JSPS Grants-in-Aid for Scientific Research (S)

Understanding Persistent Deflation in Japan

Working Paper Series

No. 025

November 2013

MEASURING THE EVOLUTION OF KOREA'S MATERIAL LIVING STANDARDS 1980-2010

Taehyoung CHO

Junghoon KIM

Paul SCHREYER

This paper was first published as OECD (2012), "Measuring the Evolution of Korea's Material Living Standards 1980-2010", OECD Statistics Working Papers, No. 2012/02, OECD Publishing.
doi: 10.1787/5k9bdcd29b5d-en

UTokyo Price Project
702 Faculty of Economics, The University of Tokyo,
7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
Tel: +81-3-5841-5595
E-mail: watlab@e.u-tokyo.ac.jp
http://www.price.e.u-tokyo.ac.jp/english/

MEASURING THE EVOLUTION OF KOREA'S MATERIAL LIVING STANDARDS 1980-2010

Taehyoung CHO
The Bank of Korea
unclecho@bok.or.kr

Junghoon KIM
The Bank of Korea
kjh911@bok.or.kr

Paul SCHREYER
OECD Statistics Directorate
Paul.Schreyer@OECD.org

Paper presented to the 2012 EMG Workshop Sydney Australia

Available as OECD Statistics Working Paper 2012/02 under

http://dx.doi.org/10.1787/5k9bdcd29b5d-en

Abstract

Based on a production-theoretic framework, we measure the effects of real output prices, primary inputs, multi-factor productivity growth, and depreciation on Korea's real net income growth over the past 30 years. The empirical analysis is based on a new dataset for Korea with detailed information on labour and capital inputs, including series on land and inventories assets. We find that while over the entire period, capital and labour inputs explain the bulk of Korean real income growth, productivity growth has come to play an increasingly important role since the mid-1990s, providing some evidence of a transition from 'input-led' to 'productivity-led' growth. Terms of trade and other price effects were modest over the longer period, but had significant real income effects over sub-periods. Overall, real depreciation had only limited effects except during periods of crises where it bore negatively on real net income growth.

Views expressed in this document are those of the authors and do not necessarily reflect the views of the Bank of Korea, the OECD or its Member countries. Financial and in-kind support by the Bank of Korea to this work is acknowledged. The authors are grateful to Seung-Hee Koh for excellent research assistance provided during the project.

MEASURING THE EVOLUTION OF KOREA'S MATERIAL LIVING STANDARDS 1980-2010

TABLE OF CONTENTS

1. Introduction

1. The vast majority of studies on economic growth have been concerned with the growth of gross domestic product (GDP), in other words with the growth of countries' production. The OECD, in common with many other organisations and economists, has also approximated material living standards in terms of the level and growth of gross domestic product.

2. Even if one remains in the realm of material well-being, and the present paper will do so, GDP is at best a rough indicator for living standards. A first and important step to track material well-being is to move from measures of volumes of production to measures of real income. This may seem odd at first because by construction, the value of domestic production equals domestic income earned in the production process.

3. However, movements of GDP over time are normally expressed as *volumes,* that is after deflating the nominal value of expenditure on final products [1] by the relevant price indices of consumption, investment, exports and imports. These volumes reflect thus 'quantities' of final goods and services. However, what counts from a perspective of the standard of living is the quantity of consumption goods that can be purchased with nominal income. Thus, the target measure for living standards is *real income*, nominal income deflated by a price index of private consumption[2].

4. Focusing on income instead of GDP captures, among other things, terms of trade effects. Hamada and Iwata (1984) were among the first to show that volume GDP can overstate living standards if import prices rise quicker than export prices. Kohli (2004) has also examined the link between terms of trade effects and volume GDP and found in a study of 26 countries that cumulative differences can be significant. Other relevant empirical studies include Diewert and Lawrence (2006) and Diewert, Mizobuchi and Nomura (2009). As it turns out, price effects are not limited to changes in the terms of trade, i.e., the evolution of relative prices with regard to the rest of the world. Real income expressed in consumption units will also be affected by domestic relative price changes, in particular between consumption and investment products.

5. Where terms of trade effects have been analysed, work has generally remained in the realm of *gross* domestic income. But when capital goods are used in production they depreciate, and lose value due to wear and tear and obsolescence. Depreciation[3] constitutes a charge against gross income and needs to be taken into account before judging how much can actually be consumed without

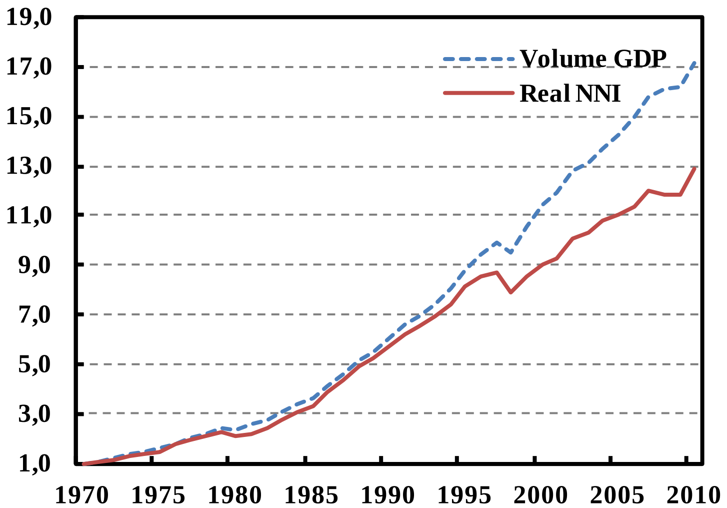
[1] Another step is to consider national rather than domestic income. Some of the income generated by residents is paid to non-residents, while residents receive some income from production in other countries. Domestic income can thus be augmented by the income flows received and reduced by the income flows leaving the country to arrive at the concept of national income, which is more relevant for the material well-being of residents of a country. For the majority of OECD countries there is little difference between the levels of GDP and GNI. There are however exceptions, most notably Ireland and Luxembourg; differences are also likely to be significant for many developing and emerging countries characterised by a significant presence of multinational enterprises in their territory (whose profits are then transferred abroad) and of immigrants working abroad (who transfer part of their income to their country of origin in the form of remittances). In the mid-1980s and late-1990s, Korean GDP was about 1 percent smaller than GNI and the gap became smaller in later years. The present analysis therefore only deals with GDP and the associated income flows.

[2] In what follows, we shall use *real* in the sense that a value has been expressed in equivalents of consumption units. We shall use *volume* to designate the quantity component that, along with a price component, makes up the value of an economic transaction. Volumes are in particular relevant in the computation of productivity, the ratio of the volume of outputs to the volume of inputs. The theory of productivity measurement is based on production functions or production possibility frontiers as in Jorgenson (1966).

[3] In what follows, 'Depreciation' is used interchangeably with 'Consumption of fixed capital', the official denomination in the System of National Accounts.

eroding the asset base. Thus, net income[4] is preferred to gross income when it comes to measuring material well-being. In national accounts terminology, and for the economy as a whole, the reference indicator is *net national income* (NNI). The pertinence of *real net income* as a measure of economic welfare has also been established in inter-temporal models (Sefton and Weale 2006) thus providing a strong theoretical foundation for targeting real net income rather than volume GDP as a measure of living standards. This is not a mute point as the comparison between the evolution of real income and volume GDP in Korea over the past 40 years shows; while volume GDP increased about 17 fold between 1970 and 2010, real net national income increased by a little less than 13 times (see Figure 1).

Figure 1. Volume GDP and real net national income in Korea, 1970=1



6. Diewert and Lawrence (2006) and Diewert, Mizobuchi and Nomura (2009) use such a net perspective in their analysis of real income, terms of trade and productivity for Australia and Japan. They use a net *product* approach, effectively treating depreciation as an intermediate input into production. To measure the volume of depreciation the authors apply a capital goods price index to the value of depreciation. The volume of depreciation is then employed to move from the volume of gross product (gross value-added) to the volume of net product. As there is now a new net measure of output, and a new net measure of capital input (purged off the volume of depreciation), a new, net productivity measure emerges. Hulten and Schreyer (2010) argue that the interpretation of this net productivity measure is less intuitively clear than the traditional productivity measure based on the volumes of gross output and gross inputs. The net productivity measure also requires additional assumptions about the nature of depreciation. The present paper obtains real net income by deducting real depreciation

[4] For the rest of this document and in line with National Accounts terminology, 'net' will always be used in the sense of the value of a variable after deduction of the value of depreciation.

from real gross income where all three variables have simply been deflated with a price index of private consumption. This avoids re-defining volume measures of inputs, outputs, and productivity and uses the welfare-relevant measure of real net income.

7. The paper at hand contributes to the existing work in two distinct ways:

- We use a production theoretic framework and show how changes in real net income can be de-composed into changes of input factors and multi-factor productivity (MFP) as traditionally measured, into terms of trade and other price effects and into depreciation effects.

- We present and use a new dataset constructed by the Bank of Korea (BOK) and analyse Korea's growth over the past three decades. Of particular note is the inclusion of land and inventories in the asset boundary with significant implications for the appreciation of the sources of growth.

2. Analytical framework

Decomposition of real gross income

8. In their adaptation of Diewert and Morrison (1986) and Kohli (1990), Diewert, Mizobuchi and Nomura (2009) show how a production-theoretic framework can be set up to consistently derive a de-composition of real income growth into changes in input quantities, productivity and relative price effects. Their framework is in discrete time and the authors demonstrate that a Törnqvist index formula provides an exact log-linear decomposition of real income into the above components. This is a powerful result and we shall simply refer to it where applicable without re-stating its derivation. To keep things simple, our analytical framework will be set out in continuous time.

9. We start by specifying a technology $(q, K, L, t) \in S$ that describes all feasible combinations of the vector of labour inputs $L = (L_1, ...L_{M_L})$, the vector of capital inputs $K = (K_1, ...K_{M_K})$ and the vector of 'netputs' $q=(q_1,...q_M)$ that are producible at time t. We employ the term 'netput' to signal that q may either be positive or negative. The negative sign applies in particular for imports. However, all q are gross in the sense that they include depreciation. Outputs are measured as consumption, investment and exports (in which case the relevant quantities will be non-negative) and imports (in which case the relevant quantities will be non-positive). Outputs are sold at prices $P=(P_1,...P_M)$ and inputs are purchased at prices $W = (W_1, ...W_{M_L})$ for labour inputs and $U = (U_1, ...U_{M_K})$ for capital

inputs. W are service prices (wages) for labour, U are service prices for capital. P·q, the cross product of prices and quantities of outputs, is the value of GDP.

10. The computation of capital services prices is described in greater detail below, and for the argument at hand it suffices to point out that the main elements of the capital services price are a rate of return, a rate of depreciation and an expected asset price change. We compute the rate of return endogenously[5], so that the value of capital services plus the value of other primary inputs exactly equals the value of final output.

