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New OECD Methods for Supply-side and Medium-term Assessments: A Capital Services Approach

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ABSTRACT/RÉSUMÉ

NEW OECD METHODS FOR SUPPLY-SIDE AND MEDIUM-TERM ASSESSMENTS: A CAPITAL SERVICES APPROACH

The OECD makes frequent use of the supply-side framework and associated measures of factor productivity, productive potential and associated output gaps in the assessment of the short-term conjunctural situation, comparative economic performance and longer-term growth determinants. This paper describes a number of recent changes and improvements in the methods used in estimating potential output for OECD countries and the systems in which they are used, notably for the production of medium-term economic scenarios. By and large, these reflect important changes and improvements in available statistical data sets, notably for measuring productive capital, as well as the development of more efficient model-based methods for making medium-term projections on a consistent international basis.

JEL classification: C53, E22, E23, E27, E32, F17, F47
Keywords: OECD, macroeconomic modelling, production function, potential output, capital services, medium-term projections

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RÉVISIONS DES MÉTHODES POUR ÉLABORER LES POTENTIELS DE CROISSANCE ET LE SCÉNARIO DE MOYEN TERME DE L'OCDE

L'OCDE utilise de façon régulière son cadre analytique de dérivation du bloc d'offre et ses mesures dérivées de productivité globale des facteurs, de potentiel de croissance et d'écart de production dans son évaluation de la situation conjoncturelle, des performances économiques relatives des différents pays et des déterminants de la croissance de long terme. Ce papier décrit les changements et améliorations récents apportés, d'une part, à la méthode d'estimation des potentiels de croissance des pays de l'OCDE et, d'autre part, aux systèmes dans lesquels ces potentiels sont utilisés, notamment ceux assurant la production de scénario de moyen terme. Globalement, ces changements reflètent la meilleure qualité des statistiques disponibles, notamment celles relatives à la mesure du stock de capital productif, mais aussi la mise en place de méthodes plus efficaces pour produire un ensemble cohérent de projections internationales de moyen terme.

Classification JEL : C53, E22, E23, E27, E32, F17, F47
Mots-clés : OCDE, modélisation macroéconomique, fonction de production, production potentielle, stock de capital productif, projections de moyen terme

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NEW OECD METHODS FOR SUPPLY-SIDE AND MEDIUM-TERM ASSESSMENTS: A CAPITAL SERVICES APPROACH

by

Pierre-Olivier Beffy, Patrice Ollivaud, Pete Richardson and Franck Sédillot[1]

1. Introduction and summary

1. In common with many other national and international economic analysts, the OECD makes frequent use of the supply-side framework and associated concepts in its macro and structural economic analyses. In particular, measures of factor productivity, productive potential and associated output gaps play important roles in the assessment of the short-term conjunctural situation, comparative economic performance and longer-term growth determinants. The purpose of this paper is to describe a number of recent changes and improvements in the methods used by the OECD in estimating potential output for OECD countries and the systems in which they are used, notably for the production of medium-term economic scenarios. By and large, these reflect important changes and improvements in available statistical data sets, notably for measuring productive capital, as well as the development of more efficient model-based methods for making medium-term projections on a consistent international basis.

2. With regard to the methods for estimating potential GDP, the revised approach described in this paper is broadly similar to the business sector production function approach in previous use,[2] but with the following important differences:

- The revised method makes specific use of new OECD estimates of capital services, which take better account of the flow of productive use of different non-residential capital assets with differing age/efficiency profiles. In particular, these estimates take explicit account of the relative marginal products of different types of assets and notably price and efficiency trends in Information and Computing Technology (ICT) equipment, thereby removing the distortions commonly prevalent in former national accounts capital stock estimates.
- The revised estimates of potential are now based on a direct "total economy" (as opposed to business sector) approach, reflecting both the coverage of available capital services data and a continuing lack of consistent and reliable business sector data from country sources.

3. Overall, the new set of estimates obtained appear to be plausible and compared with previous estimates the revisions for most countries are not large in relation to those which normally occur between

1. The authors are all members of the Macroeconomic Analysis and Systems Management Division of the Economics Department of the OECD. They are grateful to Jorgen Elmeskov, Vincent Koen and other colleagues for helpful comments and suggestions, and to Diane Scott for assistance in preparing the document.

