	1.06921	1.03506	1.00000	1.00005	1.00011	1.00178	0.99552	1.00447	0.99996	1.01767	1.00010	1.00182	1.01122
1990	1.05126	1.02519	1.00000	1.00024	1.00026	0.99912	0.99558	1.00130	0.99990	1.01950	1.00033	1.00225	1.00681
1991	1.02965	1.00309	1.00000	1.00009	0.99935	0.99462	1.00677	0.99725	0.99992	1.01905	1.00019	1.00106	1.00811
1992	1.00706	0.99215	1.00000	0.99997	0.99945	0.99537	1.00639	0.99587	1.00001	1.01730	1.00009	1.00222	0.99842
1993	0.98677	0.98013	1.00000	0.99990	0.99951	0.99131	1.00801	0.99698	1.00009	1.01236	1.00001	1.00193	0.99683
1994	1.00652	1.00134	1.00000	1.00004	0.99920	0.99630	1.00393	0.99610	1.00009	1.00732	0.99990	1.00165	1.00070
1995	1.01522	1.00527	1.00000	1.00006	0.99957	0.99810	1.00152	0.99887	0.99999	1.00543	0.99991	1.00098	1.00544
1996	1.01852	1.01525	1.00000	1.00004	0.99968	1.00399	0.99364	0.99539	0.99999	1.00697	1.00012	1.00139	1.00202
1997	1.00570	1.00576	1.00000	1.00005	1.00019	1.00090	0.99481	0.99600	0.99991	1.00884	1.00017	1.00129	0.99781
1998	0.97011	0.96419	1.00000	1.00008	0.99991	1.00235	1.00247	0.99502	0.99999	1.00896	1.00015	1.00144	0.99580
1999	0.98762	0.99432	1.00000	0.99993	0.99966	0.98883	1.00867	0.99475	0.99996	1.00572	1.00000	1.00048	0.99539
2000	1.01821	1.00746	1.00000	1.00000	1.00004	0.99535	0.99765	1.00087	0.99995	1.00482	0.99978	1.00091	1.01136
2001	0.98803	0.99554	1.00000	1.00009	1.00009	1.00440	0.99634	0.99437	1.00014	1.00656	1.00002	1.00066	0.98990
2002	1.00473	1.00788	1.00000	0.99983	1.00009	1.00063	0.99950	0.99780	0.99997	1.00596	0.99984	1.00035	0.99296
2003	1.00378	1.00593	1.00000	0.99993	0.99977	0.99627	1.00023	0.99903	0.99994	1.00334	0.99991	1.00080	0.99866
2004	1.03283	1.02725	1.00000	1.00007	1.00019	1.00032	0.99439	1.00264	0.99995	1.00429	0.99986	0.99989	1.00389
2005	1.02784	1.02958	1.00000	1.00029	1.00053	1.00462	0.98584	1.00186	1.00006	1.00473	0.99985	1.00012	1.00051
2006	1.04007	1.02384	1.00000	1.00040	1.00084	1.01021	0.98415	1.00489	1.00027	1.00691	1.00035	1.00098	1.00709

Average	ρ^t	τ^t	$\alpha_C{}^t$	$\alpha_N{}^t$	$\alpha_G{}^t$	$\alpha_X{}^t$	$\alpha_M{}^t$	$\alpha_I{}^t$	$\alpha_{IV}{}^t$	$\beta_K{}^t$	$\beta_{KIV}{}^t$	$\beta_{LD}{}^t$	$\beta_{LB}{}^t$
1956-2006	1.05000	1.02595	1.00000	1.00012	0.99944	0.99657	1.00192	0.99622	0.99965	1.01592	1.00086	1.00369	1.00858
1956-1973	1.10436	1.05820	1.00000	1.00026	0.99902	0.99563	1.00489	0.99625	0.99921	1.02316	1.00216	1.00661	1.01599
1974-1979	1.02026	1.01260	1.00000	1.00009	0.99903	0.99378	0.99753	0.99138	0.99962	1.01559	1.00034	1.00521	1.00517
1980-1990	1.03702	1.01286	1.00000	1.00002	0.99971	0.99611	1.00366	0.99624	0.99984	1.01572	1.00025	1.00198	1.01034
1991-2001	1.00304	0.99677	1.00000	1.00002	0.99970	0.99741	1.00184	0.99650	1.00000	1.00939	1.00003	1.00127	1.00016
2002-2006	1.02185	1.01889	1.00000	1.00010	1.00028	1.00241	0.99282	1.00124	1.00004	1.00504	0.99996	1.00043	1.00062

The net outputs in our most disaggregated data base are as follows:

- C; Domestic final consumption expenditure of households (excluding the imputed rent of owner-occupied dwellings);
- N; Final consumption expenditure of private non-profit institutions serving households;
- G; Net purchases of goods and services by the general government from the market sector;
- X; Exports of goods and services (excluding direct purchases in the domestic market by non-resident households);

- M; Imports of goods and services (excluding direct purchases abroad by resident households);
- I1 to I95; Gross investments for 95 asset categories;
- IV1 to IV4; Change in inventories for 4 types of inventory asset.

The primary inputs in our most disaggregated data base are as follows:

- K1 to K95; Capital services from 95 classes of fixed asssets;
- KIV1 to KIV4; Inventory services for 4 classes of inventory asset;
- LD1 to LD4; Market sector land services and
- LB1 to LB3; Labour input for 3 types of labour.

The growth rate of real income ρ^t is decomposed into a productivity growth factor τ^t, several factors due to changes in real output prices α_C^t (domestic final consumption), α_N^t (non-profit institution final consumption), α_G^t (net government purchases from the market sector), α_X^t (exports), α_M^t (imports), α_I^t (investment in reproducible capital) and α_{IV}^t (inventory change) and several factors for growth in input quantities β_K^t (reproducible capital services), β_{KIV}^t (inventory capital services), β_{LD}^t (market sector land services) and β_{LB}^t (labour services). From the average contribution factors, it can be seen that real income growth ρ^t is at a very high average annual rate of 5% per year. On average, the productivity growth factor τ^t accounted for 2.595% of the real income growth, labour input growth β_{LB}^t for 0.858% and capital input growth β_K^t for 1.592% on average while the contribution factors for real output price changes were −0.387% due to investment prices falling faster than consumption prices α_I^t, −0.343% per year due to export prices falling faster than consumption prices α_X^t, and 0.192% per year due to import prices falling more rapidly than consumption prices α_M^t. Thus, it seems that the effects of changes in the terms of trade on living standards were very small for Japan over the entire period 1955-2006: an overall negative contribution of −0.15% per year. However, during shorter periods of time, changes in the terms of trade have larger impacts. It accounted for −0.867% of the average real income growth rate of 2.026% during the stagnation period between the oil shocks (1973-1979) and it also accounted for −0.478% of the average real income growth rate of 2.185% during the period of economic recovery (2002-2006). On average over the years 1955-2006, the productivity growth factor τ^t accounted for 2.595% of the real income growth rate ρ^t of 5% and capital input factor β_K^t for 1.592%. We can see that productivity growth plays more important role in explaining real income growth than capital input over the entire period. However, the average contribution after 1973 of capital input growth (1.197% per year) is larger than that of productivity growth (0.837% per year). We can see that the importance of the contribution of capital input growth relative to the contribution by productivity growth increases over time. However, this is not the end of story. During the period of economic recovery 2002-2006, the average contribution by productivity growth of 1.889% becomes bigger than the average contribution by capital services growth, which was 0.504%. Thus we can observe that the recent economic recovery is mostly boosted by productivity growth rather than by capital deepening.

The annual change information in the previous table can be converted into cumulative changes using equations (48). Table 4 gives this cumulative growth information.

The level of real income ρ^t is decomposed into the product of the level of productivity T^t, the levels of several real output price factors A_C^t, A_N^t, A_G^t, A_X^t, A_M^t, A_I^t, and A_{IV}^t and the levels of several input quantity growth factors B_K^t, B_{KIV}^t, B_{LD}^t, and B_{LB}^t. Over the 52 year period, real income ρ^t/ρ^0 (from the gross domestic product point of view) grew over eleven fold (11.2932), which is spectacular growth.[44] From the above Table 4, it can be seen that productivity growth T^t contributes the most to the overall

[44] However, note that real income grew just over 10 fold by 1991 and in the 15 years since then, it has grown by only 11.6%.

growth in real income (3.58265), the growth in reproducible capital input B_K^t makes the next largest contribution (2.23389) followed by the growth in labour input B_{LB}^t (1.54139) while the change in real investment prices A_I^t makes a negative contribution (0.82271) as does the growth in real export price A_X^t (0.83831) and finally, the change in real import prices A_M^t makes a modest positive contribution (1.09826).

Table 4: The Decomposition of Market Sector Real Income Level into Cumulative Productivity, Real Output Price Change and Input Quantity Contribution Factors

	ρ^t/ρ^0	T^t	A_C^t	A_N^t	A_G^t	A_X^t	A_M^t	A_I^t	A_{IV}^t	B_K^t	B_{KIV}^t	B_{LD}^t	B_{LB}^t
1955	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1956	1.13349	1.06216	1.00000	1.00065	1.00110	1.00404	0.99244	1.01873	1.00309	1.00105	1.00232	1.00037	1.04230
1957	1.24491	1.11162	1.00000	1.00098	1.00142	1.00069	0.99168	1.02629	1.00161	1.01006	1.00513	1.00123	1.07745
1958	1.31208	1.12789	1.00000	1.00101	1.00015	0.99252	1.01265	1.01772	1.00119	1.02530	1.00759	1.00228	1.09579
1959	1.48175	1.24134	1.00000	1.00107	0.99934	0.99124	1.01756	1.00799	1.00091	1.03971	1.00833	1.00407	1.11386
1960	1.74267	1.39590	1.00000	1.00131	0.99853	0.99103	1.02091	1.00555	0.99938	1.05624	1.01084	1.00537	1.14406
1961	2.01192	1.54017	1.00000	1.00143	0.99742	0.98406	1.02687	1.00986	0.99547	1.08305	1.01375	1.01055	1.16033
1962	2.11133	1.55483	1.00000	1.00142	0.99554	0.97427	1.03690	0.99379	0.99273	1.11693	1.01813	1.01576	1.18314
1963	2.26726	1.64501	1.00000	1.00137	0.99319	0.96918	1.04323	0.97113	0.99096	1.14919	1.01986	1.02080	1.19048
1964	2.57097	1.78899	1.00000	1.00188	0.99209	0.96751	1.04479	0.96746	0.99050	1.17997	1.02229	1.02613	1.20589
1965	2.65093	1.79099	1.00000	1.00174	0.99026	0.95863	1.05440	0.95008	0.98931	1.21328	1.02477	1.03332	1.22244
1966	2.98631	1.90974	1.00000	1.00198	0.98968	0.95383	1.05829	0.94870	0.98857	1.24081	1.02642	1.04927	1.24645
1967	3.40364	2.05448	1.00000	1.00229	0.98958	0.95043	1.06397	0.95136	0.98751	1.27082	1.02836	1.06510	1.26310
1968	3.83398	2.23553	1.00000	1.00239	0.98864	0.94514	1.07000	0.94475	0.98649	1.30696	1.03144	1.07179	1.27084
1969	4.37284	2.41636	1.00000	1.00269	0.98784	0.94259	1.07071	0.94632	0.98668	1.34765	1.03431	1.08821	1.27819
1970	4.77413	2.52757	1.00000	1.00328	0.98669	0.93842	1.07637	0.93824	0.98525	1.39145	1.03696	1.09649	1.29164
1971	4.87863	2.49754	1.00000	1.00370	0.98481	0.93327	1.08827	0.92267	0.98437	1.43754	1.03904	1.10334	1.30058
1972	5.27411	2.60887	1.00000	1.00423	0.98305	0.92592	1.09982	0.91826	0.98456	1.47463	1.03938	1.11067	1.30736
1973	5.88873	2.73862	1.00000	1.00461	0.98244	0.92415	1.09133	0.93354	0.98583	1.50916	1.03960	1.12561	1.32937
1974	5.65098	2.65056	1.00000	1.00483	0.98759	0.93159	1.05236	0.92834	0.98378	1.54514	1.04091	1.13490	1.31486
1975	5.45849	2.64837	1.00000	1.00482	0.98009	0.92301	1.05513	0.90331	0.98322	1.57135	1.04203	1.14225	1.29449
1976	5.65661	2.69395	1.00000	1.00494	0.97920	0.91293	1.06078	0.88654	0.98322	1.59228	1.04175	1.14651	1.33002
1977	5.78191	2.70134	1.00000	1.00500	0.97806	0.89799	1.07671	0.87792	0.98314	1.61198	1.04206	1.15307	1.34816
1978	6.11483	2.78370	1.00000	1.00496	0.97624	0.88455	1.10318	0.87451	0.98326	1.63181	1.04194	1.15750	1.35707
1979	6.60374	2.94548	1.00000	1.00519	0.97670	0.88994	1.07374	0.88587	0.98361	1.65591	1.04173	1.16124	1.37027
1980	6.56412	2.93718	1.00000	1.00516	0.97852	0.89173	1.03565	0.88527	0.98271	1.68071	1.04293	1.16526	1.38552
1981	6.65840	2.91436	1.00000	1.00498	0.97883	0.88987	1.04212	0.87678	0.98237	1.70456	1.04368	1.16732	1.40124
1982	6.80975	2.92815	1.00000	1.00497	0.97785	0.89169	1.04181	0.87094	0.98234	1.72700	1.04388	1.17015	1.41259
1983	6.91157	2.88722	1.00000	1.00492	0.97744	0.88424	1.05367	0.86457	0.98239	1.74738	1.04401	1.17251	1.44101
1984	7.23966	2.97965	1.00000	1.00492	0.97678	0.88314	1.06108	0.85863	0.98236	1.76673	1.04383	1.17308	1.44879
1985	7.58067	3.04374	1.00000	1.00495	0.97805	0.87588	1.07208	0.85172	0.98206	1.80035	1.04407	1.17654	1.46016
1986	7.83875	3.04329	1.00000	1.00499	0.97557	0.85832	1.11469	0.84505	0.98208	1.83088	1.04422	1.17715	1.47164
1987	8.18209	3.08970	1.00000	1.00503	0.97427	0.85368	1.12293	0.84328	0.98206	1.86450	1.04408	1.17928	1.48547
1988	8.74065	3.19004	1.00000	1.00508	0.97326	0.85162	1.12609	0.84494	0.98207	1.89461	1.04417	1.18192	1.50696
1989	9.34560	3.30187	1.00000	1.00513	0.97336	0.85314	1.12104	0.84872	0.98203	1.92809	1.04428	1.18407	1.52387
1990	9.82464	3.38504	1.00000	1.00537	0.97361	0.85239	1.11608	0.84982	0.98192	1.96568	1.04463	1.18674	1.53425
1991	10.1160	3.39550	1.00000	1.00546	0.97298	0.84780	1.12364	0.84749	0.98184	2.00313	1.04483	1.18800	1.54670
1992	10.1874	3.36884	1.00000	1.00543	0.97245	0.84388	1.13082	0.84398	0.98185	2.03780	1.04492	1.19063	1.54426
1993	10.0527	3.30189	1.00000	1.00533	0.97197	0.83654	1.13987	0.84144	0.98194	2.06298	1.04493	1.19294	1.53936
1994	10.1182	3.30629	1.00000	1.00538	0.97119	0.83345	1.14436	0.83816	0.98202	2.07807	1.04482	1.19490	1.54045
1995	10.2722	3.32370	1.00000	1.00543	0.97078	0.83187	1.14609	0.83721	0.98201	2.08936	1.04473	1.19607	1.54883
1996	10.4624	3.37440	1.00000	1.00547	0.97047	0.83519	1.13880	0.83335	0.98200	2.10393	1.04486	1.19773	1.55195
1997	10.5220	3.39385	1.00000	1.00552	0.97065	0.83594	1.13289	0.83002	0.98191	2.12253	1.04504	1.19928	1.54856
1998	10.2075	3.27231	1.00000	1.00560	0.97056	0.83791	1.13569	0.82589	0.98190	2.14155	1.04519	1.20101	1.54205
1999	10.0812	3.25370	1.00000	1.00552	0.97024	0.82854	1.14553	0.82155	0.98187	2.15379	1.04519	1.20159	1.53494
2000	10.2647	3.27797	1.00000	1.00552	0.97028	0.82469	1.14284	0.82226	0.98182	2.16418	1.04496	1.20268	1.55238
2001	10.1419	3.26335	1.00000	1.00561	0.97037	0.82832	1.13866	0.81763	0.98195	2.17839	1.04498	1.20347	1.53670
2002	10.1898	3.28906	1.00000	1.00544	0.97046	0.82884	1.13809	0.81583	0.98192	2.19136	1.04481	1.20389	1.52588
2003	10.2283	3.30855	1.00000	1.00537	0.97023	0.82575	1.13836	0.81504	0.98186	2.19869	1.04472	1.20485	1.52384
2004	10.5641	3.39872	1.00000	1.00544	0.97042	0.82601	1.13197	0.81719	0.98181	2.20811	1.04457	1.20471	1.52977
2005	10.8581	3.49924	1.00000	1.00573	0.97093	0.82983	1.11595	0.81871	0.98187	2.21855	1.04441	1.20485	1.53054
2006	11.2932	3.58265	1.00000	1.00613	0.97174	0.83831	1.09826	0.82271	0.98213	2.23389	1.04477	1.20603	1.54139

4.3 The Decomposition of Deflated NDP Growth

There is a severe flaw with all of the analysis presented in the previous sections. The problem is that depreciation payments are part of the user cost of capital for each asset but depreciation does not provide households with any sustainable purchasing power. Hence our real income measure defined by (5) above is overstated.