11. To frame the de-composition of income, we follow Diewert, Mizobuchi and Nomura (2009) and define a GDP function that presents the maximum value of output producible in an economy given primary inputs and technology as described earlier:

$$G(P, L, K, t) = \max_q \{P \cdot q \,|(q, L, K, t) \in S\} \text{ where } P \cdot q \equiv \sum_{i=1}^{M} P_i q_i \quad (1)$$

12. The GDP function summarizes all relevant information about technology[6]. It is linearly homogenous in output prices P, non-decreasing in L and K. Under cost minimisation and constant returns to scale, GDP at current prices equals the value of primary inputs:

$$G(P, L, K, t) = P \cdot q = W \cdot L + U \cdot K \text{ where } W \cdot L \equiv \sum_{i=1}^{M_L} W_i L_i \quad U \cdot K \equiv \sum_{i=1}^{M_K} U_i K_i \quad (2)$$

13. Our first step towards real income decomposition is to derive a productivity measure from the GDP function. Let productivity growth correspond to the shift of the GDP function over time such that the rate of technical change equals the partial derivate of G with respect to time divided by G: $\pi \equiv \frac{\partial G(P, L, K, t)}{\partial t} \frac{1}{G}$. To derive a computable expression for π, differentiate (2) totally:

$$dG(P, L, K, t) = \sum_{i=1}^{M} \frac{\partial G}{\partial P_i} dP_i + \sum_{i=1}^{M_L} \frac{\partial G}{\partial L_i} dL_i + \sum_{i=1}^{M_K} \frac{\partial G}{\partial K_i} dK_i + \frac{\partial G}{\partial t} dt = \quad (3)$$
$$\sum_{i=1}^{M} (P_i dq_i + q_i dP_i)$$

[5] One standard method is to compute a nominal rate of return, given depreciation and asset price changes – see Jorgenson and Landefeld (2006). We compute a 'balancing real rate of return' following Diewert, Mizobuchi and Nomura (2009).

[6] The GDP function was introduced by Samuelson (1953). Alternative presentations include in particular Diewert's (1973) variable profit function and McFadden's (1978) restricted profit function.

14. Using the property of GDP functions that output quantities equal the marginal change in GDP with respect to output prices $\partial G/\partial P_i = q_i$ and that input prices equal the marginal change in GDP with respect to input quantities ($\partial G/\partial L_i = W_i$ and $\partial G/\partial K_i = U_i$) one has

$$\sum_{i=1}^{M} q_i dP_i + \sum_{i=1}^{M_L} W_i dL_i + \sum_{i=1}^{M_K} U_i dK_i + \pi G dt = \sum_{i=1}^{M} P_i dq_i + \sum_{i=1}^{M} q_i dP_i \tag{4}$$
$$\pi = \sum_{i=1}^{M} \frac{P_i q_i}{P \cdot q} d\ln q_i - \sum_{i=1}^{M_L} \frac{W_i L_i}{P \cdot q} d\ln L_i - \sum_{i=1}^{M_L} \frac{U_i K_i}{P \cdot q} d\ln K_i$$

15. The second line in (4) was obtained by applying the definition for productivity change π, i.e., as a shift of the GDP function over time. Productivity growth is measured as the difference between the growth rate of outputs and a weighted average of the growth rate of inputs.

16. From a producer perspective, and for purposes of productivity measurement, the valuation of outputs should be at basic prices, excluding those taxes on products that the producer simply passes on to the government but including all subsidies that the producer may receive. Such a valuation implies that P·q is equal to gross value-added at basic prices which does not necessarily correspond to GDP with its final demand components that are valued at purchasers' prices, i.e., from a consumer or demand perspective. At the level of the entire economy, the difference between the two valuations is net taxes on products. However, as GDP at purchasers' prices provides the direct link to domestic income - our target measure – and in light of the fact that Korean national accounts data does not permit valuation of final demand components at basic prices, we shall use GDP rather than value-added as the measure of output even if this is at variance with a strict producer perspective. The implication of proceeding in this way is that net taxes on products are added to the remuneration of capital. Consequently, the share of capital in gross income may be somewhat overstated.

17. Having dealt with the productivity measure, we can now turn to the main task, the decomposition of real income growth. It starts with the accounting identity (2) that shows the value of output and the corresponding value of inputs at current prices. The value of inputs corresponds to nominal domestic income. To obtain a measure of real income, divide the accounting identity by a general deflator. Our choice is P_C, the deflator of private consumption expenditure in the national accounts, a suitable measure to express income in real terms, that is in equivalents of units of private consumption. Dividing (2) by P_C and using the fact that G is linear homogenous in P gives us the following expression for real gross income. Real values are indicated through the use of small letters, for instance $w \equiv W/P_C$:

$$G(P,L,K,t)/P_C = G(P/P_C, L,K,t) = g(p,L,K,t) = W/P_C \cdot L + U/P_C \cdot K = w \cdot L + u \cdot K \quad (5)$$

18. The change in real income can now be obtained from (5) after totally differentiating g(p,L,K,t)[7] and expressing changes in log form:

$$dg(p,L,K,t) = \sum_{i=1}^{M} \frac{\partial g}{\partial p_i} dp_i + \sum_{i=1}^{M_L} \frac{\partial g}{\partial L_i} dL_i + \sum_{i=1}^{M_K} \frac{\partial g}{\partial K_i} dK_i + \frac{\partial g}{\partial t} dt \quad (6)$$
$$d\ln g = \sum_{i=1}^{M} \frac{p_i q_i}{p \cdot q} d\ln p_i + \sum_{i=1}^{M_L} \frac{w_i L_i}{p \cdot q} d\ln L_i + \sum_{i=1}^{M_K} \frac{u_i K_i}{p \cdot q} d\ln K_i + \pi$$

19. In line with Diewert, Mizobuchi and Nomura (2009), we find from the second line in (6) that there are three main sources of growth of real gross income: change in real output prices, change in the use of primary inputs and productivity growth. Note that the real output price effects encompass what is typically referred to as changes in the terms of trade. One of the M outputs is exports and a rise/fall in the real export price will positively/negatively affect real income. Similarly, imports are one of the M ‘outputs’ although they enter GDP with a negative sign. Thus, a rise in the price of imports compared to the price of domestic consumption will negatively affect real income growth. The combined effects of the real price changes of exports and imports on real gross income constitutes the overall terms of trade effect. To the extent that there are real price changes of those outputs that constitute deliveries to domestic final demand, there will also be real income effects from changes in ‘internal terms of trade’. For example, if the real price of investment goods increases, this will positively affect real income from a consumer perspective as consumption products will have become relatively cheaper in comparison with investment products. Owing to our use of the private final consumption deflator as the numéraire to construct real prices, the real price of private final consumption expenditure itself equals one and it follows that $d\ln p_1=0$, supposing that the first final demand element is private final consumption expenditure[8].

Decomposition of real net income

20. To capture material well-being and living standards, a measure of real net income is preferable to a measure of real gross income. Net income accounts for depreciation, the loss in value

---

[7] Note that $(\partial g/\partial t)/g = (\partial(G/P_C)/\partial t)/g = (\partial G/\partial t)/gP_C = \pi$ and $\partial g/\partial p_i = \partial G/\partial P_i$.

[8] It is of course possible to compute the real income contribution of sub-items of private final consumption expenditure as real prices of these sub-components may change over time. However, the sum of contributions of these sub-items will always equal zero if index numbers have been computed consistently.

of capital goods due to ageing and normal obsolescence and a charge against gross income. The welfare-relevant measure of real net income is a deflated measure of nominal net income where the private consumption deflator is again used to convert nominal into real measures. By definition, net income N equals gross income G minus depreciation D. The simple additive relation holds also in real terms and links real net income n, real depreciation d and real gross income g:

$$\begin{aligned} G &= N + D \\ G/P_C &= N/P_C + D/P_C \\ g &= n + d \end{aligned} \tag{7}$$

21. In terms of rates of change, we have real gross income as a weighted average of real net income and real depreciation, and by simple transformation one obtains a measure for the rate of change of real net income:

$$\begin{aligned} d\ln g &= \frac{n}{g} d\ln n + \frac{d}{g} d\ln d \\ d\ln n &= \frac{g}{n}\left(d\ln g - \frac{d}{g} d\ln d \right) \end{aligned} \tag{8}$$

22. The de-composition of real gross income dlng has already been achieved in (6) on the basis of the GDP function. This can readily be inserted into the second line of (8) to provide a full break-down of real net income into price effects, labour and capital input effects, productivity, and depreciation effects.

3. Measuring output

23. This paper focuses on the economy as a whole[9] and uses component output data from the official Korean National Accounts statistics.[10] These components were then re-aggregated with a superlative (Törnqvist) index number formula as theory would suggest. Our vectors of output quantities and prices comprise:

- q_1: volume of private final consumption expenditure
- p_1=1: real price index of private final consumption expenditure

[9] While output data is already available by industry and institutional sector, capital input data has not yet been compiled at this level. This has been scheduled by the Bank of Korea for 2014 in accordance with 2008 SNA.

[10] See http://ecos.bok.or.kr/EIndex_en.jsp for national accounts data. The BOK uses a chain Laspeyres index in the construction of its volume measures.

- q_2: volume of government final consumption
- p_2: real price index of government final consumption expenditure (purchasers' prices)
- q_3: volume of gross capital formation(GCF)
- p_3: real price index of GCF (purchasers' prices)
- q_4: volume of exports of goods and services
- p_4: real price index of exports of goods and services
- q_5: volume of imports of goods and services
- p_5: real price index of imports of goods and services

24. The empirical measure of aggregate output growth, in discrete time, labelled Q^t, is given by:

$$\Delta \ln Q^t = \sum_{i=1}^{M} \frac{1}{2}\left(\frac{P_i^t q_i^t}{P^t \cdot q^t} + \frac{P_i^{t-1} q_i^{t-1}}{P^{t-1} \cdot q^{t-1}} \right) \Delta \ln q_i^t \qquad (9)$$

4. Measuring inputs

25. Primary inputs comprise labour and capital. Labour input is measured as quality-adjusted hours, capital input as flows of capital services. Two types of capital measures are proposed: one more narrow in scope and comprising only fixed assets and another that comprises all non-financial assets, in particular fixed assets, inventories and land. Data on land and inventory assets are still under development whereas data for fixed assets are by now well established in the BOK dataset. As the final numbers for land and inventories could well be different from the ones presented here; the distinction between two capital measures has been made in this paper. Despite their preliminary character, it is of interest to investigate the impact on measures of productivity and contributions to real income growth of including land and inventories. Our vector of input data comprises:

- L_i: hours worked by the i^{th} type of labour, i=1,2,..M_L
- W_i: compensation per hour worked for the i^{th} type of labour
- U_i: user cost of capital or capital services price for i^{th} type of capital, i=1,2…M_K
- K_{Fi}, K_{IV}, K_{Land}: productive stock of fixed assets (i=1,2…M_K), inventories and land
- P_{Ki} , P_{IV} , P_{Land}: price indices for fixed assets (i=1,2…M_K), inventories and land.