2. General background to the development of the former business sector methods is given by Giorno *et al.* (1995).

successive OECD forecasts, as a result of changes in historic data and forecasting assumptions. The revised method will nonetheless be monitored carefully in the future, particularly in relation to the evolving data sets for capital services and the scope for taking more specific account of capacity utilisation influences.

4. With regard to the system used to construct medium-term projections, in which measures of potential play a key role, there have been changes in both modelling systems and the consistency of economic assumptions compared with those in previous use.[3] In particular, it takes advantage of a new modelling framework incorporating key estimated economic relationships and a range of tools, designed specifically for making projections on a consistent international basis. In line with the OECD's short-term forecasts, the medium-term projection system has also been revised to be fully compatible with the new (quarterly) data set used in preparing the *OECD Economic Outlook*.

5. The following sections of this paper describe these changes, along with a more detailed guide to the methods and systems in use. Part 2 focuses largely on the revised methods used to estimate potential GDP within an aggregate production function framework, describing the basis of the most recent changes and the most recent estimates for 20 OECD member countries, as published in *OECD Economic Outlook No.79*. Part 3 goes on to describe the associated methods, assumptions and modelling system used in the routine construction of medium-term baseline (MTB) scenarios.

2. Estimating potential output

2.1 General background

6. At the OECD, measures of potential output and output gaps play important roles in a wide range of short and medium-term macroeconomic analyses as:

- A guide to the current and future cyclical position of the economy and associated inflationary pressures.
- A means of judging the cyclically-adjusted or underlying stance of fiscal policies over time and across countries.
- A guide to comparative productivity and growth performance, the influence of underlying structural determinants and policy influences/requirements.
- A benchmark for projecting economic potential and growth beyond the short term on the basis of alternative supply-side assumptions.

Nonetheless, since economic potential is unobservable, such estimates are necessarily imprecise and therefore need to be used with caution and in conjunction with other relevant indicators.

7. A variety of different methods for estimating potential are possible and, in line with many other international organisations and research bodies, the OECD has moved progressively over time from using simple statistical measures, such as peak-to-peak analysis of GDP trend growth, to GDP filtering methods (notably the Hodrick-Prescott filter), to more structural economic methods, drawing on production functions and estimated inflation relationships. An important reason for doing so is that whereas statistical measures may appear to be "judgement free", they are nonetheless sensitive to the choice of arbitrary non-economic assumptions, including those about sample length, smoothness properties, end-points and out-of-sample restrictions. Although also making use of statistical filtering methods, the production

3. See for example Downes *et al.* (2003).

function/growth accounting approach provides a simple but economically meaningful decomposition of growth potential into underlying supply-side factors and thereby makes the relevant assumptions more transparent in economic terms.[4]

8. The general background to the development and use of potential output and output gap measures at the OECD is described by Giorno *et al.* (1995a and b). In common with similar measures developed elsewhere (see for example Denis *et al*., 2006), the underlying approach assumes a simple two-factor Cobb-Douglas production function, with capital and labour inputs, subject to labour augmenting technical progress. Over time this basic framework has been enriched in a number of ways, for example to correct labour inputs for hours worked and to incorporate measures of the underlying structural rate of unemployment (the NAIRU) based on a consistent model of inflation pressures (Richardson *et al.*, 2000 and Turner *et al*., 2001).

9. To date the focus of this work has been largely on the business sector,[5] reflecting two main considerations; firstly the notion that private sector enterprise is closer to theory-based representations of production relationships; and secondly because there are continuing concerns about the quality of available statistical measures of public sector inputs and outputs, which might otherwise distort the overall estimates.[6] For this purpose, the OECD has therefore maintained corresponding estimates of business sector production, employment and capital stocks for the majority of member countries drawing on available information from the National Accounts and other sources.[7] Where appropriate business sector information are not directly available from national sources (in fact for most countries), these estimates have typically been calculated as the residual between the total economy and government sector measures of the relevant concepts.