To see why Gross Domestic Product overstates income, consider the model of production that is described by the following quotations:

"We must look at the production process during a period of time, with a beginning and an end. It starts, at the commencement of the Period, with an Initial Capital Stock; to this there is applied a Flow Input of labour, and from it there emerges a Flow Output called Consumption; then there is a Closing Stock of Capital left over at the end. If Inputs are the things that are put in, the Outputs are the things that are got out, and the production of the Period is considered in isolation, then the Initial Capital Stock is an Input. A Stock Input to the Flow Input of labour; and further (what is less well recognized in the tradition, but is equally clear when we are strict with translation), the Closing Capital Stock is an Output, a Stock Output to match the Flow Output of Consumption Goods. Both input and output have stock and flow components; capital appears both as input and as output" John R. Hicks (1961; 23).

"The business firm can be viewed as a receptacle into which factors of production, or inputs, flow and out of which outputs flow...The total of the inputs with which the firm can work within the time period specified includes those inherited from the previous period and those acquired during the current period. The total of the outputs of the business firm in the same period includes the amounts of outputs currently sold and the amounts of inputs which are bequeathed to the firm in its succeeding period of activity." Edgar O. Edwards and Philip W. Bell (1961; 71-72).

Hicks and Edwards and Bell obviously had the same model of production in mind: in each accounting period, the business unit combines the capital stocks and goods in process that it has inherited from the previous period with "flow" inputs purchased in the current period (such as labour, materials, services and additional durable inputs) to produce current period "flow" outputs as well as end of the period depreciated capital stock components which are regarded as outputs from the perspective of the current period (but will be regarded as inputs from the perspective of the next period).[45]

All of the "flow" inputs that are purchased during the period and all of the "flow" outputs that are sold during the period are the inputs and outputs that appear in the usual definition of cash flow. These are the flow inputs and outputs that are very familiar to national income accountants. But this is not the end of the story: the firm inherits an endowment of assets at the beginning of the production period and at the end of the period, the firm will have the net profit or loss that has occurred due to its sales of outputs and its purchases of inputs during the period. As well, *it will have a stock of assets that it can use when it starts production in the following period*. Just focusing on the flow transactions that occur within the production period will not give a complete picture of the firm's productive activities. Hence, to get a complete picture of the firm's production activities over the course of a period, it is necessary to add the value of the closing stock of assets less the beginning of the period stock of assets to the cash flow that accrued to the firm from its sales and purchases of market goods and services during the accounting period.

We illustrate the above theory by considering a very simple two output, two input model of the market sector. One of the outputs is output in year t, Y^t and the other output is an investment good, I^t. One of the inputs is the flow of noncapital primary input X^t and the other input is K^t, capital services. Suppose that the average prices during period t of a unit of Y^t, X^t and I^t are P_Y^t, P_X^t and P_I^t respectively. Suppose further that the interest rate prevailing at the beginning of period t is r^t. The value of the beginning of period t capital stock is assumed to be P_I^t, the investment price for period t. The user cost of capital is calculated such as $u^t = (r^t + \delta^t + \tau^t)P_I^t/(1+r^t)$. As usual, it represents price of capital services input. Thus, the period t profit of the market sector is expressed as follows:

(54) $\prod^t = P_Y^t\, Y^t + P_I^t\, I^t - P_X^t\, X^t - [(r^{t*} + \delta)P_I^t/(1+r^{t*})]K^t$

Under the assumption of constant returns to scale, a zero profit condition should be satisfied such as $\prod^t = 0$. Using this condition, we obtain the following value of output equals value of input equation:

[45] For more on this model of production and additional references to the literature, see the Appendices in Diewert (1977) (1980). The usual user cost of capital can be derived from this framework if depreciation is independent of use.

(55) $P_Y{}^t\, Y^t + P_I{}^t\, I^t = P_X{}^t\, X^t + [(r^{t*} + \delta)P_I{}^t/(1+r^{t*})]K^t$.

Equation (55) is essentially the closed economy counterpart to the (gross) value of outputs equals (gross) value of primary inputs equation (4), $P^t{\cdot}y^t = W^t{\cdot}x^t$, that we have been using thus far in this study. We now come to the point of this rather long digression: *the (gross) payments to primary inputs that is defined by the right hand side of (55) is not income*, in the sense of Hicks.[46] The owner of a unit of capital cannot spend the entire period t gross rental income $(r^{t*} + \delta)P_I{}^t/(1+r^{t*})$ on consumption during period t because the depreciation portion of the rental, $\delta P_I{}^t/(1+r^{t*})$, is required in order to keep his or her capital intact. Thus the owner of a new unit of capital at the beginning of period t loans the unit to the market sector and gets the gross return $(r^{t*} + \delta)P_I{}^t$ at the end of the period plus the depreciated unit of the initial capital stock, which is worth only $(1 - \delta)P_I{}^t$. Thus $\delta P_I{}^t$ of this gross return must be set aside in order to restore the lender of the capital services to his or her original wealth position at the beginning of period t. This means that *period t Hicksian market sector income* is not the value of payments to primary inputs, $P_X{}^t\, X^t + [(r^{t*} + \delta)p_K{}^t/(1+r^{t*})]K^t$; instead it is the value of payments to labour $P_X{}^t\, X^t$ plus the reward for waiting, $r^t(1+r^{t*})^{-1}P_I{}^t\, K^t$. Using this definition of market sector (net) Hicksian income, we can rearrange equation (55) as follows:

(56) Hicksian market sector income $\equiv P_X{}^t\, X^t + [r^{t*}P_I{}^t/(1+r^{t*})]K^t$
$= P_Y{}^t\, Y^t + P_I{}^t\, I^t - [\delta P_I{}^t/(1+r^{t*})]K^t$
= Value of consumption + value of gross investment − value of depreciation.

Thus in this Hicksian net income framework, our new output concept is equal to our old output concept less the value of depreciation. We take the price of depreciation to be the corresponding investment price $P_I{}^t/(1+r^{t*})$ and the quantity of depreciation is taken to be the depreciation rate times the beginning of the period stock, δK^t.

Hence the overstatement of income problem that is implicit in the approaches used in previous sections can readily be remedied: all we need to do is to take the user cost formula for an asset and decompose it into two parts:

- One part that represents depreciation and foreseen obsolescence, $[\delta P_I{}^t/(1+r^{t*})]$ and
- The remaining part that is the reward for postponing consumption, $[r^{t*}P_I{}^t/(1+r^{t*})]$.

Thus in this section, we split up each user cost times the beginning of the period stock K^t into the depreciation component $\delta^t P_I{}^t K^t/(1+r^{t*})$ and the remaining term $r^{t*}P_I{}^t K^t/(1+r^{t*})$ and we regard the second term as a genuine income component but the first term is treated as an intermediate input cost for the market sector and is an offset to gross investment made by the market sector during the period under consideration. *Thus in this section, we use a net product approach instead of a gross product approach*. Using the chained Törnqvist indexes, we construct prices and quantities of net investment P_{NI} and y_{NI} and "reward for waiting" capital service W_{KW} and x_{KW}. Waiting capital services is compared with the gross user cost concept that was used in the previous section and net investment is also compared with the gross investment that was used in the previous section in Table 5.

[46] We will use Hicks' third concept of income here: "Income No. 3 must be defined as the maximum amount of money which the individual can spend this week, and still be able to expect to spend this week, and still be able to expect to spend the same amount *in real terms* in each ensuing week." J.R. Hicks (1946; 174).

Table 5: The Quantity and Price of Gross Investment, Depreciation, Net Investment, Capital Services, Waiting Capital Services (Billion Yen)

	Price					Quantity (Billion Yen)				
	P_I^t	P_{DEP}^t	P_{NI}^t	W_K^t	W_{KW}^t	y_I^t	y_{DEP}^t	y_{NI}^t	x_K^t	x_{KW}^t
1955	1.00000	1.00000	1.00000	1.00000	1.00000	1618.4	1014.3	604.1	2065.1	1050.9
1956	1.07799	1.08721	1.06612	1.08161	1.07844	1988.7	1011	979.8	2076.3	1065.3
1957	1.14109	1.14761	1.13173	1.15653	1.17048	2412.5	1048.7	1369.1	2147.3	1098.7
1958	1.10682	1.11161	1.09892	1.08042	1.05124	2535.6	1123.2	1417.6	2277.1	1153.8
1959	1.10405	1.09675	1.10505	1.15135	1.20888	3008.6	1202.2	1812.6	2411.5	1209.5
1960	1.12829	1.10570	1.13793	1.27192	1.44701	4052	1298.8	2755.6	2577.9	1281.6
1961	1.21004	1.15448	1.23377	1.43512	1.73040	5029.4	1475.4	3552.1	2866.3	1402.8
1962	1.23854	1.18531	1.26124	1.41653	1.66303	5640.1	1725.5	3917	3259.5	1562.7
1963	1.24414	1.18040	1.27148	1.44733	1.73583	6310.1	1985.9	4330.8	3670.9	1730.7
1964	1.26349	1.18969	1.29534	1.50726	1.85305	7336.9	2255.8	5084.7	4099.4	1907.9
1965	1.28734	1.21372	1.31904	1.48358	1.77699	7588.3	2575	5036.5	4605	2116.5
1966	1.33294	1.23593	1.37618	1.56655	1.93556	8684	2856.6	5845.7	5059.8	2307.9
1967	1.38867	1.27017	1.44196	1.64674	2.07157	10287.3	3201.8	7086.8	5600.3	2529.8
1968	1.43398	1.30113	1.49363	1.72862	2.21840	12291	3670.5	8602.6	6314	2816.7
1969	1.49314	1.35231	1.55589	1.77624	2.25942	14427	4264.3	10138.9	7203.7	3169.2
1970	1.56182	1.41349	1.62780	1.80837	2.25461	16752.8	4977.7	11751.3	8270.8	3589.7
1971	1.59780	1.45652	1.66051	1.69082	1.92477	17456.3	5823.4	11689	9524.7	4072.9
1972	1.66695	1.49897	1.74302	1.68311	1.84804	19076.6	6559.7	12602.8	10657.7	4524.1
1973	1.93393	1.69176	2.04680	1.88069	2.04261	21347.3	7319.5	14120.3	11817.6	4979.9
1974	2.35603	2.07893	2.48283	2.15972	2.17078	20167.9	8136.7	12324.9	13080.5	5481.9
1975	2.45132	2.16547	2.58154	2.11392	1.93697	19934.3	8725.5	11609.5	14043.9	5896
1976	2.55640	2.21795	2.72275	2.28015	2.25245	20778.2	9212.6	12004.2	14859.3	6258.1
1977	2.66778	2.31160	2.84373	2.34965	2.28287	21328.2	9693.7	12128.8	15660.7	6610.9
1978	2.75156	2.34723	2.96204	2.48908	2.55864	23133.3	10221	13390	16499.3	6957.1
1979	2.94182	2.45427	3.20940	2.71382	2.93883	24385.9	10900.9	14016.7	17535.7	7362
1980	3.17585	2.62322	3.48626	2.81250	2.94160	24263.4	11599.4	13375.1	18619.9	7796.6
1981	3.23351	2.66939	3.55086	2.77944	2.79437	24822.4	12300.9	13356.5	19704.4	8227.6
1982	3.24754	2.69077	3.55677	2.74332	2.67213	24950.2	13010	12938.6	20776.7	8637.7
1983	3.23932	2.69165	3.53959	2.68951	2.54286	24680.8	13690.6	12176.2	21793.6	9016.6
1984	3.24621	2.67898	3.56806	2.79480	2.81058	25790.9	14377.2	12669.7	22791.1	9370.9
1985	3.22575	2.65333	3.55574	2.84526	2.96014	27998.7	15625.9	13740.1	24562.3	9981.1
1986	3.16676	2.60139	3.49460	2.79191	2.90471	29876.4	16870.7	14515	26236.4	10504.4
1987	3.14805	2.57426	3.48775	2.75174	2.83995	32167.1	18227	15581	28155	11164.9
1988	3.17482	2.58387	3.53103	2.79703	2.93699	36212.4	19519.3	18275.8	29943.8	11757.3
1989	3.27023	2.64125	3.65851	2.87274	3.03669	39757.1	21074.1	20323.2	32011.1	12392.1
1990	3.36109	2.70393	3.77132	2.87684	2.94684	43019.1	22891.8	21926.9	34442.3	13144.1
1991	3.40907	2.73132	3.83735	2.83166	2.76680	44374.5	24723.4	21824.6	36987.6	13985.5
1992	3.41971	2.71846	3.87573	2.79504	2.68280	43485.7	26464.2	19807	39419.1	14791.7
1993	3.41945	2.71684	3.87748	2.69610	2.41883	42072	27702.8	17691.7	41217.3	15433.7
1994	3.39064	2.68307	3.86265	2.65853	2.37547	41379.6	28389.3	16603.4	42313.8	15900
1995	3.36629	2.65458	3.85114	2.64268	2.38339	41469.1	28879.8	16341.5	43143.2	16284.3
1996	3.32070	2.60818	3.81762	2.65433	2.49388	43418.8	29601.9	17543.3	44223	16692.4
1997	3.31837	2.60261	3.82142	2.63836	2.44704	43705	30628.2	17092.1	45616.1	17121
1998	3.24082	2.55398	3.70733	2.47774	2.06032	40831	31689.1	13862.4	47059.5	17559
1999	3.16801	2.49092	3.63751	2.42811	2.03498	40551.4	32389.7	13137.3	47991.7	17817.5
2000	3.15541	2.47382	3.64123	2.45181	2.14269	40711.3	32990.1	12866.3	48780.7	18030.3
2001	3.06560	2.40580	3.53154	2.34502	1.97380	40616.9	33852.7	12196.5	49868.4	18282.9
2002	2.99256	2.33766	3.48081	2.34143	2.08505	38907.7	34637.9	10187.9	50860.8	18517.1
2003	2.95501	2.29902	3.47025	2.34198	2.16536	38694.3	35060.5	9721.9	51413.1	18667.8
2004	2.93996	2.27683	3.49023	2.43956	2.46812	39364.8	35629.7	9915.7	52113	18831.4
2005	2.92164	2.26257	3.46898	2.46364	2.55840	40880.3	36247.4	10788.6	52877.7	19022.4
2006	2.92143	2.25767	3.48479	2.49213	2.62133	41472.3	37191.6	10672.6	54003.3	19276.9

Note that the price of net investment increases much more rapidly than that of the gross investment. The explanation for this fact is as follows. Machinery and equipment investment has increased much more than structures investment in Japan similar to the situation in most countries. But due to the computer chip revolution, the price of M&E equipment declined much more rapidly than the price of structures (which tended to increase). But structures have a low depreciation rate and machinery and equipment items have high depreciation rates. Thus when we subtract depreciation from gross investment, the weight of M&E is reduced in the net investment aggregate relative to the weight of structures, thus leading to a much higher rate of overall price increase in the net investment aggregate. Note that the price of waiting capital services increases much more rapidly than the other investment prices. This is mainly due to the fact that land services are included in the capital services but there is no investment in land. Hence, the situation is explained by the fact that land prices in Japan have been increasing much more rapidly than the prices of investment goods over most of the sample period. Note that gross investment in Japan grew 25.625 fold over the sample period whereas net investment grew only 17.667

fold. Note that (traditional) capital services input in Japan grew 26.15 fold over the sample period whereas waiting capital services grew only 18.343 fold.

All of the analysis presented in the previous section 4.2 above applies to the new situation with obvious modifications. The counterpart to Table 3 in the previous section using the new framework is Table 6 below.