Labour input

26. Measurement of labour input relies on data compiled by the Korean Industry Productivity (KIP) database[11] constructed by the Korea Productivity Center[12]. The primary source for employment data produced by KIP is Statistics Korea's data on Economically Active Population (EAP) while the primary source for labour hours is the Report of Monthly Labour Survey and the Report on Wage Structure by the Ministry of Labour.

27. To derive measures of labour quality, labour is classified by gender, by age group (below 29, 30-49, and 50 or above), and by level of education (middle school or below, high school, college or above). There are thus 18 categories of labour input. The KIP database relies on information on labour compensation from the Report of Monthly Labour Survey and the Report on Wage Structure by the Ministry of Labour to derive wage rates for each of these 18 categories. Information on hours worked for the years 2009-10 (not available from KIP) are estimated using OECD hours worked data. For labour quality, 2009-10 data are estimated extrapolating current trends.

28. While the information on the *structure* of compensation is sourced from the KIP database, the overall *level* of compensation of labour input has been benchmarked to the national accounts. More specifically, the total value of labour compensation equals compensation of employees as shown in the national accounts plus the part of mixed income that accrues to labour. Mixed income as shown in the national accounts is the income of unincorporated enterprises owned by households (mainly self-employed). In Korea, only the income of very small businesses and non-profit organisations servicing households figure under mixed income. While it has been customary to value the labour of self-employed and unpaid family members with the average compensation of employees, it is very likely that this would lead to a significant over-valuation of labour compensation of the self-employed in Korea. Absent better evidence, we apply a factor of 0.5 to the average compensation of employees in order to value the labour of the self-employed. To test for the sensitivity of results to this assumption, Annex tables 2 provide sensitivity tests for the choice of the adjustment factor. While the rate of return is significantly affected by this choice, the final effects on the relative contributions of labour, capital and productivity to real income growth are attenuated, in particular in Case 2 where the contribution of productivity growth is virtually unchanged.

---

[11] For more details on the KIP database, visit www.kpc.or.kr/eng .

[12] The KIP database provides data on labour and capital inputs as well as on productivity growth. Only labour measures are used here, however, whereas capital input measures rely on new data that is directly compatible with Korea's national balance sheets and national accounts.

29. Total labour income $W^t \cdot L^t$ is then the sum of compensation of employees plus labour income of the self-employed. The quality-adjusted change in labour input is computed as follows:

$$\Delta \ln L^t = \sum_{i=1}^{M_L} \frac{1}{2}\left(\frac{W_i^t L_i^t}{W^t \cdot L^t} + \frac{W_i^{t-1} L_i^{t-1}}{W^{t-1} \cdot L^{t-1}} \right) \Delta \ln L_i^t \qquad (10)$$

Capital input

30. Capital input is measured as the flow of capital services from each of the M_K different assets in the economy. Quantities of capital services are proportional to productive stocks. The price of capital services is captured by the user costs of capital whose construction is described below. Two cases are distinguished that differ by the scope of assets covered. Case 1 comprises 59 types of fixed assets, case 2 comprises also inventories and land (see Annex Table 1). In accordance with the two cases, two volume indices of capital services are constructed as weighted averages of the proportionate changes in the quantity of capital services. Each asset's share in the total value of capital services constitutes its weight in the volume index:

$$\Delta \ln K^t = \sum_{i=1}^{M_K} \frac{1}{2}\left(\frac{U_i^t K_i^t}{U^t \cdot K^t} + \frac{U_i^{t-1} K_i^{t-1}}{U^{t-1} \cdot K^{t-1}} \right) \Delta \ln K_i^t \qquad (11)$$

where M_K=59 in Case 1 and M_K=61 in Case 2.

31. Capital stocks of fixed assets K_i are estimated using the perpetual inventory method (PIM). Long investment series were constructed backward to the early 1950s and initial capital stocks estimated for end-year of 1953. The age-efficiency profile for each asset is based on a hyperbolic function. A key parameter therein is the asset's service life. Extensive surveys on service lives were conducted by the BOK to ensure appropriateness for the Korean case. Also, historical movements of service lives were estimated so that capital services measures reflect empirical trends in service lives. Thus, there is a strong and reliable empirical basis for this set of capital measures[13].

User costs and rates of return

32. The price of capital services is measured by their user costs, the standard approach developed by Jorgenson (1963) and Hall and Jorgenson (1967). A simple way of motivating the user cost formula is the following argument (Diewert 1974). Suppose the owner of an asset wants to

[13] In addition to the asset's service life, an efficiency parameter is required to hyperbolic age-efficiency function. Here, the BOK followed practice in the U.S. Bureau of Labor Statistics and the Australian Bureau of Statistics and chose 0.5 for machinery and equipment, and 0.75 for buildings and other structures. For cost of ownership transfers and mineral exploration, b is set to 1.0 (see Annex Table 1).

determine the minimum price at which he is willing to rent the asset during one period of time. In the simplest case, three main cost elements have to be considered: (i) the cost of financing or the opportunity cost of the financial capital tied up through the purchase of the asset; (ii) depreciation, i.e., the value loss due to ageing; (iii) revaluation, i.e., the price change of the class of assets under consideration. More specifically, a discrete-time formulation of the user costs of capital type j is shown below with P^t_{Kj} the price index of capital good j, r^t the nominal rate of return, δ_{0j} the rate of depreciation of a new asset and i^t the rate of change of the asset-specific price index P^t_{Kj}.

$$u^t_j = P^t_{Kj}(r^t + \delta_{0j}(1+i^t_j) - i^t_j) \qquad (12)$$

33. A different way of presenting the user cost term is by invoking a real rate of return, r^t* that is defined as $1+r^t=(1+r^t*)(1+\rho^t)$ where ρ^t is the rate of change of a general price index. The user cost expression then becomes:

$$u^t_j = P^t_{Kj}(1+\rho^t)(1+r^t * + \delta_{0j}\frac{(1+i^t_j)}{(1+\rho^t)} - \frac{(1+i^t_j)}{(1+\rho^t)}) \qquad (13)$$

34. Under the assumption that the expected asset inflation equals overall inflation ($i_j^t=\rho^t$), we derive a simplified user cost expression as shown below. The major advantage of the simplified user cost approach is that it largely avoids the occurrence of negative user costs[14] and benefits from ease of implementation (see OECD 2009 for further discussion). A disadvantage is the bias that may arise in asset weights due to the assumption of equal real price changes across all asset types.

$$u^t_j = P^t_{Kj}(1+\rho^t)(r^t * + \delta_{0j}) \qquad (14)$$

35. The real rate of return r^t* is evaluated such that the overall value of capital services plus the value of labour compensation equals GDP[15]. Letting $U^t_i K^t_{Fi}$ stand for the value of capital services for fixed asset i, $U^t_{IV}K^t_{IV}$ for inventory assets and $U^t_{Land}K^t_{Land}$ for land, the endogenous real rate is estimated by solving the following expression for r^t*:

[14] This issue has been raised in Diewert, Mizobuchi and Nomura (2009), in the case of Japan, especially for land. Similar patterns for land prices have prevailed in Korea and would lead to negative user costs of land for a number of periods if the observed revaluation term were used in the user cost equation.

[15] This implies that the full value of net other taxes on production and net taxes on products have been allocated to capital as mentioned earlier.

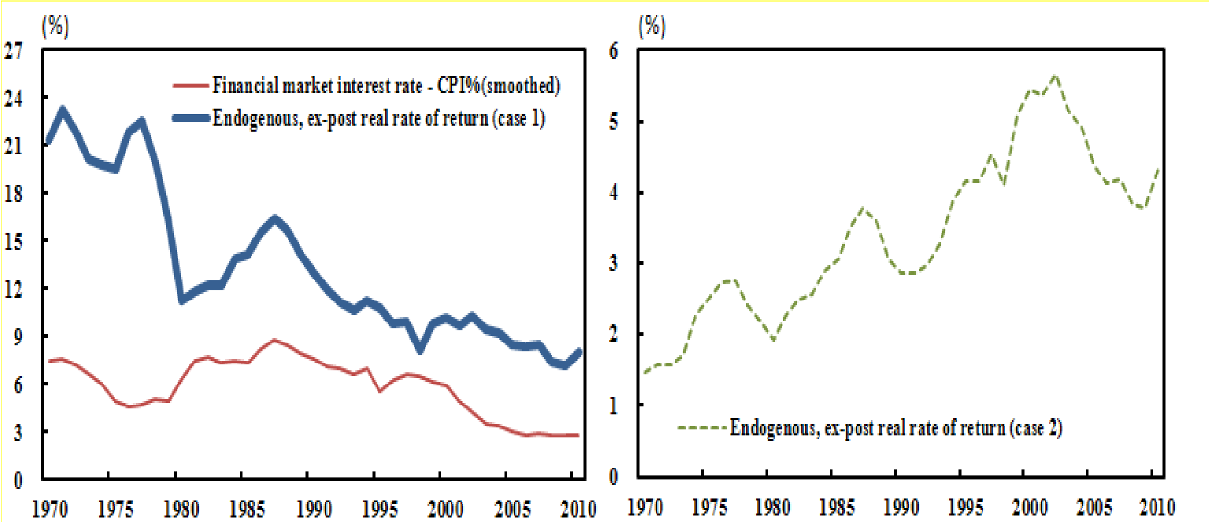
$$P^t \cdot q^t = W^t \cdot L^t + \sum_{i=1}^{M_K} U_i^t K_{Fi}^t + U_{IV}^t K_{IV}^t + U_{Land}^t K_{Land}^t \tag{15}$$

$$= W^t \cdot L^t + \sum_{i=1}^{M_K} (1+\rho^t)[(r^t * + \delta_{0i}) P_{Ki}^t K_{Fi}^t + P_{IV}^t r^t * K_{IV}^t + P_{Land}^t r^t * K_{Land}^t]$$

36. The estimated endogenous ex post real rates of return are shown in Figure 2 below. Inclusion or exclusion of land and inventories play a major role for the level of resulting real rate of return. Under case 1 – excluding land and inventories – the average real rate of return over the entire 40 year period was over 13 % per year – with over 20% at the beginning of the period and a declining trend thereafter. Such a pattern is not unusual for a country like Korea with rapid investment and economic growth that tends to be associated with a declining marginal productivity of capital. Indeed, Pyo and Nam (2001) and Pyo, Kim and Jeon (2009) find a similar pattern. As under case 1 in the present calculations, their results were derived using fixed assets only. When the endogenous real rate is computed under case 2 – including land and inventories – r^t* turns out to be 3.4 % on average over the entire period 1970 to 2010 albeit with fluctuations between 1.5 and 5.7 %. From 1980 to early 2000s it showed a rising trend, and peaked at 5.7 % in 2002. Thereafter the rate reversed, and fell to around 4 percent in recent years[16]. The differences in average levels of real rates in return between cases 1 and 2 are not surprising as the same profits are related to a smaller asset base under case 1 compared to case 2. Note the difference in the time pattern between the two cases: an upward trend with the full scope of assets and a downward trend with fixed assets only. This reflects the relatively faster growth of the value of the stock of fixed assets compared to the growth of the value of all assets, and a reflection of the significant compositional change of the Korean capital stock towards fixed assets. We conclude that the scope of the asset boundary is important for the resulting rate of return. More importantly, these differences in the scope of assets have implications for the assessment of the respective roles of capital, labour and productivity as sources of economic growth.