10. A number of recent developments have prompted the OECD to review its methods. Firstly, a considerable amount of new statistical work has been carried out at the OECD and elsewhere to improve the measurement of productive capital stocks and capital services on a consistent cross-country basis,[8] which has potentially important implications for the measurement of potential and multi-factor productivity (MFP). To date such measures are typically available at the industry level and for the total economy for a majority of OECD countries. At the same time, the progressive shift to chain-linking in measuring real GDP and its key components in the national accounts makes it considerably harder to estimate business sector variables, especially on a consistent cross-country basis.[9] This is particularly

4. Such transparency is particularly important in the context of forecasting and medium- and longer-term analyses.

5. This work has essentially involved the estimation of business sector production functions as the basis for measuring business sector potential, with total economy potential constructed by adding-in the public sector, assumed to be always working at its potential.

6. Over time, there has been some blurring of both these issues, with public sector behaviour coming closer to the business model and also some limited improvements in measuring the public sector.

7. The underlying business sector data base and associated methods are broadly as described in "The measurement of output and factors of production for the business sector in OECD countries", Keese *et al.* (1991).

8. A general background to the OECD capital services estimates and the methodologies involved are given by Schreyer (2003), Dean and Harper (1998) and by Timmer *et al.* (2003).

9. The former in-house OECD business sector data set relied on the possibility of calculating business sector series as a residual by deducting the government sector variables from the corresponding total economy counterparts. With chain linking, the former additive identity structures no longer hold for real expenditure components, the aggregation methods used also now vary considerably across countries and involve numerous *ad hoc* special adjustments, making such calculations considerably more complex.

problematic in the absence of well defined source country data.[10] Given the combination of these factors and pending future improvements in the availability of business sector data from national sources, the procedures for estimating potential output and output gaps for macroeconomic assessments have been revised to a more direct "total economy" approach.[11] In practice, such a shift considerably simplifies data handling and the complexity of the associated identity structures, whilst introducing more transparency and comparability with similar estimates made at the total economy level by other institutions. At the same time, it provides scope for using the new information on capital stocks/services.

2.2 Capital stock estimates

11. The key features of the "total economy" analogue to the previous OECD business sector production function method are as described in Box 1. In terms of data requirements, the key change relates to the choice of an appropriate measure of capital inputs.

Box 1. Estimation of historical trend output estimates

The production technology is assumed to be a constant return to scale Cobb Douglas production function for the total economy with Harrod neutral labour augmenting technical progress. Using usual *Economic Outlook* mnemonics, real GDP is defined as:

$$GDPV = \left(ELEFF * ET * HRS\right)^{\alpha} \left(KTV\right)^{1-\alpha} \qquad \text{[B1-1]}$$

where *ET* denotes total employment (the national account measure when available otherwise the Labour Force Survey). *KTV* represents the whole economy capital stock and *HRS* is the annual amount of hours worked per employee. *ELEFF* represents multi-factor productivity (or labour efficiency) which is not directly observable and is therefore computed as a residual. Finally, α is the average wage share over the sample period.

The participation rate, *LFPR*, is defined as the labour force *LF* [the sum of total employment and the number of unemployed persons (*ET* + *UN*)] divided by the working age population *POPT*. Introducing the unemployment rate *UNR* as the number of unemployed people divided by the labour force $(\frac{UN}{ET+UN})$, [B1-1] becomes:

$$GDPV = \left(ELEFF * POPT * LFPR * (1-UNR) * HRS\right)^{\alpha} \left(KTV\right)^{1-\alpha} \qquad \text{[B1-2]}$$

The computation of potential is based on the following steps and assumptions:

- *ELEFF* is obtained from solving out equation [B1-1];
- *ELEFF, HRS, LFPR* are then de-trended using a HP filter;
- The structural rate of unemployment (NAIRU) is based on the Kalman filter estimation approach described in Richardson *et al*. (2000), with estimates based on most recent internal updates;

Finally the level of potential *GDPVTR* is given using [B1-2] using the filtered variables as input in the production function:

$$GDPVTR = \left(ELEFFT * POPT * LFPRT * (1-NAIRU) * HRST\right)^{\alpha} \left(KTV\right)^{1-\alpha} \qquad \text{[B1-3]}$$

10. Recent informal contacts with national statistical services and Eurostat surveying the availability of more reliable source data also confirm that relatively few member countries are currently able to provide either the required business sector data or relevant components on a consistent set of definitions.