Table 6: The Decomposition of Market Sector Net Real Income Growth into Translog Productivity, Real Output Price Change, and Input Quantity Contribution Factors

	ρ^t	τ^t	α_C^t	α_N^t	α_G^t	α_X^t	α_M^t	α_I^t	α_{DEP}^t	α_{IV}^t	β_{KW}^t	β_{KIV}^t	β_{LD}^t	β_{LB}^t
1956	1.14088	1.07195	1.00000	1.00075	1.00126	1.00463	0.99133	1.02152	0.98732	1.00355	1.00187	1.00268	1.00043	1.04900
1957	1.10370	1.05366	1.00000	1.00037	1.00037	0.99620	0.99913	1.00847	0.99660	0.99832	1.00490	1.00321	1.00098	1.03880
1958	1.05619	1.01678	1.00000	1.00004	0.99856	0.99071	1.02409	0.99050	1.00424	0.99952	1.00726	1.00280	1.00120	1.01948
1959	1.14446	1.11490	1.00000	1.00007	0.99908	0.99855	1.00548	0.98922	1.00582	0.99969	1.00670	1.00084	1.00203	1.01875
1960	1.19128	1.14047	1.00000	1.00027	0.99909	0.99976	1.00367	0.99729	1.00250	0.99830	1.00845	1.00278	1.00146	1.03042
1961	1.15837	1.11542	1.00000	1.00012	0.99878	0.99222	1.00646	1.00475	1.00146	0.99567	1.01387	1.00320	1.00571	1.01580
1962	1.04148	1.01049	1.00000	1.00000	0.99790	0.98897	1.01084	0.98237	1.00456	0.99696	1.01677	1.00480	1.00575	1.02190
1963	1.07436	1.06487	1.00000	0.99994	0.99738	0.99420	1.00679	0.97466	1.00829	0.99801	1.01558	1.00190	1.00554	1.00693
1964	1.13614	1.09805	1.00000	1.00057	0.99877	0.99808	1.00166	0.99580	1.00204	0.99948	1.01496	1.00266	1.00582	1.01444
1965	1.02485	1.00109	1.00000	0.99984	0.99795	0.98978	1.01025	0.98003	1.00577	0.99867	1.01575	1.00271	1.00784	1.01534
1966	1.13143	1.07442	1.00000	1.00027	0.99934	0.99443	1.00411	0.99838	1.00240	0.99917	1.01297	1.00180	1.01726	1.02197
1967	1.14272	1.08478	1.00000	1.00035	0.99989	0.99604	1.00597	1.00312	1.00063	0.99881	1.01377	1.00210	1.01681	1.01489
1968	1.12764	1.09836	1.00000	1.00010	0.99894	0.99383	1.00629	0.99229	1.00294	0.99885	1.01610	1.00334	1.00699	1.00681
1969	1.13779	1.09030	1.00000	1.00034	0.99911	0.99701	1.00074	1.00184	0.99969	1.00021	1.01747	1.00309	1.01705	1.00644
1970	1.08599	1.05123	1.00000	1.00065	0.99870	0.99509	1.00588	0.99052	1.00253	0.99840	1.01795	1.00286	1.00850	1.01175
1971	1.00869	0.98574	1.00000	1.00047	0.99786	0.99383	1.01242	0.98138	1.00428	0.99899	1.01706	1.00225	1.00703	1.00779
1972	1.07878	1.05045	1.00000	1.00059	0.99798	0.99109	1.01201	0.99460	1.00339	1.00023	1.01302	1.00037	1.00754	1.00592
1973	1.11456	1.05721	1.00000	1.00044	0.99929	0.99784	0.99125	1.01888	0.99822	1.00146	1.01139	1.00024	1.01530	1.01915
1974	0.93896	0.96274	1.00000	1.00024	1.00602	1.00925	0.95910	0.99363	1.00072	0.99761	1.01133	1.00145	1.00948	0.98747
1975	0.96009	0.99817	1.00000	0.99999	0.99118	0.98931	1.00306	0.96875	1.01119	0.99935	1.00818	1.00125	1.00753	0.98200
1976	1.04497	1.02008	1.00000	1.00014	0.99894	0.98733	1.00622	0.97847	1.01101	1.00000	1.00658	0.99969	1.00434	1.03198
1977	1.02205	1.00293	1.00000	1.00007	0.99866	0.98111	1.01738	0.98877	1.00444	0.99991	1.00621	1.00035	1.00662	1.01581
1978	1.06262	1.03519	1.00000	0.99995	0.99785	0.98276	1.02842	0.99551	1.00408	1.00014	1.00591	0.99986	1.00445	1.00764
1979	1.07985	1.06755	1.00000	1.00026	1.00054	1.00702	0.96935	1.01496	0.99802	1.00041	1.00705	0.99976	1.00372	1.01123
1980	0.98487	0.99673	1.00000	0.99997	1.00216	1.00232	0.95910	0.99918	1.00183	0.99895	1.00742	1.00134	1.00401	1.01290
1981	1.01140	0.99068	1.00000	0.99980	1.00036	0.99758	1.00726	0.98881	1.00446	0.99959	1.00676	1.00083	1.00206	1.01323
1982	1.01951	1.00537	1.00000	0.99999	0.99883	1.00238	0.99965	0.99220	1.00257	0.99997	1.00586	1.00023	1.00283	1.00947
1983	1.01182	0.98344	1.00000	0.99994	0.99951	0.99023	1.01334	0.99144	1.00319	1.00006	1.00499	1.00014	1.00236	1.02362
1984	1.05217	1.03756	1.00000	1.00000	0.99922	0.99855	1.00822	0.99199	1.00471	0.99996	1.00453	0.99981	1.00057	1.00633
1985	1.04540	1.02491	1.00000	1.00003	1.00151	0.99047	1.01205	0.99066	1.00469	0.99965	1.00789	1.00026	1.00345	1.00919
1986	1.03070	0.99952	1.00000	1.00005	0.99704	0.97660	1.04660	0.99085	1.00425	1.00002	1.00648	1.00017	1.00060	1.00923
1987	1.03929	1.01782	1.00000	1.00005	0.99843	0.99364	1.00868	0.99754	1.00187	0.99998	1.00770	0.99984	1.00213	1.01108
1988	1.06758	1.03842	1.00000	1.00006	0.99878	0.99718	1.00331	1.00231	0.99982	1.00001	1.00655	1.00011	1.00264	1.01710
1989	1.06637	1.04156	1.00000	1.00006	1.00013	1.00208	0.99476	1.00523	0.99921	0.99995	1.00673	1.00012	1.00216	1.01329
1990	1.04477	1.02987	1.00000	1.00028	1.00030	0.99896	0.99481	1.00153	1.00012	0.99988	1.00742	1.00039	1.00268	1.00810
1991	1.02214	1.00342	1.00000	1.00010	0.99923	0.99363	1.00803	0.99674	1.00217	0.99990	1.00752	1.00023	1.00127	1.00971
1992	0.99815	0.99027	1.00000	0.99996	0.99935	0.99445	1.00766	0.99505	1.00379	1.00001	1.00670	1.00011	1.00268	0.99810
1993	0.97578	0.97559	1.00000	0.99988	0.99940	0.98946	1.00973	0.99634	1.00187	1.00011	1.00499	1.00001	1.00235	0.99614
1994	1.00588	1.00157	1.00000	1.00005	0.99902	0.99548	1.00481	0.99523	1.00335	1.00010	1.00342	0.99987	1.00202	1.00086
1995	1.01641	1.00648	1.00000	1.00007	0.99948	0.99769	1.00185	0.99862	1.00156	0.99999	1.00279	0.99990	1.00120	1.00667
1996	1.02117	1.01869	1.00000	1.00005	0.99961	1.00483	0.99231	0.99443	1.00385	0.99998	1.00300	1.00015	1.00170	1.00247
1997	1.00218	1.00694	1.00000	1.00006	1.00023	1.00109	0.99372	0.99516	1.00284	0.99989	1.00315	1.00021	1.00158	0.99732
1998	0.95769	0.95581	1.00000	1.00009	0.99989	1.00287	1.00302	0.99392	1.00235	0.99999	1.00300	1.00018	1.00178	0.99481
1999	0.98381	0.99294	1.00000	0.99991	0.99958	0.98614	1.01078	0.99348	1.00445	0.99996	1.00170	1.00000	1.00060	0.99426
2000	1.01818	1.00932	1.00000	1.00000	1.00006	0.99422	0.99708	1.00108	1.00005	0.99994	1.00143	0.99973	1.00114	1.01422
2001	0.98282	0.99435	1.00000	1.00011	1.00011	1.00548	0.99544	0.99299	1.00414	1.00017	1.00168	1.00003	1.00082	0.98736
2002	1.00308	1.00988	1.00000	0.99978	1.00012	1.00079	0.99938	0.99724	1.00292	0.99996	1.00157	0.99980	1.00044	0.99116
2003	1.00353	1.00747	1.00000	0.99991	0.99971	0.99533	1.00029	0.99878	1.00184	0.99992	1.00107	0.99988	1.00101	0.99832
2004	1.03598	1.03437	1.00000	1.00009	1.00024	1.00040	0.99300	1.00329	0.99892	0.99993	1.00125	0.99982	0.99986	1.00489
2005	1.02891	1.03725	1.00000	1.00036	1.00065	1.00573	0.98251	1.00231	0.99850	1.00008	1.00155	0.99981	1.00014	1.00064
2006	1.03991	1.02988	1.00000	1.00049	1.00102	1.01254	0.98060	1.00599	0.99657	1.00033	1.00209	1.00043	1.00123	1.00890

Average	ρ^t	τ^t	α_C^t	α_N^t	α_G^t	α_X^t	α_M^t	α_I^t	α_{DEP}^t	α_{IV}^t	β_{KW}^t	β_{KIV}^t	β_{LD}^t	β_{LB}^t
1956-2006	1.04857	1.02955	1.00000	1.00014	0.99936	0.99606	1.00215	0.99565	1.00231	0.99961	1.00765	1.00097	1.00421	1.00982
1956-1973	1.10552	1.06556	1.00000	1.00029	0.99890	0.99513	1.00547	0.99587	1.00182	0.99913	1.01255	1.00242	1.00740	1.01809
1974-1979	1.01809	1.01444	1.00000	1.00011	0.99887	0.99279	0.99725	0.99001	1.00491	0.99957	1.00754	1.00039	1.00602	1.00602
1980-1990	1.03399	1.01508	1.00000	1.00002	0.99966	0.99545	1.00434	0.99561	1.00243	0.99982	1.00658	1.00029	1.00232	1.01214
1991-2001	0.99856	0.99594	1.00000	1.00003	0.99963	0.99685	1.00222	0.99573	1.00276	1.00000	1.00358	1.00004	1.00156	1.00017
2002-2006	1.02228	1.02377	1.00000	1.00013	1.00035	1.00296	0.99116	1.00152	0.99975	1.00004	1.00151	0.99995	1.00054	1.00078

The growth rate of real net income ρ^t is decomposed into the product of a productivity growth factor τ^t, several factors of real output price change α_C^t, α_N^t, α_G^t, α_X^t, α_M^t, α_I^t, α_{DEP}^t, and α_{IV}^t, and several factors of input quantity growth β_{KW}^t, β_{KIV}^t, β_{LD}^t, and β_{LB}^t. The new results are quite interesting. In the previous real income model, the average rate of increase in real income ρ^t was 5% per year, which has now decreased by 0.143% per year to 4.857%. More importantly, there are some big shifts in the explanatory factors. The productivity growth factor τ^t now accounts for an average contribution of 2.955% per year compared to the old 2.595%, an increase of 0.36 percentage points per year. The contribution of (gross) capital services growth $\beta_K{}^t$ has significantly decreased from 1.592% per year to the waiting capital services contribution factor $\beta_{KW}{}^t$ of 0.765% per year, a decrease of 0.827 percentage points per year. The contribution of labour input growth $\beta_{LB}{}^t$ has marginally increased from 0.858% per year to 0.982% per year. The contributions of real export price $\alpha_X{}^t$ and real import prices $\alpha_M{}^t$ remain quite similar estimates in the previous analysis. Thus, as we stated in the previous analysis, the effects of changes in the terms of trade on living standards were negligible for Japan over the entire periods 1955-2006 but the terms of trade has larger impacts during shorter periods of time. It accounted for −1% of the average growth rate of real income during the stagnation period between oil shocks (1973-1979) and −0.591% during the period of economic recovery (2002-2006). The negative contribution of the change in real investment prices $\alpha_I{}^t$ equal to −0.434% is offset by the positive contribution of the change in real depreciation prices $\alpha_{DEP}{}^t$ equal to 0.231%. Finally, note that the TFP productivity recovery in the 2002-2006 period is quite striking. Using the gross model, average TFP growth during this period was 1.9% per year and using the net model, average TFP growth increases to a very respectable 2.2% per year. This is good news for the Japanese economy.

Table 7: The Decomposition of Market Sector Net Real Income Cumulative Growth into Productivity, Real Output Price Change, and Input Quantity Contribution Factors using the Translog Net Product Approach

	ρ^t/ρ^0	T^t	$A_C{}^t$	$A_N{}^t$	$A_G{}^t$	$A_X{}^t$	$A_M{}^t$	$A_I{}^t$	$A_{DEP}{}^t$	$A_{IV}{}^t$	$B_{KW}{}^t$	$B_{KIV}{}^t$	$B_{LD}{}^t$	$B_{LB}{}^t$
1955	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1956	1.14088	1.07195	1.00000	1.00075	1.00126	1.00463	0.99133	1.02152	0.98732	1.00355	1.00187	1.00268	1.00043	1.04900
1957	1.25918	1.12946	1.00000	1.00112	1.00163	1.00081	0.99046	1.03017	0.98396	1.00186	1.00678	1.00590	1.00141	1.08970
1958	1.32994	1.14841	1.00000	1.00116	1.00019	0.99152	1.01433	1.02038	0.98814	1.00137	1.01409	1.00872	1.00261	1.11093
1959	1.52206	1.28036	1.00000	1.00123	0.99927	0.99008	1.01988	1.00938	0.99389	1.00107	1.02089	1.00957	1.00464	1.13176
1960	1.81320	1.46022	1.00000	1.00150	0.99836	0.98984	1.02363	1.00665	0.99637	0.99936	1.02951	1.01238	1.00611	1.16618
1961	2.10035	1.62875	1.00000	1.00162	0.99714	0.98214	1.03024	1.01144	0.99782	0.99503	1.04379	1.01562	1.01185	1.18461
1962	2.18748	1.64584	1.00000	1.00162	0.99505	0.97131	1.04141	0.99360	1.00238	0.99200	1.06129	1.02049	1.01767	1.21055
1963	2.35013	1.75260	1.00000	1.00156	0.99244	0.96567	1.04848	0.96842	1.01068	0.99003	1.07782	1.02243	1.02330	1.21893
1964	2.67009	1.92444	1.00000	1.00213	0.99122	0.96382	1.05022	0.96435	1.01275	0.98952	1.09395	1.02515	1.02925	1.23653
1965	2.73644	1.92652	1.00000	1.00196	0.98918	0.95397	1.06099	0.94509	1.01859	0.98820	1.11117	1.02792	1.03732	1.25550
1966	3.09608	2.06990	1.00000	1.00224	0.98853	0.94865	1.06535	0.94356	1.02103	0.98738	1.12559	1.02977	1.05522	1.28309
1967	3.53795	2.24537	1.00000	1.00259	0.98843	0.94490	1.07171	0.94650	1.02168	0.98620	1.14109	1.03194	1.07295	1.30219
1968	3.98954	2.46623	1.00000	1.00269	0.98738	0.93906	1.07844	0.93921	1.02468	0.98507	1.15946	1.03538	1.08045	1.31106
1969	4.53924	2.68892	1.00000	1.00303	0.98650	0.93625	1.07923	0.94094	1.02436	0.98528	1.17972	1.03858	1.09887	1.31950
1970	4.92955	2.82668	1.00000	1.00368	0.98522	0.93165	1.08558	0.93202	1.02695	0.98370	1.20090	1.04155	1.10821	1.33500
1971	4.97239	2.78638	1.00000	1.00415	0.98312	0.92591	1.09907	0.91466	1.03135	0.98271	1.22139	1.04390	1.11600	1.34540
1972	5.36409	2.92694	1.00000	1.00475	0.98113	0.91766	1.11227	0.90972	1.03485	0.98293	1.23728	1.04428	1.12441	1.35336
1973	5.97860	3.09440	1.00000	1.00519	0.98043	0.91568	1.10254	0.92689	1.03301	0.98436	1.25137	1.04453	1.14161	1.37927
1974	5.61369	2.97910	1.00000	1.00543	0.98633	0.92415	1.05745	0.92098	1.03375	0.98201	1.26555	1.04605	1.15243	1.36199
1975	5.38965	2.97366	1.00000	1.00542	0.97764	0.91427	1.06068	0.89220	1.04532	0.98138	1.27590	1.04736	1.16111	1.33747
1976	5.63202	3.03337	1.00000	1.00556	0.97660	0.90268	1.06727	0.87299	1.05683	0.98138	1.28430	1.04703	1.16615	1.38024
1977	5.75619	3.04226	1.00000	1.00563	0.97529	0.88563	1.08582	0.86319	1.06151	0.98129	1.29228	1.04740	1.17387	1.40207
1978	6.11664	3.14931	1.00000	1.00559	0.97319	0.87036	1.11668	0.85931	1.06584	0.98142	1.29991	1.04725	1.17909	1.41278
1979	6.60507	3.36205	1.00000	1.00585	0.97372	0.87646	1.08246	0.87216	1.06373	0.98182	1.30908	1.04700	1.18348	1.42864
1980	6.50515	3.35106	1.00000	1.00581	0.97582	0.87850	1.03819	0.87145	1.06568	0.98079	1.31879	1.04841	1.18823	1.44707
1981	6.57932	3.31982	1.00000	1.00561	0.97618	0.87637	1.04572	0.86170	1.07043	0.98039	1.32771	1.04928	1.19068	1.46621
1982	6.70769	3.33763	1.00000	1.00560	0.97504	0.87846	1.04536	0.85498	1.07319	0.98036	1.33549	1.04952	1.19405	1.48009
1983	6.78696	3.28236	1.00000	1.00554	0.97456	0.86987	1.05930	0.84766	1.07661	0.98041	1.34215	1.04967	1.19687	1.51505
1984	7.14103	3.40563	1.00000	1.00554	0.97379	0.86861	1.06801	0.84087	1.08168	0.98038	1.34823	1.04947	1.19755	1.52463
1985	7.46521	3.49047	1.00000	1.00557	0.97526	0.86033	1.08087	0.83302	1.08675	0.98004	1.35887	1.04974	1.20169	1.53864
1986	7.69438	3.48878	1.00000	1.00562	0.97238	0.84020	1.13124	0.82540	1.09136	0.98006	1.36768	1.04992	1.20242	1.55285
1987	7.99667	3.55097	1.00000	1.00566	0.97085	0.83486	1.14106	0.82337	1.09341	0.98004	1.37820	1.04975	1.20498	1.57005
1988	8.53708	3.68740	1.00000	1.00573	0.96967	0.83251	1.14484	0.82527	1.09321	0.98005	1.38723	1.04986	1.20816	1.59690
1989	9.10371	3.84064	1.00000	1.00579	0.96979	0.83424	1.13883	0.82958	1.09234	0.98000	1.39657	1.04999	1.21077	1.61812
1990	9.51128	3.95535	1.00000	1.00607	0.97008	0.83338	1.13292	0.83085	1.09248	0.97988	1.40694	1.05041	1.21401	1.63122
1991	9.72182	3.96889	1.00000	1.00618	0.96934	0.82807	1.14201	0.82815	1.09485	0.97978	1.41752	1.05065	1.21555	1.64706
1992	9.70381	3.93027	1.00000	1.00614	0.96870	0.82347	1.15076	0.82405	1.09899	0.97979	1.42701	1.05077	1.21880	1.64393
1993	9.46876	3.83431	1.00000	1.00602	0.96812	0.81479	1.16196	0.82103	1.10105	0.97990	1.43413	1.05077	1.22167	1.63758
1994	9.52447	3.84033	1.00000	1.00607	0.96717	0.81110	1.16756	0.81712	1.10473	0.98000	1.43904	1.05064	1.22414	1.63900
1995	9.68075	3.86520	1.00000	1.00614	0.96667	0.80923	1.16971	0.81599	1.10645	0.97999	1.44304	1.05053	1.22560	1.64993
1996	9.88566	3.93743	1.00000	1.00619	0.96630	0.81314	1.16072	0.81145	1.11071	0.97997	1.44737	1.05068	1.22769	1.65400
1997	9.90721	3.96474	1.00000	1.00625	0.96652	0.81403	1.15344	0.80752	1.11386	0.97987	1.45193	1.05090	1.22963	1.64957
1998	9.48803	3.78953	1.00000	1.00634	0.96641	0.81637	1.15692	0.80261	1.11647	0.97986	1.45629	1.05109	1.23182	1.64100
1999	9.33444	3.76280	1.00000	1.00625	0.96601	0.80505	1.16939	0.79738	1.12144	0.97981	1.45876	1.05109	1.23256	1.63158
2000	9.50412	3.79786	1.00000	1.00624	0.96606	0.80040	1.16598	0.79824	1.12149	0.97975	1.46085	1.05080	1.23396	1.65478
2001	9.34087	3.77638	1.00000	1.00636	0.96617	0.80478	1.16066	0.79264	1.12613	0.97992	1.46331	1.05083	1.23497	1.63387
2002	9.36961	3.81370	1.00000	1.00614	0.96628	0.80541	1.15994	0.79046	1.12942	0.97988	1.46561	1.05062	1.23551	1.61942
2003	9.40268	3.84218	1.00000	1.00605	0.96600	0.80165	1.16028	0.78949	1.13149	0.97981	1.46718	1.05050	1.23676	1.61669
2004	9.74096	3.97425	1.00000	1.00614	0.96623	0.80197	1.15216	0.79210	1.13027	0.97974	1.46901	1.05031	1.23658	1.62459
2005	10.0226	4.12228	1.00000	1.00650	0.96686	0.80657	1.13200	0.79392	1.12857	0.97982	1.47129	1.05011	1.23676	1.62563
2006	10.4226	4.24547	1.00000	1.00700	0.96785	0.81668	1.11004	0.79868	1.12469	0.98014	1.47437	1.05056	1.23828	1.64010

The annual change information in the previous table can be converted into cumulative changes using equations (48). Table 7 gives this cumulative growth information.