[16] For an industry-level examination of user costs and rates of return in Korea, see Pyo et al. (2009).

Figure 2. Real rates of return, Korea



Note: 'Financial market rate – CPI%' = real interest rate, computed as yields on Industrial Finance Debentures (1972-1985) and nominal Treasury bond rates (since 1986) minus the rate of change of the consumer price index. 'Endogenous real rate of return' = rates for cases 1 and 2 as described in text.

5. Real income decomposition: results

Sources of growth of real gross income

37. Our decomposition of real gross income follows expression (6) and is based on a Törnqvist index number formula to aggregate output and input components:

$$\Delta \ln g^t = \sum_{i=1}^{M} \frac{1}{2}\left(\frac{p_i^t q_i^t}{p^t \cdot q^t} + \frac{p_i^{t-1} q_i^{t-1}}{p^{t-1} \cdot q^{t-1}}\right) \Delta \ln p_i^t + \sum_{i=1}^{M_L} \frac{1}{2}\left(\frac{w_i{}^t L_i^t}{p^t \cdot q^t} + \frac{w_i{}^{t-1} L_i^{t-1}}{p^{t-1} \cdot q^{t-1}}\right) \Delta \ln L_i^t + \sum_{i=1}^{M_K} \frac{1}{2}\left(\frac{u_i^t K_i^t}{p^t \cdot q^t} + \frac{u_i^{t-1} K_i^{t-1}}{p^{t-1} \cdot q^{t-1}}\right) \Delta \ln K_i^t + \pi^t \quad (16)$$

38. The first term in the decomposition captures relative price effects. There are four of them: the effects of (i) real investment goods prices; (ii) real prices of government final consumption expenditure; (iii) real prices of exports and (iv) real prices of imports. The combined effects of (iii) and (iv) constitute terms of trade effects. The second and third term of the de-composition reflects the contribution of labour and capital to real income growth. Finally, π^t captures the contribution from productivity growth. Two sets of results are presented in line with the two asset boundaries, one excluding land and inventories (case 1), and one including them (case 2).

39. Table 1 presents the decomposition of real gross income for case 1. Over the past 30 years, Korean real gross income grew at an annual rate of 6.2% on average, clearly above the OECD average

and in line with the rapid transformation of the Korean economy. Changes in input factors accounted for 5.2 percentage points or 83.0% of income growth.[17] Of the various inputs, capital contributed 3.3 percentage points, explaining 52.3% of overall income growth, and labour accounted for 1.9 percentage points or 30.6%. MFP growth contributed 1.4 percentage points to gross income growth or 22.9%. Thus, over the entire period, the overwhelming part of real income growth is explained by labour, capital and productivity growth. Combined changes in real output prices matter much less and enter with a comparatively small negative effect on real income growth (-0.4%). This reflects deterioration of the terms of trade and a secular decline in real investment prices.

40. A somewhat different picture emerges under case 2, which includes fixed assets as well as inventory and land as capital inputs. The role of MFP as a contributor to real gross income growth is enhanced (2.7 percentage points, or 43.3% of income growth) whereas the contribution of capital is reduced (2.0 percentage points or 31.9% when compared to case 1). Land input growth contributed with 0.2 percentage points annually and changes in inventory by 0.03 percentage points. Thus, moving towards the broader scope of assets changed the assessment of growth contributions in favour of MFP and away from factor inputs. This reflects the large share of land and inventory assets in the total value of capital services combined with negligible volume growth.

41. As in case 1, the impact of terms of trade changes on gross income growth over the entire period 1980~2010 was only -0.4 percentage points, or -6.3%. However, as soon as one looks at shorter intervals of years, changes in the terms of trade turn out to have significant implications for movements in income growth. Until the mid-90s, terms of trade were quite favourable to the Korean economy, reflecting reduced real oil prices and enhanced price competitiveness due to revaluation of the Japanese yen, as shown in Figure 3 and 4. Terms of trade then fell between 1996 and 2000, around the Asian currency crisis and subtracted an average of -1.9 percentage points from real gross income growth. The gradual deterioration of the terms of trade has continued since then with a negative impact on real gross income growth. Likely, this reflects the increasing concentration of Korea's exports on high-tech goods whose relative prices tend to decline in the light of technological changes and heightened international competition[18]. During the global financial crisis in 2008, terms of trade

[17] For the entire period at hand, this figure seems to confirm the East Asian miracle in economic growth as 'input-led' growth, as argued by Krugman (1994), Young (1994) and Lau and Kim (1994). If we focus on more recent years, however, the observation would be considerably different.

[18] Hahn and Ryu (2010) identify factors that are external, rather than internal to Korea as the main reasons for the decline in terms of trade during this period. In particular, they observe that China's trade expansion raised import prices for oil and raw materials while lowering the export prices of manufactured products.

changes reduced real income growth by 3.7 percentage points through a rapid rise in real import prices after a drop in the Korean Won.

Figure 3. Terms of trade

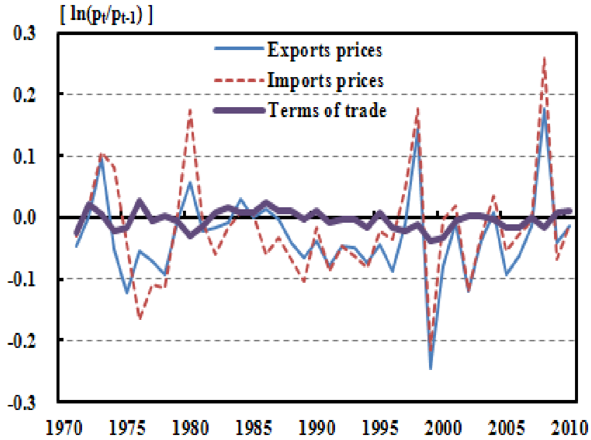
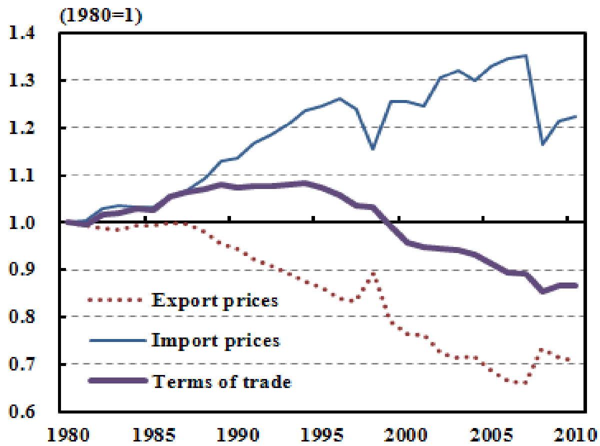


Figure 4. Cumulative effects of terms of trade on real gross income growth



42. One of the main findings in this decomposition of real gross income growth is thus the changing role of productivity growth in Korea. Whereas in the decades up to the early 2000s, much of income growth was attributable to the growth of inputs, productivity growth began to play an important role from the mid-2000s. During the past five years of 2006 to 2010, productivity growth contributed 2.0 percentage points to real gross income growth on average, more than the 1.7 percentage points annual contribution provided by labour and capital (case 2). There is thus some evidence of the Korean economy transiting from 'input-led' to a 'productivity-led' pattern of growth

and income generation.[19] This confirms findings by Pyo, Chun and Rhee (2008) who date the beginning of a productivity-led growth pattern to the late 1990s. The finding is also in broadly in line with conclusions from OECD Economic Surveys of Korea (OECD 2010, 2008). Our data set demonstrates that productivity growth has become even more important since the mid-2000s.

[19] It remains open how the eventual implementation of the 2008 SNA with its capitalisation of R&D expenditure and military assets will bear on the results. Some caution is also in place with regard to the period 2009-10 because of the preliminary nature of labour and capital input data.

Table 1. Contributions to real gross income growth; Korea, Case 1: fixed assets only