11. Nonetheless the overall data situation continues to be monitored, with the required business sector items included in the OECD's routine requests to national statistical authorities.

where *ELEFFI, LFPRI, HRST* and *NAIRU* are respectively the trended counterparts of *ELEFFU, LFPR, HRS* and *UNR.* Thus equation [B1-3] relates the evolution of potential output to trends in total factor productivity ($ELEFFI^{\alpha}$) , the quantity of labour (or potential employment *ETPT = POPT *LFPRS**(1-*NAIRU*), the amount of hours worked per employee ($HRST$) and the quantity of capital used in the production process. Over the short-term projection horizon, the capital stock would be obtained from the usual identity:

$$KTV = ITV + (1 - rscr) * KTV_{-1} \quad \text{[B1-4]}$$

where ITV represents the whole economy investment and $rscrb$, the scrapping rate.

12. For the majority of OECD countries, four principal sources for capital input data can be identified: those provided directly by national statistical authorities/institutes, the European Commission (the AMECO data base), the Groningen Institute and the OECD. Among these sources, general concepts and methods for deriving capital stock estimates often differ quite considerably. For some countries a capital services approach is used by the national authorities, while for others conventional gross or net (or wealth-based) stock approaches are used. Box 2 provides a summary of the different concepts and measurement principles involved. There are also important differences in sectoral coverage -- AMECO uses a conventional total economy gross stock approach, whilst other sources relate to non-residential capital stocks or services. Of these sources, only two are broadly comparable -- Groningen and the OECD -- which use both similar methodologies and similar levels of investment goods disaggregation to produce measures of non-residential capital services. Relatively few member country sources produce this type of measure, a notable example being the United States for which the BLS has published measures of the productive capital since 1983.[12] Figure 1 provides some comparisons of annual growth rates for a selection of available measures from a variety of sources, which for each given country differ substantially except for OECD and Groningen, reflecting the common capital services approach used.

Box 2. Gross capital stock, net capital stock and productive capital stock measures

Three types of capital stock measures can be distinguished: gross, net and productive, the latter assumed to be proportional to capital services.

The gross capital stock is the cumulative flow of investments corrected for the retirement pattern. It takes account of the withdrawal of assets but does not correct assets in operation for their loss in productive capacity.[1] Assuming a T period total service life of investment assets, the gross capital stock is given by:

$$KG_t = \sum_{i=0}^{T-1} s_i I_{t-i} \quad \text{[B2.1]}$$

where KG_t is the gross capital stock, I_t gross investment and s_i the survival rate at date t of investment at date $t-i$. After some manipulation, the gross capital stock can be rewritten as:

$$KG_t = KG_{t-1}(1-\delta_t) + I_t \quad \text{[B2.2]}$$

where δ_t represent withdrawals (or the scrapping rate) taking place between t and $t-1$. This is the well known Perpetual Inventory Method and if a geometric survival law is assumed (in this case the average life of $\frac{1}{\delta}$), the

12. Capital services are also recently available from a number of national sources, though estimation methods vary somewhat, as well as the length of available time series which are often quite short.

evolution of gross capital is given by:

$$KG_t = \sum_{i=0}^{T-1} (1-\delta)^i I_{t-i} \text{ which can be rewritten as } KG_t = KG_{t-1}(1-\delta) + I_t \qquad \text{[B2.3]}$$

In this particular case the scrapping rate is constant.

The gross capital stock implicitly assumes that the value (or equivalently efficiency) of assets remains constant. In order to capture the fact that the value of assets typically falls as its life expectancy diminishes (independently of its productive performance), measures of the net capital stock combine both a scrapping (retirement) rate and a depreciation rate (or an age-price profiles describing the relative prices of different vintage of the same asset at different points in time) to give measures of the market value of capital assets. Using broadly the same notation as above, the net capital stock is thus given by:

$$KN_t = \sum_{i=0}^{T-1} s_i \cdot d_i I_{t-i} \text{ or in a more compact form } KN_t = \sum_{i=0}^{T-1} a_i I_{t-i} \qquad \text{[B2.4]}$$

where d_i is the loss of value an assets undergoes between t and $t-i$ and $a_i = s_i \cdot d_i$. Overall, the net capital stock is:

$$KN_t = KN_{t-1}(1-\alpha_t) + I_t \qquad \text{[B2.5]}$$

where α_t is the "implicit" depreciation rate (which may or may not include scrapping rate, depending on whether a survival function is included or not).