The level of real net income ρ^t compared to its level in 1955 ρ^0 is decomposed into the product of the cumulative level of productivity factor T^t, the cumulative levels of several real output price factors A_C^t, A_N^t, A_G^t, A_X^t, A_M^t, A_I^t, A_{DEP}^t, and A_{IV}^t, and the cumulative levels of several input quantity growth factors B_{KW}^t, B_{KIV}^t, B_{LD}^t, and B_{LB}^t. Over the 52 year period, real net income ρ^t/ρ^0 grew about 10.4 fold (10.4226). The main (multiplicative) explanatory factors were productivity growth (4.24547), the growth in labour input B_{LB}^t makes the next largest contribution (1.6401) followed by the growth in waiting capital services B_{KW}^t (1.47437) and the growth in land input B_{LD}^t (1.23828). There were smaller effects due to the relative change in the output prices such as the contribution of the change in real depreciation prices A_{DEP}^t (1.12469), real export prices A_X^t (0.81668) and real import prices A_M^t (1.11004). The combined effects of cumulative changes in the output prices relative to the price of household consumption were negligible (0.94832) over the entire sample period.

5. Conclusion

On a theoretical level, the results of Diewert and Morrison (1986) were modified to give an exact decomposition of the growth in real incomes generated by the market sector. Empirically, we analyzed the contribution to Japanese living standards by the income generated by the market sector. First, we constructed a database of inputs and outputs of market sector. Second, we took measured conventional TFP growth approach by applying Fisher quantity indexes. We calculated traditional TFP under the case where land and inventories included as primary inputs and two other cases where these two inputs were excluded. Our results showed the importance of the inclusion of land stocks and inventory stocks when computing TFP growth rates.[47] Third, we applied our theoretical results to decompose the growth of Japanese real income into the contributions of changes in real output prices and changes in primary input quantities. We observed that productivity growth and the growth of capital services are the main contributors to real income growth when using a traditional user cost approach to the pricing of primary inputs. We also observed that changes in the terms of trade had very small effects on real income on average. Forth, we moved to our theoretically preferred measure of real net income. We applied our theoretical results to decompose the growth of Japanese real net income into the contributions of changes in real output prices and changes in input quantities. We observed that in this net approach, productivity growth was still the largest contributor (and was an even more important factor than before). However, the contribution of capital services was greatly reduced in this net income context, becoming smaller than the contribution of labour input.

A few problems with our approach should be mentioned:

- Our labour aggregate has not been sufficiently disaggregated to capture changes in the average quality of labour input over time. Characteristics such as education, sex, age and experience should be taken into account when constructing a measure of aggregate labour input.
- We included non-profit institutes serving households (NPISHs) as part of our market sector. However, goods and services produced by NPISHs are traded free or at prices that are not economically significant. Since our theoretical approach relies on competitive profit maximizing behaviour, NPISHs should be netted out of the market sector.
- We have not dealt with intangible assets and the problems associated with accounting for R&D investments.

[47] Nomura (2004) also made this observation. We noted also that balancing real rates of return were greatly exaggerated when inventory and land inputs were omitted.

- We were not able to provide a sectoral contributions analysis. Since a primary focus of our paper was to look at the effects of changes in the prices of exports and imports on living standards, we could not extend our analysis to industrial sectors because reliable data on exports by industry and imports used by industry are not available.

However, it would be straightforward to extend our analysis to data sets where a more detailed breakdown of exports and imports by commodity classification is available. This would enable researchers to give more precise estimates of the effects on the income produced by the market sector of an oil shock or any other unusual movement in the prices of internationally traded goods.

Appendix A. Data Construction

In this appendix, we explain our methods for data construction in detail. The main data sources are the Japanese national accounts and the KEO database and these sources will often not be explicitly acknowledged in what follows.

1. Final Demand Components other than Gross Capital Formation

There are five price and quantity series for final demand components other than investments and inventory changes in our database:

- C; Domestic final consumption expenditure of households (excluding the imputed rent of owner-occupied dwellings);
- N; Final consumption expenditure of private non-profit institutions serving households;
- G; Net purchases of goods and services by the general government;
- X; Exports of goods and services (including direct purchases in the domestic market by non-resident households);
- M; Imports of goods and services (excluding direct purchases abroad by resident households).

1.1 Data Sources

Our output data series (other than for investments and inventory changes) are based on Japanese official national accounts (JSNA), which has been published by the Economic and Social Research Institute of the Cabinet of Office and the Economic Research Institute of the Economic Planning Agency of the Japanese Government. We call Japanese national accounts JSNA. In 1978, the Japanese system of national accounts was revised to comply with the guidelines proposed by the United Nations System of National Accounts (1968 SNA). In 2000, it was revised to comply with the guidelines newly proposed by the United Nations System of National Accounts (1993 SNA). The Economic and Social Research Institute and Economic Research Institute published separate historical data series based on 1968 SNA and then later based on the 1993 SNA (but not extending back to 1955). Our basic strategy is to start with the reference data series in the JSNA based on the 1993 SNA[48] and extend this series backwards by using the growth rates of other data series in the 1968 JSNA. Before the 1968 JSNA was introduced, the Japanese national accounts were called National Income Statistics. Data from the National Income Statistics are used only for constructing the imputed rent of owner-occupied houses. Publications we used are as follows;

National Income Statistics

- *Annual Report on National Report on National Income Statistics 1975*, Economic Planning Agency

1968 JSNA

- *Report on National Accounts from 1955 to 1998*, Economic and Social Research Institute, Cabinet Office
- *Annual Report on National Accounts of 2000*, Economic Planning Agency

1993 JSNA

- *Annual Report on National Accounts of 2004-2008*, Economic and Social Research Institute, Cabinet Office

1.2 Laspeyres Quantity Indexes and Subindexes

The Laspeyres quantity index (and therefore, a corresponding Paasche price index) is applied for constructing quantity indexes everywhere in the Japanese national accounts. Therefore, we can

[48] In the future, we will abbreviate “the JSNA based on the 1993 SNA” to “the 1993 JSNA” and “the JSNA based on the 1968 SNA” to “the 1968 JSNA”.

implicitly derive the price and quantity of a component from data series for the aggregate and all other components. Suppose that 0 is the base year and there are two products, B and C. Further suppose that the statistical agency forms a fixed base Laspeyres quantity index that aggregates these two products into the aggregate A say. The base period expenditure shares of products B and C are

$$(A1)\ s_B^0 \equiv P_B^0Q_B^0/[P_B^0Q_B^0 + P_C^0Q_C^0] = V_B^0/[V_B^0 + V_C^0]\ ;$$
$$s_C^0 \equiv P_C^0Q_C^0/[P_B^0Q_B^0 + P_C^0Q_C^0] = V_C^0/[V_B^0 + V_C^0] = 1 - s_B^0$$

where $V_B^0 = P_B^0Q_B^0$ is the value of expenditures on product B in period 0 and P_B^0 and Q_B^0 are the corresponding price, etc. The price of A in period 0 can be set equal to 1 and the quantity of A in period 0 can be set equal to the expenditure on B and C in period 0. The value of the aggregate A in period t is set equal to the sum of the expenditure values on B and C, $V_B^t + V_C^t$, so that putting this all together, we have:

$$(A2)\ P_A^0 = 1;\ V_A^0 \equiv V_B^0 + V_C^0 \equiv Q_A^0\ ;\ V_A^t \equiv V_B^t + V_C^t.$$

Use the Laspeyres quantity index formula to determine the period t quantity aggregate Q_A^t and the corresponding price P_A^t as follows:

$$(A3)\ Q_A^t/Q_A^0 = s_B^0(Q_B^t/Q_B^0) + s_C^0(Q_C^t/Q_C^0)\ ;\ P_A^t = (V_A^t/V_A^0)/(Q_A^t/Q_A^0).$$

Now suppose that we have value series for A, B and C for periods 0 and t (so that in particular we can calculate the shares defined by (A1) above), we know the statistical agency has used the equations in (A3) in order to calculate the price and quantity of A in period t, and we know the prices and quantities for product A and B for periods 0 and t. Our problem is to calculate prices and quantities for product C. We can set the price of product C in period 0 to 1 so that $P_C^0 = 1$ and set the quantity of product C in period 0 to the period 0 value, so that $Q_C^0 = V_C^0$. Now use the first equation in (A3) to solve for Q_C^t, which is a straightforward linear equation in one unknown. Once Q_C^t has been determined, the corresponding price P_C^t can be set equal to $(V_C^t/V_C^0)/(Q_C^t/Q_C^0)$. We found this data recovery technique to be extremely useful in practice.

1.3 Domestic Final Consumption Expenditure of Households (C)

For the years 1955-1998, current and constant yen series for Domestic Final Consumption Expenditure of Households are found in the *Report on National Accounts from 1955 to 1998* (1968 JSNA); see Part 1 Flows, [1] Figures of Calendar Year, I Time Series Tables, 1 Arranged for Main Figures; Calendar Year, in billions of yen. The constant yen series is at the market prices of 1990. We use these series to construct price and quantity series for Domestic Final Consumption Expenditure of Households. However, this aggregate consumption is the sum of market sector sales to households (our C) plus direct purchases abroad by resident households. Therefore, we need to use the technique described in section 1.2 above to remove the latter series.

Our target consumption aggregate also excludes the imputed expenditures on owner-occupied housing and so we have to deduct these expenditures from the national accounts consumption aggregate as well. We follow two steps in order to accomplish this task. First, we construct price and quantity series for total housing consumption (rental expenses plus imputed owner-occupied expenses) from the data of the 1968 JSNA series. Second, for the years prior to 1980, we divided the total housing expenses between the owner-occupied houses and the rental houses based on their relative floor space.[49] We will explain

[49] This is the procedure which had been adopted by Japanese national accounts until 2006.

how we estimated these relative floor spaces in the following section. For the years 1970-1998, we use the current and constant yen series for the sum of rental and owner occupied housing using unpublished data from the 1968 JSNA.[50] For the years 1955-1973, current and constant yen series for total housing expenses can be found in the *Annual Report on National Income Statistics 1975*; see Part 1 Basic Accounts and Main Tables, 2 Figures of Calendar Year, Account 1 Gross National Product and Expenditure. From these two sources, we can construct price and quantity series for the years 1955-1998. We linked these two data series at the time when data series based on the 1968 JSNA started which was 1970.[51] Thus we extended backwards the series in the 1968 JSNA using the growth rates of housing expenditures tabled in the National Income Statistics for the years 1955-1970.[52] As explained in section 2.3 below, we constructed estimates for relative floor spaces of owner-occupied houses and rental houses for the years 1955-2006. Thus, we could decompose our already constructed data series for the total quantity of housing services into quantity components for imputed rent and market rent by using the ratios of floor spaces. Thus we have obtained price and quantity series for the imputed rent of the owner-occupied houses. We then constructed price and quantity series for C for the years 1955-1998 by applying chained Fisher indexes to the price and quantity series for Domestic Final Consumption Expenditure of Households of the 1968 JSNA and our price and quantity series for the imputed expenditures on owner-occupied housing, with the quantity of owner occupied housing entering the index number formula with a negative sign. The resulting series will be linked to the more recent 1993 JSNA household consumption series to be described in the next paragraph.

For the years 1980-2002, current and constant yen series for (1) Final Consumption Expenditures of Household (excluding imputed rents for the services of owner-occupied dwellings), (2) Direct Purchases Abroad by Resident Households, and (3) Direct Purchases in the Domestic Market by Non-Resident Households can be found in the *Annual Report on National Accounts of 2004* (1993 JSNA), and these data series are further updated for the years 1980-2003 (constant yen series only for the years 1994-2003) using the *Annual Report on National Accounts of 2005* (1993 JSNA) and for the years 1994-2006, using the information posted on the Cabinet Office website: *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 1 Flow Accounts; 1.Integrated Accounts; (1) Gross Domestic Product Account (Production and Expenditure Approach); Calendar Year, in billions of yen. The constant yen series in the *Annual Report on National Accounts of 2004* is at the market prices of 1995. The constant yen series in the *Annual Report on National Accounts of 2005* is at the market prices of 2000. The constant yen series in the *Annual Report on National Accounts of 2008* is at the market prices of 2000 (chained).[53] From these data series, we constructed price and quantity series for each of the three variables listed above for the years 1980-2006.

[50] Shuji Hasegawa at the Japanese Cabinet Office has made available to us these data series.
[51] Some variables in JSNA based on 1968 SNA are revised back to 1955. However, total housing expenses in the 1968 JSNA are available only after 1970.
[52] There is another database consisting of gross outputs, exports, and imports for the years 1951-1968. This database was constructed at the joint project between Japan Center of Economic Research and Keio Economic Observatory in the early 1970s, headed by Professor Iwao Ozaki, Keio University. We used the estimates of households' housing expenditure from this database in order to extrapolate the JSNA data based on the 1968 SNA backwards for the years 1955-1968.
[53] Constant yen series based on chained indexes have been introduced in the *Annual Report on National Accounts of 2006*. Since a chained index avoids the substitution bias that the usual fixed based index is likely to show, we use constant yen series based on chained indexes as much as possible.

One difference between the 1968 JSNA and the 1993 JSNA is in the treatment of social benefits in kind.[54] It was a part of Domestic Final Consumption Expenditure of Households instead of a part of Government Final Consumption Expenditure in the 1968 JSNA. However, it became a part of Government Final Consumption Expenditure instead of a part of Domestic Final Consumption Expenditure of Households in the 1993 JSNA. We consider social benefits in kind as a part of Domestic Final Consumption Expenditure of Households following the treatment of the 1968 JSNA.[55] For the years 1990-2003, current and constant yen series for Social Benefits in Kind etc. are found in the *Annual Report on National Accounts of 2005* (1993 JSNA), and these data series are further updated for the years 1996-2006 in the *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 1 Flow Accounts; 5. Supporting Tables, (8) Final Consumption Expenditure of General Government classified by Purpose; Fiscal Year, in billions of yen. The constant yen series in the *Annual Report on National Accounts of 2005* are at the market prices of 1995. The constant yen series of the updated data series in the *Annual Report on National Accounts of 2008* is at the market prices of 2000. Since these annual data series are based on a fiscal year, we transformed these data series of Social Benefits in Kind etc. based on fiscal years into those based on calendar years by linear interpolation.[56] From these data series, we constructed price and quantity series for Social Benefits in Kind etc. based on calendar years for the years 1991-2006.

For the years 1991-2006, we constructed price and quantity series for our consumption aggregate C by applying chained Fisher indexes to the above data series, which were essentially equal to an aggregate of: (1) Final Consumption Expenditures of Household (excluding imputed rent services of owner-occupied dwellings), (2) (less) Direct Purchases Abroad by Resident Households, plus (3) Direct Purchases in the Domestic Market by Non-Resident Households and plus (4) Social Benefits in Kind.

We constructed two data series for C: one data series constructed from the data of the 1968 JSNA for the years 1955-1998 and the other data series for C constructed from the data of the 1993 JSNA for the years 1991-2006. We linked these two data series at 1991, the time when the data series for social benefits in kind became available in the 1993 JSNA.

There is a final adjustment to our concept for the Domestic Final Consumption Expenditures of Households, C. Goods and services purchased for the maintenance of owner-occupied houses (in other words, maintenance expenses) are part of the imputed rent of owner-occupied houses. Since they are produced by the market sector, we must add these maintenance expenses to our aggregate C.[57] We aggregated these two variables by applying chained Fisher indexes. The operating surplus from the owner-occupied houses is the imputed rent minus the maintenance expenses for owner-occupied houses. Thus, once we obtain the imputed rent and the operating surplus from the owner-occupied houses, we can implicitly construct maintenance expenses.[58] For the years 1980-2003, current yen series for

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[54] Social benefits in kind consist of transfers made by government units to households. It consists of subsidies for medical treatment and for text books which are supposed to be delivered to all the students without any cost. However, these goods are also produced by the production sector.