Year	Real gross income	Real price effect					Input effect		Productivity
	(1)=(2)+(3) +(6)+(7) +(8)+(9)	(2) Government consumption	(3) Gross investment	(4) Exports	(5) Imports	(6)=(4)+(5) Terms of trade	(7) Capital input	(8) Labour input	(9)
1980	-5.18%	0.48%	0.92%	1.64%	-6.37%	-4.74%	4.50%	-0.50%	-5.84%
1981	5.24%	0.00%	-1.71%	-0.72%	0.38%	-0.34%	3.61%	0.77%	2.91%
1982	9.75%	0.55%	-0.15%	-0.52%	2.26%	1.74%	3.58%	3.26%	0.77%
1983	12.74%	0.58%	0.27%	-0.29%	0.53%	0.24%	3.76%	4.13%	3.76%
1984	10.03%	0.10%	-0.40%	1.02%	-0.25%	0.77%	3.94%	3.33%	2.29%
1985	7.98%	0.60%	0.22%	-0.03%	-0.13%	-0.17%	3.83%	2.89%	0.60%
1986	14.04%	0.60%	-0.30%	0.44%	1.85%	2.29%	4.25%	3.43%	3.77%
1987	12.31%	0.37%	-0.44%	-0.11%	1.02%	0.91%	4.73%	4.43%	2.30%
1988	12.11%	0.42%	0.22%	-1.55%	2.04%	0.49%	4.71%	3.09%	3.19%
1989	6.80%	0.50%	-1.01%	-2.15%	2.93%	0.78%	4.81%	2.62%	-0.89%
1990	9.76%	0.28%	0.86%	-1.08%	0.45%	-0.64%	5.19%	3.03%	1.03%
1991	8.60%	0.19%	-0.72%	-2.14%	2.44%	0.30%	5.21%	3.43%	0.19%
1992	5.30%	0.28%	-0.49%	-1.22%	1.27%	0.05%	4.38%	3.95%	-2.86%
1993	5.89%	-0.09%	-0.58%	-1.31%	1.62%	0.31%	4.06%	1.96%	0.23%
1994	6.71%	-0.03%	-1.80%	-1.92%	2.11%	0.19%	4.27%	1.77%	2.31%
1995	9.37%	0.40%	0.78%	-1.22%	0.57%	-0.64%	4.43%	2.87%	1.52%
1996	5.24%	0.19%	-0.61%	-2.42%	1.07%	-1.35%	4.12%	-0.28%	3.17%
1997	3.42%	-0.03%	-0.23%	-0.34%	-1.48%	-1.83%	3.39%	1.30%	0.81%
1998	-6.95%	0.03%	-2.06%	5.47%	-5.69%	-0.23%	1.48%	-2.02%	-4.15%
1999	6.48%	-0.09%	-0.64%	-9.98%	6.72%	-3.26%	1.97%	2.74%	5.76%
2000	5.06%	0.28%	-0.56%	-2.98%	0.10%	-2.88%	2.65%	1.46%	4.11%
2001	3.37%	0.61%	-0.25%	-0.26%	-0.68%	-0.94%	2.25%	1.56%	0.14%
2002	7.01%	0.16%	0.01%	-4.11%	3.91%	-0.20%	2.35%	1.22%	3.47%
2003	3.05%	0.27%	0.45%	-1.33%	0.95%	-0.38%	2.17%	1.72%	-1.18%
2004	4.41%	0.35%	0.57%	0.31%	-1.27%	-0.96%	2.03%	3.58%	-1.17%
2005	2.33%	0.29%	-0.23%	-3.69%	2.00%	-1.69%	1.97%	-0.64%	2.64%
2006	3.32%	0.22%	-0.34%	-2.50%	1.00%	-1.49%	1.94%	1.52%	1.47%
2007	5.11%	0.15%	0.27%	-0.53%	0.23%	-0.30%	1.98%	-0.74%	3.75%
2008	0.68%	0.07%	1.99%	8.43%	-12.16%	-3.73%	1.71%	0.31%	0.33%
2009	1.18%	0.04%	-0.46%	-2.06%	3.43%	1.36%	1.39%	0.19%	-1.34%
2010	6.79%	0.00%	0.87%	-0.66%	0.51%	-0.14%	1.74%	0.47%	3.86%
Multi-year average									
1981~2010	6.24%	0.24%	-0.22%	-0.98%	0.59%	-0.39%	3.26%	1.91%	1.43%
1981~1990	10.07%	0.40%	-0.24%	-0.50%	1.11%	0.61%	4.24%	3.10%	1.97%
1991~2000	4.91%	0.11%	-0.69%	-1.81%	0.87%	-0.93%	3.60%	1.72%	1.11%
2001~2010	3.72%	0.22%	0.29%	-0.64%	-0.21%	-0.85%	1.95%	0.92%	1.20%
2001~2005	4.03%	0.34%	0.11%	-1.81%	0.98%	-0.83%	2.15%	1.49%	0.78%
2006~2010	3.41%	0.10%	0.47%	0.54%	-1.40%	-0.86%	1.75%	0.35%	1.61%

Table 2. Contributions to real gross income growth; Korea, Case 2: fixed assets plus land and inventories

Year	Real gross income	Real price effect					Input effect				Productivity
	(1)=(2)+(3) +(6)+(7~9) +(10)+(11)	(2) Government consumption	(3) Gross investment	(4) Exports	(5) Imports	(6)=(4)+(5) Terms of trade	(7) Fixed capital input	(8) Inventory input	(9) Land Input	(10) Labour input	(11)
1980	-5.18%	0.48%	0.92%	1.64%	-6.37%	-4.74%	1.78%	0.01%	0.12%	-0.50%	-3.26%
1981	5.24%	0.00%	-1.71%	-0.72%	0.38%	-0.34%	1.61%	0.04%	0.18%	0.77%	4.69%
1982	9.75%	0.55%	-0.15%	-0.52%	2.26%	1.74%	1.56%	0.03%	0.36%	3.26%	2.39%
1983	12.74%	0.58%	0.27%	-0.29%	0.53%	0.24%	1.64%	0.04%	0.17%	4.13%	5.67%
1984	10.03%	0.10%	-0.40%	1.02%	-0.25%	0.77%	1.74%	0.04%	0.15%	3.33%	4.30%
1985	7.98%	0.60%	0.22%	-0.03%	-0.13%	-0.17%	1.66%	0.07%	0.19%	2.89%	2.51%
1986	14.04%	0.60%	-0.30%	0.44%	1.85%	2.29%	1.93%	0.07%	0.35%	3.43%	5.67%
1987	12.31%	0.37%	-0.44%	-0.11%	1.02%	0.91%	2.16%	0.06%	0.33%	4.43%	4.48%
1988	12.11%	0.42%	0.22%	-1.55%	2.04%	0.49%	2.14%	0.10%	0.30%	3.09%	5.36%
1989	6.80%	0.50%	-1.01%	-2.15%	2.93%	0.78%	2.21%	0.10%	0.31%	2.62%	1.29%
1990	9.76%	0.28%	0.86%	-1.08%	0.45%	-0.64%	2.38%	0.04%	0.30%	3.03%	3.51%
1991	8.60%	0.19%	-0.72%	-2.14%	2.44%	0.30%	2.45%	0.06%	0.29%	3.43%	2.61%
1992	5.30%	0.28%	-0.49%	-1.22%	1.27%	0.05%	2.10%	0.03%	0.28%	3.95%	-0.89%
1993	5.89%	-0.09%	-0.58%	-1.31%	1.62%	0.31%	2.02%	0.00%	0.33%	1.96%	1.95%
1994	6.71%	-0.03%	-1.80%	-1.92%	2.11%	0.19%	2.32%	0.04%	0.27%	1.77%	3.95%
1995	9.37%	0.40%	0.78%	-1.22%	0.57%	-0.64%	2.57%	-0.02%	0.35%	2.87%	3.05%
1996	5.24%	0.19%	-0.61%	-2.42%	1.07%	-1.35%	2.51%	0.05%	0.31%	-0.28%	4.43%
1997	3.42%	-0.03%	-0.23%	-0.34%	-1.48%	-1.83%	2.10%	0.04%	0.23%	1.30%	1.83%
1998	-6.95%	0.03%	-2.06%	5.47%	-5.69%	-0.23%	0.80%	-0.10%	0.16%	-2.02%	-3.53%
1999	6.48%	-0.09%	-0.64%	-9.98%	6.72%	-3.26%	1.29%	-0.02%	0.13%	2.74%	6.32%
2000	5.06%	0.28%	-0.56%	-2.98%	0.10%	-2.88%	1.85%	0.03%	0.17%	1.46%	4.71%
2001	3.37%	0.61%	-0.25%	-0.26%	-0.68%	-0.94%	1.55%	0.02%	0.16%	1.56%	0.66%
2002	7.01%	0.16%	0.01%	-4.11%	3.91%	-0.20%	1.63%	0.03%	0.16%	1.22%	4.00%
2003	3.05%	0.27%	0.45%	-1.33%	0.95%	-0.38%	1.46%	0.03%	0.15%	1.72%	-0.64%
2004	4.41%	0.35%	0.57%	0.31%	-1.27%	-0.96%	1.35%	0.03%	0.14%	3.58%	-0.66%
2005	2.33%	0.29%	-0.23%	-3.69%	2.00%	-1.69%	1.31%	0.04%	0.12%	-0.64%	3.15%
2006	3.32%	0.22%	-0.34%	-2.50%	1.00%	-1.49%	1.29%	0.05%	0.16%	1.52%	1.92%
2007	5.11%	0.15%	0.27%	-0.53%	0.23%	-0.30%	1.31%	0.03%	0.14%	-0.74%	4.24%
2008	0.68%	0.07%	1.99%	8.43%	-12.16%	-3.73%	1.14%	0.06%	0.16%	0.31%	0.68%
2009	1.18%	0.04%	-0.46%	-2.06%	3.43%	1.36%	0.91%	-0.08%	0.15%	0.19%	-0.93%
2010	6.79%	0.00%	0.87%	-0.66%	0.51%	-0.14%	1.22%	-0.03%	0.14%	0.47%	4.27%
Multi-year average											
1981~2010	6.24%	0.24%	-0.22%	-0.98%	0.59%	-0.39%	1.74%	0.03%	0.22%	1.91%	2.70%
1981~1990	10.07%	0.40%	-0.24%	-0.50%	1.11%	0.61%	1.90%	0.06%	0.26%	3.10%	3.99%
1991~2000	4.91%	0.11%	-0.69%	-1.81%	0.87%	-0.93%	2.00%	0.01%	0.25%	1.72%	2.44%
2001~2010	3.72%	0.22%	0.29%	-0.64%	-0.21%	-0.85%	1.32%	0.02%	0.15%	0.92%	1.67%
2001~2005	4.03%	0.34%	0.11%	-1.81%	0.98%	-0.83%	1.46%	0.03%	0.15%	1.49%	1.30%
2006~2010	3.41%	0.10%	0.47%	0.54%	-1.40%	-0.86%	1.17%	0.01%	0.15%	0.35%	2.04%

Sources of growth of real net income

43. The next step consists of linking the determinants of real gross income to measures of real depreciation to obtain a decomposition of real net income. The simple relationship between these terms was derived in expression (8). For implementation purposes, we require a discrete time formulation:

$$\Delta \ln n^t = \frac{1}{2}\left(\frac{g^t}{n^t} + \frac{g^{t-1}}{n^{t-1}}\right)\Delta \ln g^t - \frac{1}{2}\left(\frac{d^t}{n^t} + \frac{d^{t-1}}{n^{t-1}}\right)\Delta \ln d^t \quad (17)$$

44. Since depreciation occurs only for fixed assets, no distinction needs to be made between cases 1 and 2 in the measurement of real depreciation. However, the distinction remains valid for the decomposition of real gross income $\Delta \ln g^t$. During the past 30 years, real net income grew by 6.0% on average – slightly less than the 6.2% growth of real gross income, reflecting a somewhat faster rate of real depreciation. By construction, the relative importance of each of the components of gross income does not change in the explanation of net income but each factor's contribution is scaled up by the ratio of gross to net income (see Tables 3 and 4). Under case 1, capital input contributed 3.8 percentage points or 63.4% to real net income growth, labour input contributed 2.2 percentage points or 37.0% and productivity growth contributed 1.7 percentage points or 27.9%. Real output price changes and depreciation reduced real net income growth by 0.4 and 1.3 percentage points, respectively. Again, under case 2 the contribution of productivity growth rose to 3.2 percentage points at the expense of input factors.