The definition of the productive capital stock (or capital services) is similar to that of the net capital stock, but uses age/efficiency profile assumptions instead of an age/price profile.[2] Overall the productive capital stock can be expressed as:

$$KP_t = \sum_{i=0}^{T-1} s_i \cdot e_i I_{t-i} \qquad \text{[B2.6]}$$

where e_i represents the age efficiency function, generally assumed to be hyperbolic and of the form:

$$e_i = \frac{T-(i-1)}{T-\beta(i-1)}.$$

As before, the productive capital measure can be rewritten in a more compact form, as follows:

$$KP_t = KP_{t-1}(1-\theta_t) + I_t \qquad \text{[B2.7]}$$

On the basis of the above capital stock measures, it is always possible to compute either an implicit scrapping rate δ_t, an implicit rate of depreciation α_t or an implicit rate of loss of productive capacity θ_t, although they do not represent the same thing.

Both the derivation of the aggregating weights and the aggregation method are at the core of the capital services approach. For each type of assets, the weight computation is based on the construction of an implicit rental price from which a cost share is derived which is assumed to reflect the marginal product of each type of assets in the production process. The cost share of each type of assets $\alpha_{a,t}$ is defined as:

$$\alpha_{a,t} = \frac{KP_{a,t} C_{a,t}}{\sum_{a=1}^{A} KP_{a,t} C_{a,t}} \quad \text{[B2.8]}$$

where $C_{a,t}$ is the rental price at time t of asset a. The rental price is given by:

$$C_{a,t} = P_{a,t} r_t + P_{a,t} \theta_{a,t} + \Delta P_{a,t} \quad \text{[B2.9]}$$

where r_t is the discount rate. Apart from the unknown discount rate which is assumed to be the same for all assets, all variables are known: $P_{a,t}$ is the investment deflator, $\theta_{a,t}$ is the implicit rate of depreciation (see B2.7) and $KP_{a,t}$ is given by [B2.6]. The computation of the discount rate makes use of observable property income PI_t (defined as value added at factor cost minus wage share). r_t is obtained by solving out the following equation:

$$PI_t = \sum_{a=1}^{A} KP_{a,t} C_{a,t} = \sum_{a=1}^{A} KP_{a,t} C_{a,t} \left(P_{a,t} r_t + P_{a,t} \theta_{a,t} + \Delta P_{a,t} \right) \quad \text{[B2.10]}$$

The main effect in using this weighting scheme is to place relatively larger weights on assets which are depreciating quickly compared to the weights that would result from a direct aggregation of individual assets (a simple sum across assets). The rationale for placing more weights on short-lived assets is the following: investors must collect more rents on a dollar worth of short lived asset to compensate for their higher depreciation cost. The aggregation of productive capital stock measure across individual assets into a single aggregated capital service input is based on chained Tornqvist method: $\Delta \ln(KP_t) = \sum_{a=1}^{A} \Delta \ln\left(KP_{a,t}\right)\left(0.5\alpha_{a,t} + 0.5\alpha_{a,t-1}\right)$ [B2.11]