[55] Following the same treatment of social benefits in kind as in the 1968 JSNA, we can construct price and quantity series for C for a longer period than we can construct following the same treatment in the 1993 SNA.

[56] The fiscal year in Japan is from April for the current year to May for the next year. Suppose that data series of fiscal year t are v_t. Then, data series of calendar year t, V_t is calculated as follows: $V_t = (1/4) \times v_{t-1} + (3/4) \times v_t$.

[57] It is possible to make a separate data series of the goods and services for the maintenance. However, since its value is relatively small (about 5 % of the imputed rent), we treat it as a part of household consumption.

[58] We assume that the deflators for the maintenance expenses and the operating surplus of the owner-occupied houses are the same as that of the imputed rent of the owner-occupied houses.

Operating surplus (imputed services of owner-occupied dwellings) can be found in the *Annual Report on National Accounts of 2005* (1993 JSNA) and this data is updated for the years 1996-2006 using the *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 1 FLOWS, 2. Income and Outlay Accounts classified by Institutional Sectors, (5) Households (Including Private Unincorporated Enterprises). For the years 1955-1979, we assume the ratio of the imputed rent to maintenance expenses is constant and is the same as the average ratio over the five years 1980-1984. By utilizing this ratio and the imputed rent of owner-occupied houses, we can extrapolate the maintenance expenses backwards.

1.4 Consumption Expenditures of Non-Profit Institutes (N)

For the years 1955-1998, current and constant yen series for Final Consumption Expenditure of Private Non-Profit Institutions Serving Households (N) is found in the *Report on National Accounts from 1955 to 1998* (1968 JSNA); see Part 1 Flows, [1] Figures of Calendar Year, I Time Series Tables, 1 Arranged for Main Figures; Calendar Year, in billions of yen. The constant yen series is at the market prices of 1990.

For the years 1980-2003, current and constant yen series for Final Consumption Expenditure of Private Non-Profit Institutions Serving Households N is found in the *Annual Report on National Accounts of 2004* (1993 JSNA), and these data series are further updated for the years 1980-2003 (constant yen series only for the years 1994-2003) in the *Annual Report on National Accounts of 2005* (1993 JSNA), the years 1994-2006 on the Cabinet Office website, *Annual Report on National Accounts for 2008* (1993 JSNA); see Part 1 Flow Accounts; 1.Integrated Accounts; (1) Gross Domestic Product Account (Production and Expenditure Approach); Calendar Year, in billions of yen.

Thus we have two data series for N. We link these two data series at 1980, the time when data series for the 1993 JSNA starts.

1.5 Net Purchases of Goods and Services by the Government (G)

We define net purchases of goods and services by the general government (G) as the purchases of intermediate inputs by the general government (G1) minus the sales of goods and services of the general government to the market sector (G2):

- G (= G1 – G2): Net purchases of goods and services by the general government;
- G1: Purchases of intermediate inputs by the general government;
- G2: Sales of goods and services of the general government.

By definition, sales of goods and services of the general government (G1) is equal to government final consumption expenditures (G3) minus the gross output of general government (G4).

- G2: (= G3 − G4) Sales of goods and services by the general government;
- G3: Gross output of the general government;
- G4: Government final consumption expenditures.

For the years 1955-1998, current and constant yen series for (1) Purchases of intermediate inputs by the general government (G1), (2) Gross output of the general government (G3), and (3) Government final consumption expenditures (G4) are found in the *Report on National Accounts from 1955 to 1998* (1968 JSNA); see Part 1 Flows, [2] Figures of Calendar Year, I Time Series Tables 1, Arranged for Main Figures. The constant yen series is at the market prices of 1990. From these data series, we constructed price and quantity series for G1, G3, and G4. Thus, we can implicitly construct price and quantity series for G2 by using the data series of G3, and G4. In the end, we constructed data series of G for the years 1955-1998 by applying chained Fisher indexes to the price and quantity series of G1 and G2.[59]

In the 1993 JSNA, current and constant yen series for G1 and G2 are available for the years 1990-2006. For the years 1990-2003, current and constant yen series for Commodity and Non-Commodity Sales of the General Government (G2) are found in the *Annual Report on National Accounts of 2005* (1968 JSNA); see Part 1 Flows, 5. Supporting Tables, Table 8, Final Consumption Expenditure of General Government classified by Purpose, Fiscal Year, in billions of yen. These data series are further updated for the years 1996-2006 in the *Annual Report of National Accounts of 2008* (1993 JSNA). The constant yen series in the *Annual Report on National Accounts of 2005* is at the market prices of 1995. The constant yen series of the updated data series in the *Annual Report on National Accounts of 2008* is at the market prices of 2000 (chained). We transform the data series for G2 based on fiscal years into those based on calendar years by linear interpolation.[60] We construct price and quantity series for G1 from the data of the 1993 JSNA for the years 1990-2006. For the years 1990-2003, current and constant yen series for Purchases of intermediate inputs by the general government (G1) are found in the *Annual Report on National Accounts of 2005* (1993 JSNA), and these data are updated for the years 1996-2006 in the *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 1 Flow, 5. Supporting Tables, (2) Gross Domestic Product and Factor Income classified by Economic Activities; Calendar year, in billions of yen. The constant yen series in *Annual Report on National Accounts of 2005* is at the market prices of 1995. The constant yen series of the updated data series in *Annual Report on National Accounts of 2008* is at the market prices of 2000 (chained). From these data series, we construct price and quantity series for G1 for the years 1990-2006.

Thus we have two data series for G: one data series constructed using the data of the 1968 JSNA for the years 1955-1998 and the other data series for G constructed from the data of the 1993 JSNA for the years 1991-2006. We linked these two data series at 1991.

1.6 Exports and Imports of Goods and Services (X and M)

For the years 1955-1998, current and constant yen series on the 1968 JSNA basis are available for the following four variables; (1) Exports of goods and services (S1), (2) Imports of goods and services (S2), (3) Direct purchases abroad by resident households (S3), and (4) Direct purchases in the domestic market by non-resident households, (S4). These series are found in the *Report on National Accounts from 1955 to 1998* (1968 JSNA); see Part 1 Flows, [1] Figures of Calendar Year, I Time Series Tables, 1 Arranged for Main Figures; Calendar Year, in billions of yen. The constant yen series are at the market prices of 1990. For the years 1980-2003, current and constant yen series for the above variables such as S1, S2, S5, and S6 can be found in the *Annual Report on National Accounts of 2005* (1993 JSNA), and these data are further updated for the years 1994-2006 in the *Annual Report on National Accounts of 2008*; see Part 1 Flow Accounts; 1.Integrated Accounts, (1) Gross Domestic Product Account (Production and Expenditure Approach), Calendar Year, in billions of yen. The constant yen series in the *Annual Report on National Accounts of 2005* is at the market prices of 1995. The constant yen series of the updated data series in the *Annual Report on National Accounts of 2008* is at the market prices of 2000 (chained).

We have two data series for S1, S2, S3, and S4 individually. As usual, we linked these two data series at 1980, the time when the data of the 1993 JSNA start.

[59] When we aggregated these two data series, we put a negative sign in front of the quantity series G2.

[60] G2 based on fiscal years is available for the years 1990-2006. However, since we transform data based on fiscal yeas to data based on calendar years by using linear interpolation as we explained before, G2 based on calendar years is available only for the years 1991-2006.

Finally, we constructed data series of X by applying chained Fisher indexes to the price and quantity series of S1 and S4 and constructed data series for M by applying chained Fisher indexes to the price and quantity series for S2 and S3.[61]

2. Capital Services and Investments

There are price and quantity series for investments and capital stocks for 95 asset classes; 90 tangible assets and 5 intangible assets. These data are taken from the KEO data base.[62]

- I1 to I95: Investments for asset classes;
- K1 to K95: Capital services for the asset classes.

We have already listed the 95 asset classes in Table 1. The numbering of investments corresponds to that of capital services. Quantities of capital services are proportional to capital stocks at the beginning of the year. Thus, we first describe how we constructed the capital stocks.

2.1 Capital Stocks

For constructing capital services, we make use of the following data from the KEO database:

- Gross fixed capital formation by asset class for the whole country for the years 1955-2006;
- Gross fixed capital formation by asset class for the market sector for the years 1955-2006;[63]
- Asset price indexes for the years 1955-2007;
- Capital stocks by asset class at the end of 1955;
- Depreciation rates.

Time series for Gross Fixed Capital Formation (GFCF) and for asset price indexes for each asset class are available in the latest version of the KEO database. By subtracting the investment in 1955 from the corresponding capital stock in 1955, we can construct capital stocks at the beginning of 1955. If the initial constructed capital stock of a good becomes negative, we set the resulting capital stock to be zero. These constructed capital stocks at the beginning of 1955 are our initial benchmark estimate of the capital stocks. Now, all the requirements to apply the Perpetual Inventory Method (PIM) are ready and we can apply the method to estimate the capital stocks. Since asset price indexes are available for the years 1955-2006, we obtain nominal and real capital stocks for 95 asset classes for the years 1955-2006. By applying the user cost formula (53) in the main text, we can construct prices and quantities for the capital services of these 95 asset classes.

2.2 Investments

All investment goods are produced by the market sector. However, the bit of GFCF that is used by the government sector must be subtracted from the total economy estimates for GFCF by asset. Fortunately, the required information is available for constructing market sector investment by asset class and is available on the KEO data base. Thus we could obtain price and quantity data on investments for 95 asset classes for the market sector over the years 1955-2006 based on the KEO database.[64] However, the stock of residential structures includes the stocks held by owner occupiers of houses. We need to extract the residential capital held by owner occupiers from the total stock of residential structures in order to obtain the market sector's residential capital that is used to produce market rental housing. We now turn to the problem of estimating the owner's portion of the residential housing capital stock.

[61] When we constructed these aggregates, we put negative sign in front of the quantity series for S3 and S4.
[62] Nomura (2004) gives the detailed explanation of the construction of capital data of KEO data base.
[63] Nominal and real GFCF for the market sector are available at KEO database.
[64] These data are used for constructing capital services for the market sector.

2.3 The Decomposition of Residential Structures Capital into Two Components

Overall residential structures can be classified into owner-occupied houses and rental houses. The owner-occupied houses are attributed to household sector. The household sector earns imputed rent by providing the services of its owned houses to itself. Therefore, the residential structures held by owner occupiers should be subtracted from the total stock of residential housing. In order to accomplish this task, we first calculate the total floor space of owner-occupied houses and rental houses. Second, we divide the total stock of residential structures into owner-occupied houses and rental houses according to their relative total floor spaces.

2.3.1 Data sources

- *Housing Survey of Japan Volume 1,* R*esults for the Whole of Japan* (1968) (1973) (1978) (1983) (1988) (1993), Statistics Bureau;
- *Revised Report on National Income Statistics* (1951-1973), Economic Planning Agency;
- *Housing Survey of Japan, volume 1, results for whole Japan* (1968)(1973)(1978)(1983)(1988), Statistics Bureau;
- *Housing and Land Survey of Japan volume 1, results for whole Japan* (1993)(1998)(2003), Statistics Bureau;
- *Monthly of Construction Statistics* (1955-2006), Ministry of Land, Infrastructure and Transport

2.3.2 Total Floor Space Estimates for Owner-Occupied Houses and Rental Houses

Point estimates for total floor space for owned and rented houses are available every five years from 1968 to 2003 in the *Housing survey of Japan* (1968) (1973) (1978) (1983) (1988) (1993) and the *Housing and land survey of Japan* (1998) (2003). We use these data as benchmarks. We extend these benchmarks by utilizing the information on the net investment of the housing stock every year. Annual data for residential investment and loss of residential buildings are available from *Monthly of Construction Statistics* (for the years 1960-2006). Annual investment (loss) is the floor space which has been newly added to (subtracted from) the existing stock of housing.

The following two data series from *Monthly of Construction Statistics* are used:

- New dwellings started: new construction starts of dwellings by owner occupant relation (floor area) for the years 1955-2006.
- Loss of residential buildings: changes in total area and in dwelling units, by cause of loss for the years 1955-2006.

New dwellings started provide estimates for the area of new construction of the following four different kinds of houses:

- (1) Owned houses; Dwellings which are owned by the households occupying them.
- (2) Rented houses; Rented houses which are owned and administrated by the local government or public corporations.
- (3) Issued houses; Dwellings which are owned or administered by private companies, public bodies, etc and rented to their employees or officials in order to meet the needs of their work or issued as a part of salaries and wages regardless of rent being paid.
- (4) Houses built for sales; Dwellings constructed by the public or private sectors in order to be sold with the site under the house included in the sale.

We classify the types of overall houses as owned houses or rental houses. Since the data in the *Monthly of Construction Statistics* have a more detailed classification than we are using, we regroup the four different kinds of overall houses listed there into two categories; owned houses and rental houses. We regard the floor area of new construction of owned houses (1) and houses built for sales (4) as additions (new investment) to the floor stock of the owned houses. We regard the floor area of new construction of rental houses (2) and issued houses (3) as additions (new investment) to the floor stock of the rented houses.[65]

Statistics on the loss of residential buildings show the destroyed floor space of total residential building by aging, natural disaster, and fires. These statistics include the loss of the owner-occupied houses and the loss of rental houses. We distribute the area of the floor space losses between the owner-occupied houses and the rental houses in proportion to the areas of their stocks and we obtain net investment series (in terms of floor space) for the two types of house. We adjust these net investments every 5 years between benchmarks by a linear interpolation method so that the accumulated floor spaces coincide with the benchmark floor spaces. The earliest benchmark floor space is the one in 1968. For the years 1955-1967, we use the same adjustment coefficient as the one used between 1968 and 1973. We apply the Perpetual Inventory Method to estimate floor space of housing for the years 1955-1967.

Now, we calculate floor spaces of overall residential structures, owner-occupied houses, and rental houses. The last step is to make this database of floor space more consistent with the 1993 JSNA data. Until 2003, housing expenses have been divided between owner-occupied houses and rental houses according to their floor space in JSNA. The 1993 JSNA based data for imputed rents for owner-occupied houses and for market rents gives us another estimate for the ratio of the floor space of owner-occupied houses and the floor space of rental houses for the years 1981-2006. These 1993 JSNA based estimates are quite similar to our estimates which have just been described. However, for the years 1981-2006, we use the 1993 JSNA based estimates as the primary estimate and link our earlier series to the 1993 JSNA data. This enables us to provide a breakdown of the total stock of residential structures into owner-occupied stocks and market sector rental stocks.

3. Inventory Services and Changes in Inventories

We regard the change in inventories as outputs and the stock of inventories as inputs to production of the market sector.[66] There are price and quantity series for 4 types of changes in inventory and 4 types of inventory services in our database.

- IV1: Changes in finished-goods inventories;
- IV2: Changes in work-in-process inventories;
- IV3: Changes in work-in-process inventories for cultivated assets;
- IV4: Changes in materials inventories.
- KIV1: Finished-goods inventory services;
- KIV2: Work-in-process inventory services;
- KIV3: Work-in-process inventory services for cultivated assets;
- KIV4: Material inventory services.

The quantities of inventory services are proportional to inventory stocks held at the beginning of the year. Thus, first of all, it is necessary to construct prices and quantities for the inventory stocks. For constructing inventory stocks, we make use of the following data from the KEO database. The following nominal and real inventory stocks are available at the KEO database:

[65] This assumption will only be approximately correct since some of the houses built for sale can be sold to home owners who lend their houses for tenants. As will be seen shortly, our assumptions here do not have to be precisely correct. We just need them to be approximately correct so that we can construct reasonable estimates of floor space by type of house between censuses.

[66] This follows the treatment advocated by Diewert (2005a).

- (1) Finished-goods inventories at the end of the years 1955-2004;
- (2) Work-in-process inventories at the end of the years 1955-2004;
- (3) Work-in-process inventories for cultivated assets at the end of the years 1955-2004;
- (4) Material inventories at the end of the years 1955-2004.

Since they are stock at the end of the years 1955-2004, we use them as stocks at the beginning of the years 1956-2005. We extend these data series backward to 1955 and forward to 2007. For the years 1997-2007, current yen series for inventory stocks (1), (2), and (4) are found in the *Annual Report on National Accounts of 2008* (1993 JSNA); Part 2 STOCKS, 5. Supporting Tables, (1) Closing Stocks of Assets/Liabilities for the Nation. For the years 2006-2007, we extrapolate the data series in the KEO data base by using the growth rate in the corresponding data series of the JSNA. Since there is no information on the inventory stocks (3), we assumed that the growth rate of the nominal inventory stocks (3) is the same as that of the nominal inventory stocks (4). For the same periods 1955 and 2005-2006, we extend prices of these four types of inventory stocks using the average growth rate over the recent 5 years.

The change in inventories over a year for each of our four types of inventory is regarded as an (investment) output of the market sector and it is equal to the difference between the stock of the inventory class under consideration at the beginning of current year and the stock of the same inventory class at the beginning of the next year. Since we have already prepared estimates for our 4 types of inventory stock, it is straightforward estimates of inventory change for the years 1956-2006. For 1955, we extrapolate the change in inventory backward by using the average growth rate over the following 5 years. Adding change in inventory in 1955 to the inventory stock at the beginning of 1956, we obtain inventory stock at the beginning of 1955.

In the end, we obtain estimates for the 4 types of changes in inventories IV1-IV4 for the years 1955-2006. We also obtain estimates for the four types of nominal and real inventory stocks (1)-(4). By applying the user cost formula (53), we can construct prices and quantities of four types of inventory services KIV1-KIV4 for the years 1955-2006.

4. Land Services

There are price and quantity series for four types of land in our database:

- LD1: Agricultural land services;[67]
- LD2: Industrial land services;
- LD3: Commercial land services;
- LD4: Residential land services.