45. While the effects of other factors showed significant variation over the period under consideration, the effects of depreciation on real net income growth remained relatively stable, albeit with an upward trend.

46. Figure 5 compares the growth rates of real gross and real net income. During the past 30 years, annual growth rates moved very much in parallel. On average, Korean real net income grew by 6.0%, compared with 6.2% for real gross income. Depreciation reduced real net income growth by between 0.9 and 1.6 percentage points over 10 year intervals. Three years are, however, exceptional: 1980, 1998 and 2008. In each of these years, there was a noticeable gap between net and gross income. Each of these years is associated with an economic shock: the second oil price shock, the Asian foreign currency crisis, and the global financial crisis. The common feature of these years is that prices of machinery and equipment rose much more sharply than private consumption expenditure prices: [20] many fixed assets are imported and the depreciation of the won in times of crisis led to a hike in asset

[20] In 1980 and 2008, prices of buildings and structures also rose sharply relative to prices of consumption goods while in 1998, those prices fell. As depreciation of machinery and equipment accounts for more than 50% of all depreciation, the sharp rise in prices of machinery and equipment dominated the increase of consumption of fixed capital in those three years. The value of depreciation of fixed capital used in this paper is a result of our integrated system of capital measures for Korea, which will be further developed for integration into the official national accounts by 2014. There are thus some differences to the official depreciation measures as presented in the national accounts.

price inflation. Rising capital goods prices raised depreciation and dragged down net income (Figure 6).

Table 3. Contributions to real net income growth; Korea, Case 1: fixed assets only

Year	Real net income	Real Depreciation effect	Real gross Income effect	Real price effect					Input effect		Productivity effect
	(1)=(2)+(3)	(2)	(3)=(4)+(5)+(8)+(9)+(10)+(11)	(4) Government consumption	(5) Gross investment	(6) Export	(7) Import	(8)=(6)+(7) Terms of trade	(9) Capital input	(10) Labour input	(11)
1980	-8.23%	-2.38%	-5.85%	0.54%	1.04%	1.85%	-7.20%	-5.35%	5.08%	-0.56%	-6.60%
1981	5.13%	-0.88%	6.01%	0.00%	-1.96%	-0.83%	0.44%	-0.39%	4.14%	0.88%	3.34%
1982	9.59%	-1.62%	11.21%	0.63%	-0.17%	-0.60%	2.59%	2.00%	4.11%	3.75%	0.89%
1983	12.82%	-1.83%	14.64%	0.66%	0.31%	-0.33%	0.61%	0.28%	4.32%	4.75%	4.32%
1984	10.40%	-1.11%	11.51%	0.12%	-0.46%	1.17%	-0.29%	0.88%	4.52%	3.82%	2.63%
1985	7.36%	-1.80%	9.16%	0.69%	0.25%	-0.04%	-0.15%	-0.19%	4.40%	3.32%	0.69%
1986	14.52%	-1.61%	16.13%	0.69%	-0.34%	0.50%	2.13%	2.63%	4.88%	3.94%	4.33%
1987	12.49%	-1.60%	14.10%	0.43%	-0.50%	-0.12%	1.17%	1.04%	5.42%	5.08%	2.63%
1988	11.98%	-1.89%	13.87%	0.48%	0.25%	-1.77%	2.33%	0.56%	5.40%	3.54%	3.65%
1989	6.39%	-1.41%	7.80%	0.58%	-1.17%	-2.47%	3.36%	0.89%	5.52%	3.01%	-1.02%
1990	9.19%	-2.08%	11.26%	0.32%	1.00%	-1.25%	0.52%	-0.73%	5.99%	3.50%	1.19%
1991	8.32%	-1.65%	9.97%	0.23%	-0.84%	-2.48%	2.83%	0.35%	6.04%	3.98%	0.22%
1992	4.62%	-1.55%	6.17%	0.32%	-0.57%	-1.42%	1.48%	0.06%	5.10%	4.59%	-3.33%
1993	5.66%	-1.22%	6.88%	-0.11%	-0.68%	-1.53%	1.90%	0.36%	4.75%	2.29%	0.27%
1994	7.07%	-0.77%	7.84%	-0.03%	-2.11%	-2.25%	2.47%	0.22%	4.99%	2.07%	2.70%
1995	9.29%	-1.65%	10.94%	0.47%	0.91%	-1.42%	0.67%	-0.75%	5.17%	3.35%	1.78%
1996	4.68%	-1.47%	6.14%	0.23%	-0.71%	-2.83%	1.25%	-1.58%	4.83%	-0.33%	3.71%
1997	2.47%	-1.56%	4.03%	-0.03%	-0.27%	-0.41%	-1.75%	-2.15%	4.00%	1.54%	0.96%
1998	-10.55%	-2.16%	-8.38%	0.03%	-2.48%	6.60%	-6.87%	-0.27%	1.79%	-2.44%	-5.01%
1999	8.23%	0.33%	7.89%	-0.12%	-0.78%	-12.16%	8.18%	-3.97%	2.40%	3.34%	7.02%
2000	5.32%	-0.78%	6.10%	0.34%	-0.67%	-3.60%	0.12%	-3.48%	3.19%	1.76%	4.96%
2001	3.20%	-0.86%	4.06%	0.73%	-0.31%	-0.31%	-0.82%	-1.13%	2.72%	1.88%	0.17%
2002	7.72%	-0.71%	8.43%	0.20%	0.01%	-4.94%	4.70%	-0.24%	2.82%	1.46%	4.17%
2003	2.69%	-0.97%	3.66%	0.32%	0.54%	-1.59%	1.14%	-0.46%	2.60%	2.07%	-1.41%
2004	4.25%	-1.05%	5.30%	0.42%	0.68%	0.37%	-1.52%	-1.15%	2.45%	4.30%	-1.41%
2005	2.22%	-0.58%	2.80%	0.35%	-0.28%	-4.45%	2.41%	-2.04%	2.37%	-0.77%	3.18%
2006	3.27%	-0.72%	4.00%	0.27%	-0.41%	-3.01%	1.21%	-1.80%	2.34%	1.84%	1.77%
2007	5.27%	-0.88%	6.15%	0.18%	0.33%	-0.64%	0.28%	-0.36%	2.38%	-0.90%	4.51%
2008	-1.09%	-1.91%	0.82%	0.08%	2.42%	10.23%	-14.76%	-4.53%	2.08%	0.37%	0.40%
2009	0.14%	-1.31%	1.45%	0.04%	-0.57%	-2.54%	4.22%	1.68%	1.71%	0.23%	-1.64%
2010	7.98%	-0.38%	8.35%	0.00%	1.07%	-0.81%	0.63%	-0.18%	2.14%	0.58%	4.75%
Multi-year average											
1981~2010	6.02%	-1.26%	7.28%	0.28%	-0.25%	-1.16%	0.68%	-0.48%	3.82%	2.23%	1.68%
1981~1990	9.99%	-1.58%	11.57%	0.46%	-0.28%	-0.57%	1.27%	0.70%	4.87%	3.56%	2.27%
1991~2000	4.51%	-1.25%	5.76%	0.13%	-0.82%	-2.15%	1.03%	-1.12%	4.22%	2.01%	1.33%
2001~2010	3.57%	-0.94%	4.50%	0.26%	0.35%	-0.77%	-0.25%	-1.02%	2.36%	1.11%	1.45%
2001~2005	4.02%	-0.83%	4.85%	0.40%	0.13%	-2.18%	1.18%	-1.00%	2.59%	1.79%	0.94%
2006~2010	3.11%	-1.04%	4.16%	0.12%	0.57%	0.65%	-1.68%	-1.04%	2.13%	0.42%	1.96%

Table 4. Contributions to real net income growth; Korea, Case 2: fixed assets plus land and inventories