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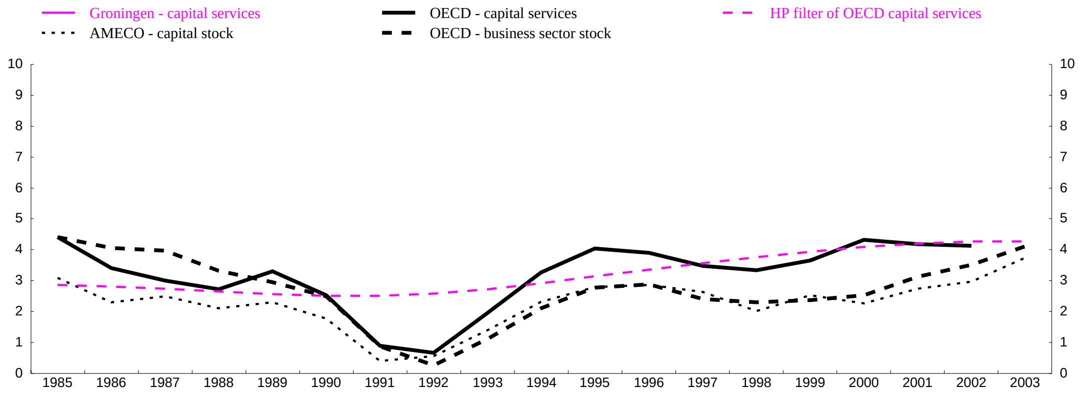
1. Alternatively, gross capital stocks can be considered a special case of the productive stock, where the age-efficiency profile follows a pattern where an asset's productive capacity remains fully intact until the end of its service life.

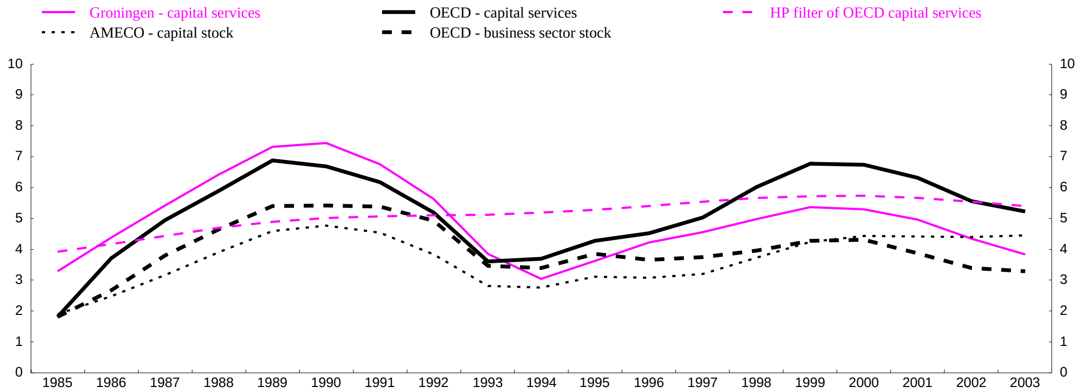
2. A concave age efficiency profile (whereby capital efficiency diminishes slowly at first and then more rapidly as the asset ages) is broadly consistent with a convex price profile (whereby the price diminishes more rapidly at the beginning of the capital life).

Figure 1
Comparison of capital stock data
(annual rates of growth)