Quantities of land services are proportional to land stocks at the beginning of the year. Thus, first of all, we have to construct land stocks.

4.1 Four Types of Land

For measuring land stocks, we make use of the following data from the KEO database, where estimates for nominal and real land stocks are available for the following types of land:

- (1): Land for agricultural use;
- (2): Land for industrial use;
- (3): Land for commercial use;

[67] Our estimates for agricultural land only include the land used for agricultural production. Other types of land such as waste and fields are excluded from land for agricultural use.

- (4): Land for residential use;
- (5): Land for general government.

KEO estimates are supplemented by data taken from the following websites.

- Website of *Land Use Survey*, http://www.mlit.go.jp/hakusyo/tochi/tochi_.html, Ministry of Land, Infrastructure, Transport and Tourism;
- Website of *Prefectural Land Price Survey*, http://tochi.mlit.go.jp/english/index.html, Ministry of Land, Infrastructure, Transport and Tourism

Since the KEO estimates are for stocks at the end of the years 1955-2004, we use them as estimates for the land stocks at the beginning of the years 1956-2005. We extend these data series backward to 1955 and forward to 2006. For the stocks of 1955, we assume that they are equal to the corresponding stocks of 1956. For stocks of 2006, we estimate the real land stocks (1)-(4) by using the growth rates for the area space information found in the website of the *Land Use Survey* and we also extrapolate nominal land stock (1)-(4) by using the growth rate of nominal land stocks calculated from the real land stocks and land prices that are found in the website of the *Prefectural Land Price Survey*. For information on land for the general government sector, current yen estimates for land for general government for the years 1996-2006 can be found in the *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 2 Stocks, 2 Accounts classified by Institutional Sectors, (3) General Government; Calendar Year in billion yen. We obtain an estimate for the nominal land stock (5) in 2006 by using the growth rate of nominal land for general government using the JSNA just described. The price of land for residential use (4) in 2006 is obtained by using the rate of growth in the land price for general government (5) over 2005-2006.

We attribute land for general government as land that is being used for commercial uses. It is not quite true but it is a reasonable approximation. Thus, by subtracting land for general government from land for commercial use, we obtain final estimates for commercial land. Since the stocks of land in the KEO database are stocks at the end of the period, we convert these stocks to beginning of period stocks. We assume that between 1955 and 1956, the area of each type of land is constant and the price of each land changes at the average growth rate over the years 1956-1960. There remains one problem that land for residential use also includes land being used for owner-occupied houses. Since the imputed rent of owner-occupied houses is an output by household sector, it is excluded from the output produced by the market sector. Therefore, the services of the land and residential building stocks for owner-occupied houses should also be excluded from the input of market sector. We will explain how to subtract land for owner-occupied houses from land for residential use in the following section.

4.2 Residential Land

Residential land is the land that lies under residential structures. We divide the residential land into the owned residential land and the rental residential land in proportion to the land areas utilized by the two types of residential structures. We calculate the area of the site under owner occupied and rental houses.[68] The nominal and real residential land is divided into owned residential land and rental residential land according to their areas of use. The owned residential land will be excluded from land for residential use of the market sector.

4.2.1 Data Sources

- *Housing Survey of Japan, Volume 1, Results for the Whole of Japan* (1968) (1973) (1978) (1983) (1988) (1993), Statistics Bureau;

[68] Unfortunately, the land under owner-occupied houses is not always owned land.

- *Housing and Land Survey of Japan, Volume 1, Results for the Whole of Japan* (1998) (2003), Statistics Bureau;
- *Monthly of Construction Statistics* (1955 to 2004), Ministry of Land, Infrastructure and Transport;

4.2.2 The Land under the Owned Houses and the Site under the Rental Houses

For the years 1968-2006, we use benchmark land areas under owned houses and rental houses, which are available every five years; see *Housing and Land Survey of Japan* and *Housing Survey of Japan*. We interpolate these areas between benchmarks using annual "Areas of finished housing sites" reported annually by the *Monthly Statistics of Construction*. The area of a finished housing site is the area of the site which is currently transformed into residential land. There are four types of site:

- (1) Housing sites for a public housing complex;
- (2) Housing sites for individual houses;
- (3) Housing sites for re-development; and
- (4) Sites for villas.

We regard (2) plus (3) as the newly added area under owned houses. We regard (1) as the newly added area of under rental houses.

Initially, we assume the change in land areas under owned houses is proportional to the newly added areas for owned houses and the change in the areas under rental houses is proportional to the newly added areas for rental houses. We then proportionally adjust these initial estimates for land areas by type of housing so that the accumulated area of residential land coincides with their benchmark values in the 5 year surveys.

The earliest benchmark survey for land areas is the one in 1968. However, there is no benchmark and annual data to impute the areas under owned houses and rental houses for prior years. We extend backward the area of land for owner-occupied houses and rental houses by using their average growth rates over the 10 years 1968-1978.

In the end, we obtain estimates for four types of nominal and real land stocks (1)-(4). By applying the user cost formula in (53), we can construct prices and quantities of four types of land services LB1-LB4 for the years 1955-2006.

5. Labour Inputs

There are price and quantity series for 3 types of labour input in our database;

- LB1: Labour input of employees in the market sector[69];
- LB2: Labour input of the self-employed;
- LB3: Labour input of family workers;

First, we calculate the number of workers who are actually working and the average yearly hours of works. Second, we multiply the number of workers by the average yearly hours worked. Thus we can get the yearly hours of work for the four types of workers.

5.1 Data Sources

The Japanese *Labour Force Survey* plays the key role in the construction of our labour input database. There are six types of workers in *Labour Force Survey*. We construct the number of workers and the

[69] Employees include paid family workers.

average weekly hours of works for these six types of workers using the data in the *Labour Force Survey*; see the following publications:

- *Annual Report on the Labour Force Survey* (1970, 1972-2006), Statistics Bureau;
- Website for the *Labour Force Survey* http://www.stat.go.jp/data/roudou/index.htm, Statistics Bureau

There were two major revisions of the *Labour Force Survey* in 1961 and 1967:

- Revision of 1961; population coverage is changed from 14 years old to 15 years old and
- Revision of 1967; the definition of "employed persons not at work" is changed. The coverage of population is smaller after the revision than before the revision.

We ignore the revision of 1961. Education is compulsory for children between the ages of 6 and 15 in Japan. Thus, we expect that the revision of 1961 did not affect the result of the survey. However, there is clear evidence that the revision of 1967 has had a large impact on the survey results.[70] The *Annual Report on the Labour Force Survey* issued in 1970 contains old data series for the years 1955-1967 and new data series for the years 1967-1970. Since the old data series follows the definition before the revision of 1967, we need to adjust the old data series so that it is consistent with the new data series. We extend the new data series by using the growth rate of old data series for the years 1955-1966.

5.2 Three Types of Workers in Labour Force Survey

In the *Labour Force Survey*, all the workers are classified into three types of worker according to their "characteristics of employment" and then they are further divided into two types of "labour force status". Therefore, there are data on six types of worker and the total number of workers by type and their average hours of work can be found in the *Labour Force Survey*.

Labour Force Status

According to the definitions in the *Labour Force Survey*, employed persons are the workers in the labour force who are not unemployed. Employed persons are classified into the following two types according to their labour force status:

- Employed persons at work: all persons who worked for pay or profit or worked as unpaid family workers for at least one hour during the survey week
- Employed persons not at work: employees who were absent from work but received or expected to receive wages or salaries or self-employed workers whose absence from work has not exceeded 30 days.

Characteristics of Employment

All the employed persons are classified into following three types of worker according to the following characteristics of employment:

- Self-employed workers: persons who own and operate unincorporated enterprises;
- Family workers: persons who work in unincorporated enterprises operated by family members;
- Employees: persons who work for wages or salaries as employees of unincorporated enterprises, companies, corporations and associations or levels of government.

Six Types of Workers in the Labour Force Survey

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[70] According to *Annual Report on the Labour Force of Survey* issued at 1970, the number of total employed persons in 1967 is 4940 (before the revision) and 4920 (after the revision) in ten thousands of persons. The average weekly hours worked of total employed persons is 46.4 hours (before the revision) and 48.8 hours after the revision.

There are data on the following six types of worker in the *Labour Force Survey*:

- L1: Employees at work;
- L2: Employees not at work;
- L3: Self-employed workers at work;
- L4: Self-employed workers not at work;
- L5: Family workers at work;
- L6: Family workers not at work.

Average Yearly Hours Worked

Average weekly hours worked for three types of workers (self-employed workers, family workers and employees) are available in the *Labour Force Survey*. Multiplying the weekly hours worked by fifty two, we can calculate the yearly hours worked. They are the average yearly hours of works for employed persons at work; those who are actually working during the week of survey investigation.

- AH1: Average yearly hours worked for employees at work;
- AH2: Average yearly hours worked for self-employed workers at work;
- AH3: Average yearly hours worked for family workers at work.

5.3 Three Types of Worker in the National Accounts

The numbers of the three types of worker are available in the National Accounts. There are labour data in the 1968 JSNA for the years 1955-1998. There are labour data in the 1993 JSNA for the years 1980-2006. We extend the data of the 1993 JSNA backwards by using the growth rates of the 1968 JSNA data. The three types of worker in the JSNA are:

- L7: Employees;
- L8: Family workers and the self-employed workers;
- L9: Government workers.

In comparison with the data series of the *Labour Force Survey*, the number of workers in JSNA includes the number of employed persons not at work such as employees who were absent from work but received or expected to receive wages or salaries or self-employed workers whose absence from work has not exceeded thirty days. By using the ratio of the number of the employed persons at work and the number of the employed persons not at work in *Labour Force Survey*, we constructed the number of three types of the employed persons at work as follows:

- L10 = L1–L9: Employees in market sector;
- L11 = L3: The self-employed;
- L12 = L5: Family workers.

Multiplying the number of employed persons by category by the corresponding average hours worked, we can calculate total hours worked by category of worker:

- TH1 = L10 $\times$ AH1: Total hours worked by employees in the market sector;
- TH2 = L11 $\times$ AH2: Total hours worked by the self-employed;
- TH3 = L12 $\times$ AH3: Total hours worked by family workers.

5.4 Compensation of Employees

For the years 1955-1998, current yen series for the compensation of employees is found in the *Report on National Accounts from 1955 to 1998* (1968 JSNA); Part 1 Flows, [1] Figures of Calendar Year, II Time Series Tables 2 Arranged for Main Figures, Distribution of National Income and National Disposable Income, in Calendar Year (Billion Yen) at current prices. For the years 1980-2003, current yen series for compensation of employees can be found in the *Annual Report on National Accounts of 2005* (1993

JSNA), and these data are further updated for the years 1996-2006 in the *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 1 Flows, 1. Integrated Accounts, (2) Distribution of National Income and National Disposable Income, in Calendar Year (billion yen) at current prices. We link the data of the 1993 JSNA to the data of the 1968 JSNA at 1980, the time when data based on the 1993 JSNA start. Thus we have constructed a data series for the compensation of employees for the whole economy for the years 1955-2006.

For the years 1955-1998, compensation of employees for the general government is found in the *Report on National Accounts from 1955 to 1998* (1968 JSNA); see Part 3 Long Time Series of Production, II Gross Domestic Product and Factor Income by Kind of Economic Activity (1) at current prices. For the years 1990-2003, current yen series for compensation of employees for the government sector is found in the *Annual Report on National Accounts of 2005* (1993 JSNA) and these data are further updated for the years 1996-2006 in the *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 1 Flows, 1. Supporting tables, (2) Gross Domestic Product and Factor Income classified by Economic Activities, in Calendar Year (billion yen) at current prices. We link the data of 1993 JSNA to the earlier data of the 1968 JSNA at 1990, the year when data of the JSNA 1993 start. Therefore, we have constructed the data series of compensation of employees for the government sector for the years 1955-2006.

The difference between the total compensation of employees and compensation of employees for the government sector is considered to be the compensation of employees of the market sector and period t, we denote this market sector labour compensation by $V_{LB1}{}^{t}$. The period t hourly wage for employees in the market sector $W_{LB1}{}^{t}$ is obtained by dividing $V_{LB1}{}^{t}$ by the period t yearly hours worked for employees in the market sector $TH1^{t}$ as follows:

(B1) $W_{LB1}{}^{t} = V_{LB1}{}^{t}/TH1^{t}$

There remains the problem of determining appropriate wage for the self-employed and family workers. We certainly expect the wage for a family worker to be very much less than the wage for an employee and we would expect the wage for a self-employed person to be somewhat less than the wage for an employee. However, it is difficult to know what exactly is the appropriate wage for self-employed and family workers.

We hypothesize that the wage for the self-employed $W_{LB2}{}^{t}$ is a fraction f_2 of the wage for employees in market sector $W_{LB1}{}^{t}$ and the wage for family workers $W_{LB3}{}^{t}$ is a fraction f_3 of the wage for employees in market sector $W_{LB1}{}^{t}$.

(B2) $W_{LB2}{}^{t} = f_2\, W_{LB1}{}^{t}\,;\; W_{LB3}{}^{t} = f_3\, W_{LB1}{}^{t}$ for $t = 1955,\cdots,2006$

For the ratio between the wage per employee and the average wage per the self-employed, we use the estimate in the KEO database of 32.8%. For the average ratio between the wage per employee and the wage per family worker, we use the estimate in the KEO database of 11.3%. We assume that the average wage per worker coincides with the mean of "the average yearly hours worked times hourly wages" for the years 1955-2006:

(B3) $0.328 = (1/52)\sum_{t=1955}^{2006}[(AH_2{}^{t}\times f_2W_{LB1}{}^{t})/(AH_1{}^{t}\times W_{LB1}{}^{t})]$

(B4) $0.113 = (1/52)\sum_{t=1955}^{2006}[(AH_3{}^{t}\times f_3W_{LB1}{}^{t})/(AH_1{}^{t}\times W_{LB1}{}^{t})]$

Thus, we can derive estimates for the two fractions f_2 and f_3 from equations (B3) and (B4). Solving these equations, we obtain f_2= 0.3252 and f_3= 0.1014.

6. Taxes and Subsidies

There are 8 types of taxes in our database. We allocated all Japanese direct and indirect taxes and subsidies into the following categories:[71]

- TA1 Consumption taxes: Taxes that fall on final demands such as H, I1-I95 (these taxes must be deducted from the final demand consumption prices, since producers do not get the revenue from these taxes);
- TA2 Labour taxes: Taxes that fall on labour input plus contributions to social securities (we do not deduct these taxes from the SNA estimates of labour income since firms must pay these taxes but we require estimates of labour taxes as an aid in determining capital taxes);
- TA3 Capital taxes[72]: Taxes that fall on capital stock components such as the corporation tax (these taxes are added to the user cost of capital);
- TA4 Property taxes[73]: Taxes that fall on specific capital stock components (these taxes are added to the user cost of capital for the relevant specific capital stock);
- TA5 Household capital taxes: Taxes on household non productive physical assets like durable goods;
- TA6 Poll taxes: Taxes that households pay, regardless of their incomes;
- TA7 Tariffs: Taxes imposed on imported goods[74];
- TA8 Subsidies on products: (these subsidies act as an offset to the indirect taxes that fall on final consumption).

Household capital taxes and poll taxes do not change any prices which the production sector faces. Therefore, we ignore them in our model of production. Other taxes such as TA1-TA4, TA7, and TA8 have been reflected in the prices of net outputs and primary inputs in our database.

There are several taxes which can be attributed more than one category. We will explain how to allocate these taxes into different categories later in this section.

6.1 Data Sources for Taxes

We use tax revenue data of central and local government.

- *National Tax Agency Annual Statistics Report* (1955 to 2006), National Tax Agency;
- *Annual Statistical Report on Local Government Finance* (1955 to 2006), Ministry of Internal Affairs and Communications;
- *1970 National Wealth Survey of Japan, Volume 1, Summary Report* (1973), Economic Planning Agency.

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[71] Some categories have subcategories. The subcategories are explained in footnotes.

[72] Capital taxes are decomposed into the following categories: (1) General capital taxes; (2) Capital taxes on tangible capital; (3) Capital taxes on tangible capital excluding land; (4) Capital taxes on tangible capital excluding land, structures, and inventories; (5) Capital taxes on tangible capital including land and excluding inventories and (6) Financial capital.

[73] Different rates of property tax are imposed on the following specific types of property capital stock: (1) Structures; (2) Structures and land in general; (3) Transportation equipment; (4) Forest wood; (5) Land in general; (6) Land for agricultural use; (7) Non agricultural land and (8) Forest lands, waste lands and land used for purposes other than agricultural use.

[74] The total tax on an imported good can consists of consumption taxes, liquor taxes, tobacco taxes, gasoline taxes, etc. Therefore, a different level of tariffs may be imposed on each imported good. We group tariffs into the following four categories: (1) Tariffs for imported goods in general; (2) Tariffs for foodstuffs; (3) Tariffs for mineral fuels and (4) Tariffs for miscellaneous goods.

6.2 Adjustments of Tax Data from Fiscal Years to Calendar Years

Tax revenues in the various data sources are the amounts of tax revenue settled during a fiscal year. However, many taxes are imposed on economic activity using *different* fiscal years. Therefore, tax revenues in a fiscal year are not necessarily revenues from economic activity during the "regular" fiscal year, which is April 1 to March 30. By linear interpolation, we adjust the tax revenues of each tax so that tax revenues are imposed on economic activities during calendar years. For example, the tax revenue from the tobacco tax in a "tobacco fiscal year" is imposed on tobacco sales from March 1 in the current year to February 28 in the next year. Thus, using the following linear interpolation, we can adjust tax revenue from tobacco tax so that the adjusted tax revenue is from tobacco sales during a calendar year (from January to December in the current year).