Year	Real net income	Real Depreciation	Real gross income	Real price effect					Input effect		Productivity
	(1)= (2)+(3)	(2)	(3)=(4)+(5) +(8)+(9) +(10)+(11)	(4) Government consumption	(5) Gross investment	(6) Export	(7) Import	(8)=(6)+(7) Terms of trade	(9) Capital input	(10) Labour input	(11)
1980	-8.23%	-2.38%	-5.85%	0.54%	1.04%	1.85%	-7.20%	-5.35%	2.17%	-0.56%	-3.69%
1981	5.13%	-0.88%	6.01%	0.00%	-1.96%	-0.83%	0.44%	-0.39%	2.11%	0.88%	5.38%
1982	9.59%	-1.62%	11.21%	0.63%	-0.17%	-0.60%	2.59%	2.00%	2.25%	3.75%	2.75%
1983	12.82%	-1.83%	14.64%	0.66%	0.31%	-0.33%	0.61%	0.28%	2.13%	4.75%	6.52%
1984	10.40%	-1.11%	11.51%	0.12%	-0.46%	1.17%	-0.29%	0.88%	2.22%	3.82%	4.93%
1985	7.36%	-1.80%	9.16%	0.69%	0.25%	-0.04%	-0.15%	-0.19%	2.20%	3.32%	2.89%
1986	14.52%	-1.61%	16.13%	0.69%	-0.34%	0.50%	2.13%	2.63%	2.70%	3.94%	6.51%
1987	12.49%	-1.60%	14.10%	0.43%	-0.50%	-0.12%	1.17%	1.04%	2.92%	5.08%	5.13%
1988	11.98%	-1.89%	13.87%	0.48%	0.25%	-1.77%	2.33%	0.56%	2.91%	3.54%	6.14%
1989	6.39%	-1.41%	7.80%	0.58%	-1.17%	-2.47%	3.36%	0.89%	3.01%	3.01%	1.49%
1990	9.19%	-2.08%	11.26%	0.32%	1.00%	-1.25%	0.52%	-0.73%	3.13%	3.50%	4.05%
1991	8.32%	-1.65%	9.97%	0.23%	-0.84%	-2.48%	2.83%	0.35%	3.24%	3.98%	3.02%
1992	4.62%	-1.55%	6.17%	0.32%	-0.57%	-1.42%	1.48%	0.06%	2.81%	4.59%	-1.04%
1993	5.66%	-1.22%	6.88%	-0.11%	-0.68%	-1.53%	1.90%	0.36%	2.75%	2.29%	2.28%
1994	7.07%	-0.77%	7.84%	-0.03%	-2.11%	-2.25%	2.47%	0.22%	3.08%	2.07%	4.61%
1995	9.29%	-1.65%	10.94%	0.47%	0.91%	-1.42%	0.67%	-0.75%	3.39%	3.35%	3.56%
1996	4.68%	-1.47%	6.14%	0.23%	-0.71%	-2.83%	1.25%	-1.58%	3.35%	-0.33%	5.19%
1997	2.47%	-1.56%	4.03%	-0.03%	-0.27%	-0.41%	-1.75%	-2.15%	2.80%	1.54%	2.16%
1998	-10.55%	-2.16%	-8.38%	0.03%	-2.48%	6.60%	-6.87%	-0.27%	1.04%	-2.44%	-4.26%
1999	8.23%	0.33%	7.89%	-0.12%	-0.78%	-12.16%	8.18%	-3.97%	1.72%	3.34%	7.70%
2000	5.32%	-0.78%	6.10%	0.34%	-0.67%	-3.60%	0.12%	-3.48%	2.47%	1.76%	5.68%
2001	3.20%	-0.86%	4.06%	0.73%	-0.31%	-0.31%	-0.82%	-1.13%	2.09%	1.88%	0.79%
2002	7.72%	-0.71%	8.43%	0.20%	0.01%	-4.94%	4.70%	-0.24%	2.18%	1.46%	4.81%
2003	2.69%	-0.97%	3.66%	0.32%	0.54%	-1.59%	1.14%	-0.46%	1.96%	2.07%	-0.77%
2004	4.25%	-1.05%	5.30%	0.42%	0.68%	0.37%	-1.52%	-1.15%	1.84%	4.30%	-0.80%
2005	2.22%	-0.58%	2.80%	0.35%	-0.28%	-4.45%	2.41%	-2.04%	1.76%	-0.77%	3.79%
2006	3.27%	-0.72%	4.00%	0.27%	-0.41%	-3.01%	1.21%	-1.80%	1.80%	1.84%	2.31%
2007	5.27%	-0.88%	6.15%	0.18%	0.33%	-0.64%	0.28%	-0.36%	1.79%	-0.90%	5.11%
2008	-1.09%	-1.91%	0.82%	0.08%	2.42%	10.23%	-14.76%	-4.53%	1.66%	0.37%	0.82%
2009	0.14%	-1.31%	1.45%	0.04%	-0.57%	-2.54%	4.22%	1.68%	1.21%	0.23%	-1.14%
2010	7.98%	-0.38%	8.35%	0.00%	1.07%	-0.81%	0.63%	-0.18%	1.63%	0.58%	5.26%
Multi-year average											
1981~2010	6.02%	-1.26%	7.28%	0.28%	-0.25%	-1.16%	0.68%	-0.48%	2.34%	2.23%	3.16%
1981~1990	9.99%	-1.58%	11.57%	0.46%	-0.28%	-0.57%	1.27%	0.70%	2.56%	3.56%	4.58%
1991~2000	4.51%	-1.25%	5.76%	0.13%	-0.82%	-2.15%	1.03%	-1.12%	2.66%	2.01%	2.89%
2001~2010	3.57%	-0.94%	4.50%	0.26%	0.35%	-0.77%	-0.25%	-1.02%	1.79%	1.11%	2.02%
2001~2005	4.02%	-0.83%	4.85%	0.40%	0.13%	-2.18%	1.18%	-1.00%	1.97%	1.79%	1.57%
2006~2010	3.11%	-1.04%	4.16%	0.12%	0.57%	0.65%	-1.68%	-1.04%	1.61%	0.42%	2.47%

Figure 5. Growth of real net and gross incomes

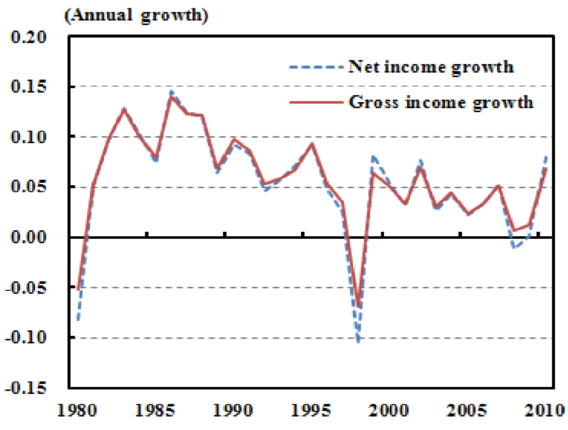
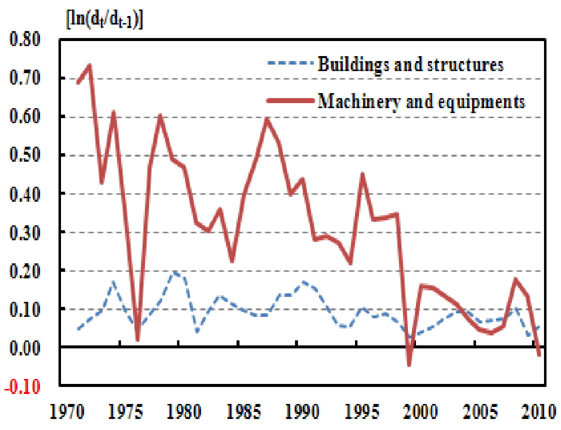


Figure 6. Growth of real depreciation



6. Conclusion

47. This paper presents a decomposition of real income growth in Korea. It uses a production-theoretic framework that permits identifying the effects of real output prices, primary inputs and multi-factor productivity growth, and depreciation on real net income. The empirical analysis is based on a new dataset for Korea with detailed information on labour and capital inputs. Furthermore, the sensitivity of results with respect to including land and inventories into the scope of assets has been tested.

48. The empirical results show, first, that over the past 30 years, capital and labour inputs explain the bulk of Korean real income growth. The second most important factor, on average, has been productivity growth. However, there has been a reversal of the relative importance of factor inputs and productivity with MFP growth progressively gaining importance and dominating income growth over the past five years. This provides some evidence of Korean growth being transformed from 'input-led' to 'productivity-led'.

49. A second conclusion is that for the period at hand, the inclusion of land and inventory meanwhile increased markedly the relative contribution to real income growth of MFP growth mainly at the expense of capital input. If land and inventory assets are excluded from the scope of assets, the role of capital (and labour) inputs may thus be overstated. Third, terms of trade effects were modest over the longer period, but had significant real income effects over sub-periods. In particular, the terms of trade have worsened since the mid-1990s, with a rising negative impact on real income. This is a consequence of the rising share of high-tech products dependence in Korea's exports and the importance of exports for Korea's growth more generally. Fourth, the effect of depreciation on real net

income growth was very stable during the whole period compared to other factors, with a range of 0.9 to 1.6 percentage points over 10-year intervals. However, during periods of crises, real depreciation tended to rise and bear negatively on real net income growth.

50. Looking ahead, some additional data development will be needed. This includes further work on labour input data to improve timeliness and consistency with other input and output data; finalisation of the capital data on land and inventory stocks. For a more comprehensive application of our framework, and to trace productivity growth back to individual industries, sector accounts need to be constructed. Some more work will also be needed to put the allocation of mixed income to labour and capital on a firmer footing. With the implementation of the 2008 SNA, which will includes R&D and military assets as new capital assets, the asset boundary will change and possibly again alter the contribution of capital and productivity to real income growth.

REFERENCES

Bank of Korea (2011); *Korean system of National Accounts –Concepts, Sources and Methods*; The Bank of Korea.

Bauer, P. W. (1990); "Decomposing TFP growth in the present of cost inefficiency, non-constant Returns to Scale and Technical Progress"; *Journal of Productivity Analysis* 1; 287-299.

Denny, M., Fuss, M., Waverman, L. (1981); "The measurement and interpretation of total factor productivity in regulated industries, with an application to Canadian telecommunications". In: Cowing, T., Stevenson (Eds.), *Productivity Measurement in Regulated Industries*. Academic Press, New York, pp. 179–218.

Diewert, W. E. (1974); "Intertemporal Consumer Theory and Demand for Durables"; *Econometrica* 42, 497-516.

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.

Diewert, W.E., and K. Fox (2008); "On the estimation of returns to scale, technical progress and monopolistic mark-ups"; *Journal of Econometrics* 145 (2008) 174–193

Diewert, W. E., H. Mizobuchi and K. Nomura (2009); "On Measuring the Productivity and the Standard of Living in Japan, 1955-2006"; *KEO Discussion Paper* No. 115.

Hahn, Ch. and S. Ryu (2010); “Causes of the decline of terms of trade in Korea since the mid-1990s”; (in Korean) *KDI Journal of Economic Policy* Vol. 32, No 3, Korean Development Institute.

Hall R. E. and D. W. Jorgenson (1967); “Tax Policy and Investment Behavior”; American Economic Review 91, no 3; 341-414.

Hamada, K. and Iwata (1984); “National Income, Terms of trade and Economic Welfare”; *Economic Journal*, 94, pp. 752-771.

Hulten, Ch. and P. Schreyer (2010); “GDP, Technical Change, and the Measurement of Net Income: the Weitzman Model Revisited”; *NBER Working Paper* no16010.

International Monetary Fund (2010); “Republic of Korea: Report on Observance of Standards and Codes—Data Module, IMF Country Report No. 10/229, July.

Jorgenson, D. W. (1963); “Capital Theory and Investment Behavior”; *American Economic Review* 53, no 2; 247-259.

Jorgenson, D. W. (1966); “The Embodiment Hypothesis”, *Journal of Political Economy*, 74, No 1; pp. 1-17.

Jorgenson, D. W., Frank M. Gollop, and Barbara M. Fraumeni (1987); *Productivity and U.S. economic growth*. Harvard University Press. Cambridge, Mass.

Jorgenson, D. W. and J. S. Landefeld (2006); “Blueprint for Expanded and Integrated U.S. Accounts: Review, Assessment, and Next Steps,” in Jorgenson, Landefeld, and Nordhaus (eds.), 13-112.

Jorgenson, D. W., J. Steven Landefeld, and William D. Nordhaus, (eds) (2006); *A New Architecture for the U.S. National Accounts*, Chicago, University of Chicago Press, 13–112.

Kohli, U. (2004); “Real GDP, Real Domestic Income and Terms of Trade Changes”; *Journal of International Economics* 62, pp. 83-106.

Kohli, U. (1990), “Growth Accounting in the Open Economy: Parametric and Nonparametric Estimates”, *Journal of Economic and Social Measurement 16*, 125-136.

Krugman, Paul (1994); "The Myth of Asia's Miracle," *Foreign affairs*, November/December.

Lau, Lawrence J. and Jong-Il Kim (1994); "The Sources of Growth of East Asian Newly Industrialized Countries," *Journal of the Japanese and International Economies*.

OECD (2010); Economic Survey of Korea 2010, Paris.

OECD (2009); *Measuring Capital – OECD Manual, Second Edition*; OECD Paris.

OECD (2008); Economic Survey of Korea 2008, Paris.

Pyo, Hak K., Hyunbae Chun and Keun Hee Rhee (2008); Total Factor Productivity by 72 Industries in Korea and International Comparison (1970-2005), BOK working papers no.324, Economic Research Institute, The Bank of Korea.

Pyo, Hak K. and Kwanghee Nam (2001), "Chapter 3 International Comparison of Rates of Capital and Test of Convergence Theorem", *The Limit and Potential in Growth of the Korean Economy*, Korea Economic Research Institute, August

Pyo, Hak K., Woocheol Kim and Eunkyung Jeon (2009), "The Estimation of User Costs by Industries in Korea (1970-2006), Korea Institute of Public Finance.

Schreyer, Paul (2010); "Measuring Multi-factor Productivity when Rates of Return are Exogenous"; in: W. Erwin Diewert, Bert M. Balk, Dennis Fixler, Kevin J. Fox and Alice O. Nakamura (eds.), *Price and Productivity Measurement Volumes 1 and 2*, Trafford Press.

Sefton, J. A. and M. R. Weale (2006); The Concept of Income in a General Equilibrium, *Review of Economic Studies*, Vol. 73, pp. 219-249.

Timmer, M.P., van Moergastel, T., Stuivenwold, E., Ypma, G., O'Mahony, M. and Kangasniemi, M. (2007); *EU KLEMS Growth And Productivity Accounts*, Version 1.0, March, available at http://www.euklems.net.

Young, Alwyn (1994); "Lessons from the East Asian NICs: A Contrarian View," *European Economic Review Papers and Proceedings*, 1994.

Annex Table 1: Fixed asset types, service lives, efficiency parameters, and implied depreciation rates

	Time-varying service lives of assets by year						Std. dev. over mean	Efficiency parameter (b)	Depreciation rate	
	1960	1970	1980	1990	2000	2010			δ (2001~2010)	δ_0 (2001~2010)
Fixed assets									**6.11%**	**4.13%**
Buildings									**3.47%**	**1.96%**
Residential building construction	35	35	35	40	50	50	1/3	0.75	3.17 %	1.70 %
Cost of ownership transfer on houses	10						1/3	1.00	14.02 %	8.15 %
Buildings for manufacturing and mining	30	30	30	35	40	40	1/3	0.75	3.95 %	2.31 %
Commercial buildings	35	35	35	40	45	45	1/3	0.75	3.40 %	1.97 %
Other buildings	40	40	40	45	50	50	1/3	0.75	2.67 %	1.70 %
Cost of ownership transfer on non-residential buildings	16.8						1/3	1.00	8.35 %	4.37 %
Other construction									**3.35%**	**2.01%**
Highways	45	45	45	50	60	60	1/4	0.75	2.09 %	1.24 %
Railways	55	55	55	60	65	65	1/4	0.75	1.61 %	1.10 %
Subways	55	55	55	60	65	65	1/4	0.75		
Harbors	38	39	43.5	48.5	50	50	1/4	0.75	3.25 %	1.62 %
Airports	35.0						1/4	0.75	3.76 %	2.66 %
Dam and river works	30	33	33	37	37	37	1/4	0.75	4.13 %	2.47 %
Water supply and sewerage	25	25	25	30	30	30	1/4	0.75	5.27 %	3.25 %
Engineering works for agriculture and fishery	60.0						1/4	0.75	2.22 %	1.24 %
Urban civil engineering works	35	35	37.5	42.5	45	45	1/4	0.75	3.11 %	1.89 %
Electric power facilities	40.0						1/4	0.75	3.54 %	2.22 %
Telecommunication facilities	30.0						1/4	0.75	5.23 %	3.25 %
Other civil engineering works	40.0						1/4	0.75	3.59 %	2.22 %
Forestry	60.0						1/4	0.75	2.63 %	1.24 %
Cost of ownership transfer on other structures	16.8						1/3	1.00	7.92 %	4.37 %
Transport equipment									**17.14%**	**11.36%**
Sedans	9.7	9.7	9.4	6.2	7.4	7.7	1/2	0.50	24.70 %	17.69 %
Buses	9.4	9.4	8.4	7.1	8.8	11.7	1/2	0.50	20.25 %	13.12 %
Trucks and others	10.7	10.7	10.0	7.0	9.3	12.8	1/2	0.50	19.63 %	12.07 %
Ships	23.0	23.0	23.0	27.0	29.0	29.0	1/2	0.50	6.76 %	4.68 %
Trains	26.0						1/4	0.50	7.45 %	4.88 %
Aircraft	20.0						1/3	0.50	13.53 %	6.67 %
Other transport equipment	9.7	9.7	9.4	6.2	7.4	7.7	1/2	0.50	25.70 %	17.69 %
Machinery and equipment									**17.46%**	**13.80%**
Pumps and compressors	12.8						0.61	0.50	14.82 %	11.28 %
Lifting and handling equipment	14.2						0.83	0.50	12.49 %	10.79 %
Air conditioning and refrigerating equipment	10.8						0.61	0.50	17.19 %	13.29 %
Other general-purpose machinery	11.9						0.61	0.50	15.98 %	12.06 %
Machine-tools for working metal	13.6						0.57	0.50	14.24 %	10.53 %
Agricultural machinery	11.9						0.45	0.50	17.87 %	11.67 %
Machinery for mining and construction	13.4						0.90	0.50	12.96 %	11.59 %
Machinery for food processing	10.6						0.54	0.50	18.65 %	13.28 %
Machinery for textiles	12.6						0.67	0.50	17.13 %	11.61 %
Machinery for service	11.9						0.70	0.50	15.35 %	12.39 %
Machinery for semiconductor manufacturing	9.1						0.60	0.50	20.37 %	15.60 %
Other special-purpose machinery	10.1						0.77	0.50	17.34 %	14.59 %
Electrical motors,generators and transformers	13.7						0.60	0.50	13.55 %	10.57 %
Wires,cables and other electrical equipment	8.5						0.64	0.50	21.09 %	16.71 %
Domestic electric appliances	10.9						0.51	0.50	17.43 %	12.87 %
TVs	11.0						0.60	0.50	16.81 %	13.05 %
Video and audio equipment	12.0						0.56	0.50	16.13 %	11.86 %
Wired communication apparatuses	6.8						0.76	0.50	24.82 %	20.77 %
Wireless communication and broadcasting apparatuses	7.6						0.45	0.50	24.14 %	17.85 %
PC and peripheral equipment	Until 1985 : 7.00, After 1986 : 5.42						0.5, 0.7	0.50	30.36 %	24.89 %
Office appliances	8.7						0.59	0.50	20.79 %	16.21 %
Medical instruments	12.5						0.63	0.50	14.63 %	11.64 %
Measuring and testing instruments	11.6						0.71	0.50	15.46 %	12.66 %
Optical instruments	10.2						0.68	0.50	17.47 %	14.22 %
Metal products	11.2						0.58	0.50	16.41 %	12.74 %
Textiles	9.8						0.53	0.50	19.57 %	14.36 %
Furniture	7.6						0.67	0.50	23.42 %	18.54 %
Other manufacturing products	8.5						0.75	0.50	20.66 %	16.99 %
Intangible fixed assets									**29.09%**	**21.71%**
Computer software	Until 1985 : 8, After 1986 : 6						0.50	0.50	29.58 %	22.12 %
Mineral exploration	19.0						1/3	1.00	7.59 %	3.72 %
Cultivated assets										
Animal resources										
Tree, crop and plant resources										

Note: An asset's depreciation rate is indirectly derived from its current year depreciation divided by its net stock at the end of the previous year in volume terms. δ_0 implies the first-year depreciation rate of a new asset.

Annex Table 2: Sensitivity of results to choice of remuneration rates of self-employed persons

Case 1: fixed assets only

	Ex-post real rate of return				Contribution to growth of real net income											
					Labour				Capital				Productivity			
Wage rate*	0.50	0.70	0.80	1.00	0.50	0.70	0.80	1.00	0.50	0.70	0.80	1.00	0.50	0.70	0.80	1.00
1981~2010	10.99%	8.78%	7.68%	5.47%	1.91%	2.12%	2.22%	2.42%	3.26%	2.79%	2.56%	2.09%	1.43%	1.69%	1.83%	2.09%
1981~1990	13.92%	10.64%	9.00%	5.72%	3.10%	3.48%	3.66%	4.04%	4.24%	3.52%	3.17%	2.45%	1.97%	2.31%	2.48%	2.82%
1991~2000	10.38%	8.36%	7.35%	5.33%	1.72%	1.88%	1.96%	2.11%	3.60%	3.11%	2.86%	2.38%	1.11%	1.44%	1.60%	1.93%
2001~2010	8.67%	7.34%	6.68%	5.35%	0.92%	0.99%	1.03%	1.11%	1.95%	1.74%	1.64%	1.43%	1.20%	1.33%	1.39%	1.53%
2001~2005	9.45%	7.92%	7.16%	5.64%	1.49%	1.61%	1.68%	1.81%	2.15%	1.91%	1.79%	1.54%	0.78%	0.90%	0.95%	1.07%
2006~2010	7.88%	6.76%	6.19%	5.06%	0.35%	0.37%	0.39%	0.41%	1.75%	1.58%	1.49%	1.32%	1.61%	1.76%	1.83%	1.98%

Case 2: fixed assets, land and inventories

	Ex-post real rate of return				Contribution to growth of real net income											
					Labour				Capital				Productivity			
Wage rate*	0.50	0.70	0.80	1.00	0.50	0.70	0.80	1.00	0.50	0.70	0.80	1.00	0.50	0.70	0.80	1.00
1981~2010	3.88%	3.15%	2.78%	2.06%	1.91%	2.12%	2.22%	2.42%	1.99%	1.79%	1.70%	1.50%	2.70%	2.69%	2.69%	2.68%
1981~1990	3.01%	2.31%	1.96%	1.25%	3.10%	3.48%	3.66%	4.04%	2.23%	2.00%	1.88%	1.66%	3.99%	3.84%	3.76%	3.61%
1991~2000	4.05%	3.27%	2.88%	2.10%	1.72%	1.88%	1.96%	2.11%	2.26%	2.04%	1.93%	1.70%	2.44%	2.51%	2.54%	2.60%
2001~2010	4.57%	3.87%	3.52%	2.82%	0.92%	0.99%	1.03%	1.11%	1.48%	1.34%	1.28%	1.14%	1.67%	1.73%	1.76%	1.81%
2001~2005	5.09%	4.27%	3.86%	3.03%	1.49%	1.61%	1.68%	1.81%	1.63%	1.47%	1.39%	1.23%	1.30%	1.33%	1.35%	1.38%
2006~2010	4.05%	3.47%	3.18%	2.61%	0.35%	0.37%	0.39%	0.41%	1.33%	1.22%	1.16%	1.05%	2.04%	2.12%	2.16%	2.25%

*Coefficient applied to average wage rate of salaried workers in order to value the average wage of self-employed workers.