(B5) $T_{2006} = (1/6)\times t_{2005}+(5/6)\times t_{2006}$

where t is tax revenue from March in the current year to February in the next year and T is adjusted tax revenue of the current calendar year.

Prefectural and municipal inhabitants' taxes also require special attention. As we explain later, these inhabitants' taxes consist of two parts: one is a poll tax and the other one is proportional to income in the previous year. The poll tax is attributed to the current year. However, the income part of the inhabitants' tax is attributed to the previous year.

6.3.1 Income Tax

A careful treatment is needed for modelling the income tax. Since households' incomes can be considered as returns to labour or capital or more specific property, we divide total income tax revenue between labour taxes, capital taxes, and property taxes.

For the national income tax, the tax collection agency adopts two tax collection methods: (a) withholding at source, and (b) self-assessment on a tax return basis. Income tax is paid by self-assessment unless it is withheld at the income source. Income taxes on wages, salaries, interest, dividends, etc. are withheld by the payers of such income who remit the withheld tax to the government on the behalf of taxpayers. Under the self-assessment tax system, each taxpayer is required to file a return and pay the appropriate amount of tax at the same time. The withholding tax system is firmly built into the basic structure of the individual income tax. The amount withheld is treated as an advance payment of the income tax payable by the recipient of the income.

Withholding Income Tax

The amounts of withholding taxes on the different sources of income are listed in *National Tax Agency Annual Statistics Report*. Based on the characteristics of the sources of income, all withholding income taxes are classified into the following categories of taxes:

- (1) Interest income, etc. (treated as a general capital tax);
- (2) Dividends (capital tax);
- (3) Capital gains of listed stocks, etc. (capital tax);
- (4) Wage and salaries (labour tax);
- (5) Retirement income (labour tax);
- (6) Remuneration, fees, etc. (labour tax);
- (7) Income of non residents, etc. (ignored).

Thus we attribute (1) Interest income, (2) Dividends, and (3) Capital gains of listed stocks, etc. to financial assets and (4) Wage and salaries, (5) Retirement income and (6) Remuneration, fee, etc. to labour. We ignore (7) Income of non residents, etc.

Self-Assessed Income Tax

With respect to the taxpayers of self-assessed income tax, the statistics of the amounts of incomes is listed by type of income in *National Tax Agency Annual Statistics Report*. First, self-assessed income tax is split between the different types of income on the basis of the relative sizes of the types of income. Then, we attribute taxes on different types of income into the categories of taxes based on the characteristics of the source of income:[75]

- Operating income:
  Business income (labour tax and capital tax)
  Farm income (labour tax and capital tax)
- Rental income (capital tax);
- Comprehensive capital gains (capital tax);
- Sporadic income (labour tax);
- Miscellaneous income (labour tax);
- Difference by aggregation of profit and loss (capital tax);
- Sales of wood in forest (property tax);
- Long term separate capital gains (capital tax);
- Short term separate capital gains (capital tax)[76];
- Capital gains of stocks, etc. (capital tax)

Operating income refers to the incomes of farmers and the self-employed. Therefore, operating income is considered as a return to labour and capital. We attribute tax on operating income in proportion to labour input and capital service.[77] The majority of all employees pay income tax for their salaries through the withholding tax system.[78]

Prefectural and Municipal Inhabitants' Tax

Prefectures and municipals impose an income tax called the individual inhabitants' tax. Individual inhabitants' tax consists of two parts: (a) individual inhabitants' tax as a lump sum payment that households pay regardless of their incomes and (b) individual inhabitants' tax with an income rate that households pay based on their income. There is no doubt that we can attribute tax (a) as a poll tax. However, since we do not know the source of income for tax (b), we encounter the same problem as we do in allocating self-assessed income tax into different categories. We split tax (b) on the basis of the relative sizes of the types of income. Then, we attribute taxes on different types of income into the categories of taxes based on the characteristics of the source of income. Since we know the types of incomes of those who pay withholding income tax and those who pay self-assessed income tax, we can calculate the type of income for total households. Corporate inhabitants' tax is imposed on corporations.

[75] The tax category to which each income tax is attributed is in a parenthesis.

[76] Long and short term separate capital gains are imposed when capital stocks are transferred from one agent to the other.

[77] Output and labour input at current prices can be calculated independent from tax on operating income. The differences between output at current prices and labour input at current prices can be considered as capital service at current prices.

[78] The employees who earn more than certain amount (for example, more than 20 million yen in 2003) have to pay more income tax in addition to income tax paid under the withholding tax system. However, the number of those earners is very small.

Since it is imposed on the financial capital and the profits of corporations, we regard these taxes as capital taxes.

6.3.2 Inheritance Tax

An inheritance tax is tax imposed on the acquisition of the types of property listed below. We split the inheritance tax between these properties on the basis of the relative sizes of the values of properties. Then, we attribute the inheritance taxes to the categories of taxes based on the characteristics of properties. The types of property are listed below and our attribution of the associated tax is noted in parentheses:

- Housing land including leasehold (property tax);
- Rice fields, farm fields, forest lands and other lands (property tax);
- Total land (property tax);
- Houses, structures (property tax);
- Business (agriculture) property (property tax);
- Securities (capital tax);
- Cash, deposit (capital tax);
- Household properties (household capital tax);
- Other properties (capital tax);
- Obligations and funeral expenses (poll tax).

6.3.3 Taxes on the Holdings of Transportation Equipment

Motor vehicle weight taxes, motor vehicle taxes and light motor vehicle taxes are imposed on the holdings of motor vehicles. Since households and the production sector own motor vehicles, these taxes are paid by both households and producers. The part of these taxes paid by households is attributed to household capital tax (and is not relevant for the purposes of this study). The other part of these taxes is attributed to the production sector and should be regarded as a specific tax on the services of the taxed vehicles, just as property taxes on structures used by the production sector are part of the user costs of business structures. We need to construct the total stock of automobile vehicles and divide this stock between households and the production sector. Following the convention of JSNA, we divide the stock in half. We observe the automobile vehicle stock of households from the *National Wealth Survey* in 1970. The survey tells us the relative sizes of the value of motor vehicles owned by households and producers. Cutting the stock in half is consistent with this data source.[79]

6.3.4. Fuel Tax

There are taxes on the use of fuels such as electricity, gas, gasoline, and light oil.

National Fuel Taxes:

- Gasoline taxes;
- Local road taxes (fuel taxes on gasoline);
- Promotion of power resources development tax (fuel taxes on electricity).

Local Fuel Taxes:

- Light oil delivery taxes (fuel taxes on light oil);
- Electricity and gas taxes;
- Electricity taxes;

[79] The *National Wealth Survey* in 1970 is a comprehensive survey of assets for all sectors in the Japanese economy. The total transportation equipment wealth for all sectors less the household sector was 2678.4 billion yen. The household sector owned transportation equipment valued by 2471.9 billions yen.

- Gas taxes.

These taxes are charged when these fuels such as electricity, gas, gasoline, and light oil are purchased. These fuels are consumed both by households and the market sector. Therefore, it is not clear about how to categorize fuel taxes. We attributed the payment of these taxes by households as a consumer tax. We attributed the payment of these taxes by the market sector as a property tax which is necessary for using a specific capital stock.

Total values for the above energy sources purchased within the whole country and the values of these purchases by the household sector are available in the *Input Output Tables* for Japan and this enables us to apportion the above taxes into household and market sector components. Since Input Output tables are constructed only every five years, there are no data available between years. We interpolate the data between the 5 year censuses using the assumption of constant growth rates.

6.4 Subsidies

For the years 1955-1998, the amount of subsidies is found in the *Report on National Accounts from 1955 to 1998* (1968 JSNA); see Part 1 Flows, 2. Income and Outlay Accounts classified by Institutional Sectors, (1) Total Economy, 1. Generation of Income Account, Calendar Year (Billion Yen). We transformed this data series into that based on calendar years by linear interpolation. For the years 1980-2003, the amount of subsidies can be found in the *Annual Report on National Accounts of 2005* (1993 JSNA) and this data series is updated for the years 1996-2006 in the *Annual Report on National Accounts of 2008* (1993 JSNA); see Part 1 Flows, 1. Consolidated Accounts for the Nation, (1) Gross Domestic Product Account (Production and Expenditure Approach), Fiscal Year (Billion Yen). Hence, we linked the data of the 1993 JSNA to the data of the 1968 JSNA at 1980, the time when the 1993 JSNA data starts. We treat the amount of subsidies as a deduction from consumption taxes.

Appendix B. Tables of Prices, Quantities, and Value for Inputs and Outputs

Table B- 1: Market Sector Output and Input Prices for Japan 1955-2006

	P_C^t	P_N^t	P_G^t	P_X^t	P_M^t	P_I^t	P_{IV}^t	W_K^t	W_{KIV}^t	W_{LD}^t	W_{LB}^t
1955	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
1956	0.99703	1.04615	1.03388	1.02965	1.05376	1.07799	1.04712	1.08169	1.05204	1.16196	1.05179
1957	1.02738	1.10446	1.07826	1.03426	1.09109	1.14107	1.05224	1.15659	1.19164	1.36070	1.10638
1958	1.02625	1.10634	1.02659	0.96878	0.94146	1.10683	1.03845	1.08086	1.08918	1.40745	1.17209
1959	1.05894	1.14682	1.02660	0.98937	0.93343	1.10406	1.06320	1.15192	1.28222	1.83905	1.27721
1960	1.09084	1.20386	1.02179	1.01738	0.93658	1.12828	1.06145	1.27237	1.54259	2.53976	1.38571
1961	1.15469	1.28583	1.02797	1.01018	0.94761	1.21002	1.05061	1.43545	1.87937	3.19594	1.57035
1962	1.23612	1.37610	1.00577	0.98142	0.93746	1.23850	1.06323	1.41725	1.73852	3.30404	1.76259
1963	1.32449	1.46796	0.96413	0.99917	0.95406	1.24410	1.07810	1.44819	1.83008	3.73650	2.00535
1964	1.35950	1.56704	0.93538	1.00856	0.96725	1.26346	1.09280	1.50856	1.93255	4.28573	2.27010
1965	1.45886	1.66444	0.90383	0.99720	0.95975	1.28731	1.12958	1.48553	1.80848	4.27477	2.54831
1966	1.51695	1.76062	0.90717	0.99403	0.96561	1.33289	1.14260	1.56866	2.00951	4.87588	2.83193
1967	1.56786	1.86445	0.93176	0.99545	0.95097	1.38861	1.14488	1.64873	2.22900	5.72138	3.17469
1968	1.64996	1.97776	0.91819	0.99573	0.95036	1.43391	1.17562	1.73058	2.42545	6.82919	3.65518
1969	1.71027	2.10943	0.90076	1.00810	0.97895	1.49307	1.22446	1.77813	2.47623	7.76855	4.25721
1970	1.82794	2.40092	0.89024	1.03805	0.99677	1.56173	1.25690	1.81056	2.39880	8.44544	4.99450
1971	1.94992	2.70055	0.84140	1.06033	0.96150	1.59771	1.28639	1.69350	1.95785	7.86309	5.80183
1972	2.05921	3.05621	0.79548	1.05206	0.91509	1.66686	1.41150	1.68574	1.92085	8.73231	6.65593
1973	2.29351	3.59806	0.85186	1.15271	1.09624	1.93381	1.66319	1.88330	2.23789	10.1912	8.06301
1974	2.83264	4.58741	1.45022	1.51236	1.75661	2.35584	1.90937	2.16313	2.26767	9.13653	10.3362
1975	3.16042	5.10880	1.02494	1.58677	1.92722	2.45112	2.00804	2.11839	1.92912	7.78490	12.2298
1976	3.46526	5.70934	1.06147	1.61790	2.03849	2.55621	2.11166	2.28546	2.27598	8.85856	13.1718
1977	3.71534	6.17437	1.05674	1.55768	1.96681	2.66758	2.15311	2.35609	2.19766	8.79634	14.3949
1978	3.87391	6.40351	0.97740	1.45874	1.68134	2.75138	2.18031	2.49634	2.42779	10.0163	15.4132
1979	3.99783	6.80715	1.03956	1.57767	2.15086	2.94163	2.39012	2.72136	2.84131	11.6653	16.3529
1980	4.32413	7.33700	1.25680	1.73055	2.93771	3.17559	2.48710	2.81714	2.72588	11.6000	17.3548
1981	4.52158	7.52015	1.33660	1.78649	2.95808	3.23328	2.53195	2.78784	2.49284	11.4760	18.4482
1982	4.62834	7.69027	1.29913	1.85101	3.03352	3.24736	2.57551	2.75534	2.35093	11.4128	19.2703
1983	4.71786	7.79175	1.29664	1.79280	2.86988	3.23912	2.57967	2.70003	2.16338	11.0573	19.5932
1984	4.82858	7.97162	1.28407	1.82130	2.79678	3.24600	2.55926	2.80297	2.37885	12.5124	20.4581
1985	4.91842	8.14610	1.39614	1.76755	2.64136	3.22555	2.46696	2.85117	2.44114	13.6090	21.1035
1986	4.94545	8.22560	1.23620	1.55180	1.84760	3.16648	2.32755	2.79144	2.26552	13.9688	21.6777
1987	4.94737	8.26421	1.15510	1.48687	1.69649	3.14775	2.26676	2.74862	2.14757	14.6776	22.0999
1988	4.96136	8.33565	1.09534	1.46098	1.64759	3.17448	2.27921	2.79144	2.22673	16.1472	22.7855
1989	5.04884	8.52905	1.12116	1.50919	1.75642	3.26989	2.29860	2.86819	2.29217	18.1520	23.9454
1990	5.17153	8.96291	1.16374	1.53466	1.87546	3.36079	2.32319	2.87526	2.18253	18.8101	25.6530
1991	5.28303	9.23972	1.15241	1.49857	1.79612	3.40881	2.33815	2.83200	1.97694	17.5637	27.3283
1992	5.35828	9.34334	1.14051	1.46065	1.70317	3.41944	2.74114	2.79482	1.88367	16.0579	28.2152
1993	5.40276	9.33467	1.12573	1.36261	1.56573	3.41916	2.97697	2.69461	1.60441	13.6690	28.8677
1994	5.41735	9.39690	1.09140	1.32033	1.49759	3.39038	2.92008	2.65835	1.54632	12.8586	29.3625
1995	5.39662	9.40567	1.06876	1.29255	1.46656	3.36617	2.89429	2.65010	1.53414	12.4829	29.5263
1996	5.39591	9.43497	1.05542	1.33823	1.56054	3.32070	2.88663	2.66805	1.63862	12.6933	29.7140
1997	5.45523	9.57777	1.07503	1.36274	1.65065	3.31842	2.87727	2.65228	1.59586	11.9657	30.5118
1998	5.40850	9.55327	1.06211	1.37515	1.60171	3.24115	2.83786	2.49595	1.27424	9.59550	30.1564
1999	5.37479	9.44358	1.04311	1.25304	1.47021	3.16839	3.17806	2.44727	1.26667	9.10836	29.6677
2000	5.33873	9.37894	1.03769	1.20100	1.49125	3.15573	3.07127	2.47140	1.36088	9.20322	29.2208
2001	5.28118	9.33973	1.02959	1.22783	1.52040	3.06595	2.99237	2.36571	1.16493	8.08721	29.3849
2002	5.19282	9.07042	1.01556	1.21287	1.50088	2.99292	2.95949	2.36221	1.26244	8.18701	28.8293
2003	5.14486	8.94323	0.99858	1.17108	1.48431	2.95534	2.97245	2.36290	1.36052	8.09554	28.4695
2004	5.07268	8.85937	0.99077	1.15700	1.52514	2.94031	2.94441	2.46092	1.61013	8.71952	28.0511
2005	5.00953	8.91312	0.99601	1.17380	1.65354	2.92203	2.95698	2.48659	1.67861	8.79902	28.3146
2006	4.92842	8.98647	1.00967	1.21863	1.78359	2.92197	2.96864	2.51649	1.73151	8.94577	28.4287

Table B- 2: Market Sector Output and Input Quantities for Japan 1955-2006 (Billion Yen)

	y_C^t	y_N^t	y_G^t	y_X^t	y_M^t	y_I^t	y_{IV}^t	x_K^t	x_{KIV}^t	x_{LD}^t	x_{LB}^t
1955	5021.9	99.7	246.2	887.1	931.2	1618.5	467.3	2072.1	250.7	1351.2	3733.0
1956	5530.3	108.3	221.3	1062.3	1182.0	1988.9	501.7	2083.4	268.5	1353.9	4051.1
1957	6012.1	115.2	226.2	1201.5	1453.0	2412.8	492.7	2154.5	290.7	1359.9	4325.0
1958	6386.9	117.2	261.7	1276.6	1256.4	2535.9	157.5	2284.7	311.6	1367.3	4468.9
1959	6887.8	130.5	281.1	1465.4	1543.0	3008.9	529.2	2419.4	318.3	1379.1	4612.9
1960	7717.1	147.4	313.7	1647.3	1892.7	4052.4	653.6	2586.2	340.9	1386.8	4870.2
1961	8572.7	164.8	347.9	1730.9	2394.6	5030.0	1122.7	2875.3	367.2	1414.8	5019.3
1962	9191.6	174.0	409.6	2062.2	2366.2	5640.8	501.1	3269.3	410.8	1443.7	5232.8
1963	10044.5	187.8	486.2	2225.5	2830.4	6310.8	767.8	3681.7	430.5	1472.9	5301.1
1964	11177.3	229.2	504.2	2733.8	3217.2	7337.8	874.4	4111.2	461.0	1504.1	5445.8
1965	11716.0	254.0	539.3	3415.8	3396.7	7589.2	652.6	4617.9	496.3	1548.6	5600.1
1966	12984.0	260.4	607.9	4004.3	3805.3	8685.0	855.7	5073.8	522.5	1652.5	5824.7
1967	14445.6	258.1	613.6	4273.1	4671.9	10288.5	1521.2	5615.4	554.9	1755.7	5985.9
1968	15681.1	263.0	744.0	5297.6	5244.2	12292.3	1597.9	6330.6	610.4	1798.8	6063.1
1969	17369.9	272.4	897.6	6425.7	5950.8	14428.7	1738.5	7222.1	668.2	1905.2	6137.7
1970	18768.9	219.5	1107.8	7530.7	7299.4	16754.7	1696.7	8291.3	731.2	1961.3	6273.5
1971	19777.2	200.8	1357.6	8841.4	7766.2	17458.3	339.7	9547.5	793.2	2012.8	6359.8
1972	21619.9	195.7	1630.1	9225.3	8530.1	19078.7	251.8	10682.9	805.9	2072.9	6422.8
1973	23557.2	182.3	1875.0	9733.5	10560.7	21349.7	1720.4	11845.2	815.0	2200.0	6627.2
1974	23359.7	175.0	1363.1	12014.8	11045.2	20170.2	1765.4	13110.9	876.1	2292.0	6496.4
1975	24406.4	164.7	2084.9	11903.8	9894.3	19936.5	-486.3	14077.0	939.1	2385.5	6325.8
1976	25034.8	164.1	2107.7	13889.8	10533.7	20780.5	565.5	14895.0	921.7	2446.5	6616.0
1977	25928.1	195.1	2384.0	15520.9	10906.3	21330.6	-238.0	15699.1	942.1	2544.5	6765.3
1978	27211.6	199.6	2760.1	15504.0	11461.0	23135.9	-400.6	16540.1	933.6	2612.7	6839.0
1979	29010.0	222.9	2985.7	16156.4	12917.3	24388.7	2330.4	17578.8	918.9	2667.8	6951.8
1980	29175.7	247.4	2961.1	18909.4	11991.4	24266.1	1632.9	18665.5	1003.3	2727.9	7084.7
1981	29574.4	255.8	3221.6	21127.0	12220.9	24825.2	499.1	19752.5	1062.5	2761.1	7221.0
1982	31045.2	257.5	3490.6	21105.8	12401.6	24953.0	331.2	20827.0	1080.9	2809.3	7318.5
1983	32055.8	277.1	3832.2	21747.5	12004.1	24683.6	-482.8	21846.1	1093.3	2851.7	7561.5
1984	32799.6	295.0	4079.0	24565.9	13270.7	25793.8	664.3	22845.5	1075.3	2862.0	7628.6
1985	33817.0	309.2	3823.3	26018.5	13399.1	28001.8	471.7	24619.8	1100.0	2922.3	7729.0
1986	34804.3	331.6	4761.2	24414.8	13447.7	29879.8	-494.4	26296.4	1117.4	2932.8	7832.0
1987	36189.6	342.7	4864.9	24189.0	15084.7	32170.8	354.2	28219.0	1099.4	2969.8	7957.2
1988	37910.8	358.7	5392.2	25437.1	17470.0	36216.4	432.5	30011.6	1112.1	3014.7	8155.5
1989	39642.6	377.6	5872.1	27800.0	20373.4	39761.6	1511.8	32083.4	1127.6	3050.3	8315.4
1990	41428.7	393.6	6377.3	29635.7	21940.3	43024.0	1007.8	34519.3	1181.2	3094.4	8414.6
1991	42338.8	417.6	7506.2	30911.4	21754.5	44379.5	543.8	37069.3	1216.7	3116.8	8532.2
1992	43275.0	455.3	8017.2	32142.5	21465.2	43490.6	30.7	39505.4	1236.2	3169.5	8509.5
1993	43637.1	475.9	8417.2	32169.2	21223.4	42076.7	-578.0	41307.4	1237.6	3221.9	8464.7
1994	44856.8	490.1	9057.3	33343.9	22881.5	41384.3	-485.1	42406.7	1210.6	3272.0	8474.5
1995	45742.7	516.3	9800.6	34833.0	25941.8	41473.7	682.7	43239.0	1188.0	3303.4	8549.6
1996	46895.8	524.7	10109.7	36801.7	29815.4	43423.7	941.3	44321.0	1220.0	3349.1	8577.8
1997	46975.7	516.5	10034.4	40874.6	30304.4	43709.9	898.4	45714.8	1264.3	3393.2	8547.1
1998	46367.6	574.2	10676.1	39773.4	28421.3	40835.5	-24.1	47158.7	1306.9	3448.9	8489.3
1999	46760.0	620.3	11401.7	40588.1	29241.0	40556.0	-1246.7	48091.3	1305.6	3469.8	8426.8
2000	47416.2	575.0	11257.3	45789.5	32202.5	40715.9	121.2	48880.3	1238.4	3509.9	8581.6
2001	48359.5	584.1	11463.2	42592.6	32777.7	40621.5	-933.6	49965.7	1244.9	3540.3	8442.7
2002	48857.9	617.1	11668.2	45801.9	33060.5	38912.1	-501.0	50955.8	1193.8	3557.2	8347.0
2003	49114.5	657.1	11982.7	49728.8	34448.3	38698.7	-702.5	51507.4	1166.4	3595.5	8328.7
2004	50179.5	690.6	12023.3	56596.3	37014.3	39369.2	-101.3	52205.3	1128.0	3590.2	8382.7
2005	51190.1	723.2	11688.8	60478.9	39484.7	40884.9	1130.4	52968.3	1091.3	3595.5	8389.9
2006	52727.9	742.5	10671.3	66512.1	41765.2	41477.0	2469.5	54090.1	1173.8	3640.5	8491.4

References

Archibald, R.B. (1977), "On the Theory of Industrial Price Measurement: Output Price Indexes", *Annals of Economic and Social Measurement* 6, 57-72.

Balk, B.M. (1998), *Industrial Price, Quantity and Productivity Indices*, Boston: Kluwer Academic Publishers.

Christensen, L.R. and D.W. Jorgenson (1969), "The Measurement of U.S. Real Capital Input, 1929-1967", *Review of Income and Wealth* 15, 293-320.

Christensen, L.R., D.W. Jorgenson and L.J. Lau (1971), "Conjugate Duality and the Transcendental Logarithmic Production Function", *Econometrica* 39, 255-256.

Denison, Edward F. (1974); *Accounting for United States Economic Growth 1929-69*, Washington D.C.: The Brookings Institution.

Diewert, W.E. (1973), "Functional Forms for Profit and Transformation Functions", *Journal of Economic Theory* 6, 284-316.

Diewert, W.E., (1974), "Applications of Duality Theory," pp. 106-171 in M.D. Intriligator and D.A. Kendrick (ed.), *Frontiers of Quantitative Economics*, Vol. II, Amsterdam: North-Holland.

Diewert, W.E. (1977), "Walras' Theory of Capital Formation and the Existence of a Temporary Equilibrium", pp. 73-126 in *Equilibrium and Disequilibrium in Economic Theory*, E. Schwödiauer (ed.), Reidel Publishing Company.

Diewert, W.E. (1978), "Superlative Index Numbers and Consistency in Aggregation", *Econometrica* 46, 883-900.

Diewert, W.E. (1980), "Aggregation Problems in the Measurement of Capital", pp. 433-528 in *The Measurement of Capital*, D. Usher (ed.), Chicago: The University of Chicago Press.

Diewert, W.E. (1983), "The Theory of the Output Price Index and the Measurement of Real Output Change", pp. 1049-1113 in *Price Level Measurement*, W.E. Diewert and C. Montmarquette (eds.), Ottawa: Statistics Canada.

Diewert, W.E. (1993), "Symmetric Means and Choice Under Uncertainty", pp. 355-433 in *Essays in Index Number Theory, Volume I,* Contributions to Economic Analysis 217, W.E. Diewert and A.O. Nakamura (eds.), Amsterdam: North Holland.

Diewert, W.E. (1997), "Commentary" on Mathew D. Shapiro and David W. Wilcox, "Alternative Strategies for Aggregating Price in the CPI", *The Federal Reserve Bank of St. Louis Review*, 79:3, 127-137.

Diewert, W.E. (2004), "Measuring Capital", Discussion Paper 04-10, Department of Economics, The University of British Columbia, Vancouver, Canada, V6T 1Z1. Available at http://www.econ.ubc.ca/discpapers/dp0410.pdf

Diewert, W.E. (2005a), "On Measuring Inventory Change in Current and Constant Dollars", Discussion Paper 05-12, Department of Economics, The University of British Columbia, Vancouver, Canada, V6T 1Z1. Available at http://www.econ.ubc.ca/diewert/disc.htm

Diewert, W.E. (2005b), "Issues in the Measurement of Capital Services, Depreciation, Asset Price Changes and Interest Rates", pp. 479-542 in *Measuring Capital in the New Economy*, C. Corrado, J. Haltiwanger and D. Sichel (eds.), Chicago: University of Chicago Press.

Diewert, W.E. and K.J. Fox (2005), "The New Economy and an Old Problem: Net versus Gross Output", University of New South Wales, April.

Diewert, W.E. and D. Lawrence (2005), "Australia's Productivity Growth and the Role of Information and Communications Technology: 1960-2004", Report prepared for the Department of Communications, Information Technology and the Arts, Canberra, Australia, March. 14.

Diewert, W.E. and D. Lawrence (2006), *Measuring the Contributions of Productivity and Terms of Trade to Australia's Economic Welfare*, Report by Meyrick and Associates to the Productivity Commission, Canberra, Australia. http://www.oecd.org/dataoecd/7/19/37503743.pdf

Diewert, W.E., H. Mizobuchi and K. Nomura (2005), "On Measuring Japan's Productivity, 1955-2003", Discussion Paper 05-22, Department of Economics, University of British Columbia, Vancouver, B.C., Canada, V6T 1Z1, December. http://www.econ.ubc.ca/discpapers/dp0522.pdf

Diewert, W.E. and C.J. Morrison (1986), "Adjusting Output and Productivity Indexes for Changes in the Terms of Trade", *The Economic Journal* 96, 659-679.

Diewert, W.E. and A.M. Smith (1994), “Productivity Measurement for a Distribution Firm”, *the Journal of Productivity Analysis* 5, 335-347.
Edwards, E.O. and P.W. Bell (1961), *The Theory and Measurement of Business Income*, Berkeley: University of California Press.
Feenstra, R.C. (2004), *Advanced International Trade: Theory and Evidence*, Princeton N.J.: Princeton University Press.
Fisher, F.M. and K. Shell (1972), “The Pure Theory of the National Output Deflator”, pp. 49-113 in *The Economic Theory of Price Indexes*, New York: Academic Press.
Fisher, I. (1922), *The Making of Index Numbers*, Houghton-Mifflin, Boston.
Fox, K.J. and U. Kohli (1998), “GDP Growth, Terms of Trade Effects and Total Factor Productivity”, *Journal of International Trade and Economic Development* 7, 87-110.
Gorman, W.M. (1968), “Measuring the Quantities of Fixed Factors”, pp. 141-172 in *Value, Capital and Growth: Papers in Honour of Sir John Hicks*, J.N Wolfe (ed.), Chicago: Aldine Press.
Hamada, K. and K. Iwata (1984), “National Income, Terms of Trade and Economic Welfare.” *Economic Journal,* 94, 752-771.
Hayashi, F. and E.C. Prescott (2002), “The 1990s in Japan: A Lost Decade”, *Review of Economic Dynamics* 5, 206-235
Hayashi, F. and K.Nomura (2005), “Can IT be Japan’s Savior?”, *Journal of Japanese and International Economies*. 19, 543-567
Hicks, J.R. (1946), *Value and Capital*, Second Edition, Oxford: The Clarendon Press.
Hicks, J.R. (1961), “The Measurement of Capital in Relation to the Measurement of Other Economic Aggregates”, pp. 18-31 in *The Theory of Capital*, F.A. Lutz and D.C. Hague (eds.), London: Macmillan.
Hotelling, H. (1932), “Edgeworth’s Taxation Paradox and the Nature of Demand and Supply Functions”, *Journal of Political Economy* 40, 577-616.
Jorgenson, D.W. (1989), “Capital as a Factor of Production”, pp. 1-35 in *Technology and Capital Formation*, D.W. Jorgenson and R. Landau (eds.), Cambridge MA: The MIT Press.
Jorgenson, D.W. (1996a), “Empirical Studies of Depreciation”, *Economic Inquiry* 34, 24-42.
Jorgenson, D.W. (1996b), *Investment: Volume 2; Tax Policy and the Cost of Capital*, Cambridge, Massachusetts: The MIT Press.
Jorgenson, D.W. and Z. Griliches (1967), The Explanation of Productivity Change”, *The Review of Economic Studies* 34, 249-283.
Jorgenson, D.W. and Z. Griliches (1972), “Issues in Growth Accounting: A Reply to Edward F. Denison”, *Survey of Current Business* 52:4, Part II (May), 65-94.
Jorgenson, D.W., M. Kuroda, and M. Nishimizu (1987). “Japan–U.S. Industry-Level Productivity Comparisons, 1960 –1979.”, *Journal of the Japanese and International Economies* 1, 1–30.
Jorgenson D.W. and M. Nishimizu (1978), “U.S. and Japanese Economic Growth 1952-1974: An International Comparison”, *Economic Journal* 88, 707-726
Jorgenson, D.W. and K.Nomura (2005), “The Industry Origins of Japanese Economic Growth”, *Journal of Japanese and International Economies*. 19, 482-542
Kohli, U. (1978), “A Gross National Product Function and the Derived Demand for Imports and Supply of Exports”, *Canadian Journal of Economics* 11, 167-182.
Kohli, U. (1990), “Growth Accounting in the Open Economy: Parametric and Nonparametric Estimates”, *Journal of Economic and Social Measurement* 16, 125-136.
Kohli, U. (1991), *Technology, Duality and Foreign Trade: The GNP Function Approach to Modeling Imports and Exports*, Ann Arbor: University of Michigan Press.
Kohli, U. (2003), “Growth Accounting in the Open Economy: International Comparisons”, *International Review of Economics and Finance* 12, 417-435.
Kohli, U. (2004a), “An Implicit Törnqvist Index of Real GDP”, *Journal of Productivity Analysis* 21, 337-353.
Kohli, U. (2004b), “Real GDP, Real Domestic Income and Terms of Trade Changes”, *Journal of International Economics* 62, 83-106.

Kuroda, M. Shimpo, K., Nomura, K., Kobayashi, N. (1997), KEO Data Base-The Measurement of Output, Capital, and Labor (in Japanese). Monograph Series no. 8. Tokyo: Keio Economic Observatory.

Lau, L. (1976), "A Characterization of the Normalized Restricted Profit Function", *Journal of Economic Theory*, 12:1, 131-163.

Marshall, A. (1890), Principles of Economics, London: Macmillan.

McFadden, D. (1978), "Cost, Revenue and Profit Functions", pp. 3-109 in *Production Economics: A Dual Approach to Theory and Applications*. Volume 1, M. Fuss and D. McFadden (eds.), Amsterdam: North-Holland.

Miyagawa, T., Y. Ito, and N. Harada (2004), "The IT Revolution and Productivity Growth in Japan", *Journal of the Japanese and International Economy* 18, 362-389.

Nomura, K. (2004), *Measurement of Capital and Productivity in Japan*, (in Japanese), Tokyo: Keio University Press.

Oulton, N. (2004), "Productivity Versus Welfare: Or GDP Versus Weitzman's NDP", *Review of Income and Wealth* 50-3, 329-355.

Pigou, A.C. (1924), *The Economics of Welfare*, Second Edition, London: Macmillan.

Rymes, T.K. (1968), "Professor Read and the Measurement of Total Factor Productivity", *The Canadian Journal of Economics* 1, 359-367.

Rymes, T.K. (1983), "More on the Measurement of Total Factor Productivity", *The Review of Income and Wealth* 29 (September), 297-316.

Samuelson, P.A. (1953), "Prices of Factors and Goods in General Equilibrium', *Review of Economic Studies* 21, 1-20.

Samuelson, P. A. (1961), "The Evaluation of 'Social Income': Capital Formation and Walth", 32-57 in *The Theory of Capital*, F.A. Lutz and D.C. Hague (eds.), London: Macmillan

Samuelson, P.A. and S. Swamy (1974), "Invariant Economic Index Numbers and Canonical Duality: Survey and Synthesis", *American Economic Review* 64, 566-593.

Sato, K. (1976), "The Meaning and Measurement of the Real Value Added Index", *Review of Economics and Statistics* 58, 434-442.

Schreyer, P. (2001), *Measuring Productivity: Measurement of Aggregate and Industry Level Productivity Growth*, Paris: OECD.

Schreyer, P. (2007), *Measuring Capital*, OECD Statistics Directorate, STD/CSTAT/WPNA (2007)2, Paris: OECD.

Schreyer, P. (2008), "Measuring Multi-factor Productivity when Rates of Return are Exogenous", *Price and Productivity Measurement*, W. Erwin Diewert, Bert M. Balk, Dennis Fixler, Kevin J. Fox and Alice O. Nakamura (eds.), Trafford Press, forthcoming.

Törnqvist, L. (1936), "The Bank of Finland's Consumption Price Index", *Bank of Finland Monthly Bulletin* 10: 1-8.

Törnqvist, L. and E. Törnqvist (1937), "Vilket är förhällandet mellan finska markens och svenska kronans köpkraft?", *Ekonomiska Samfundets Tidskrift* 39, 1-39 reprinted as pp. 121-160 in *Collected Scientific Papers of Leo Törnqvist*, Helsinki: The Research Institute of the Finnish Economy, 1981.

United Nations (1993). System of National Accounts 1993. New York: United Nations.

Weitzman, M. (1976), "On the Welfare Significance of National Product in a Dynamic Economy", *Quarterly Journal of Economics* 90, 156-162

Weitzman, M. (2003), *Income, Wealth and the Maximum Principle*, Cambridge, MA: Harverd University Press

Woodland, A.D. (1982), *International Trade and Resource Allocation*, Amsterdam: North-Holland.