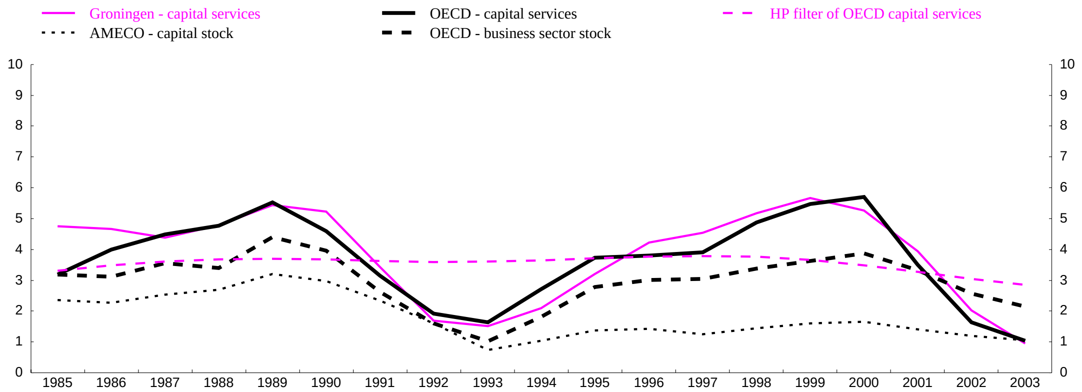
New Zealand



Spain



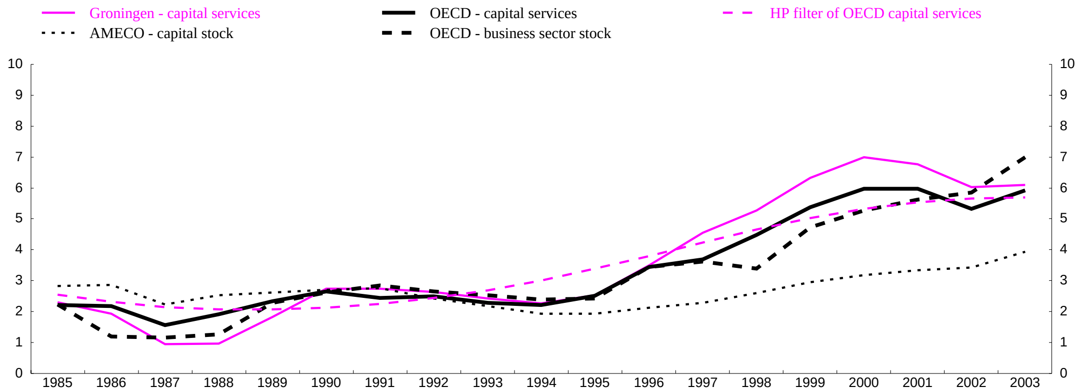
Sweden



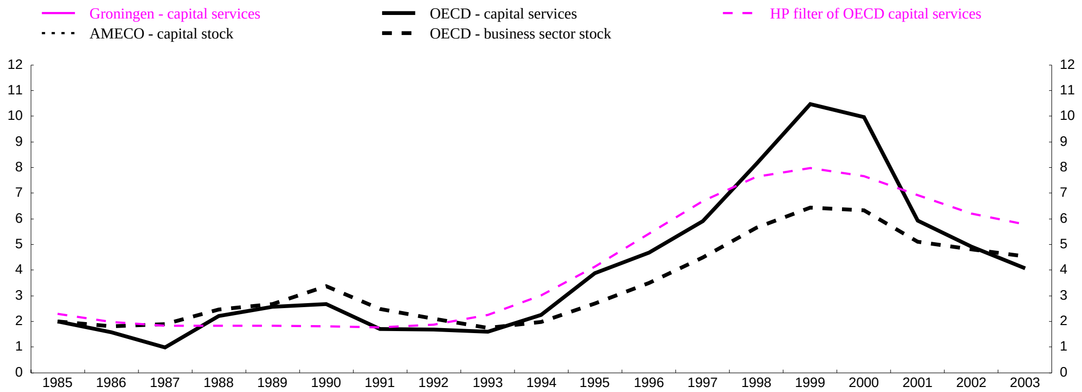
Note: Scales differ in some cases

Figure 1
Comparison of capital stock data
(annual rates of growth)

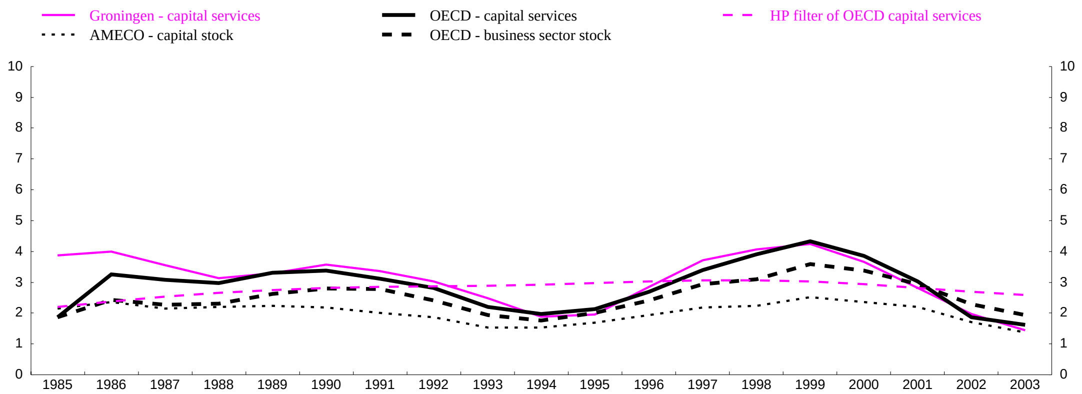
Greece



Ireland

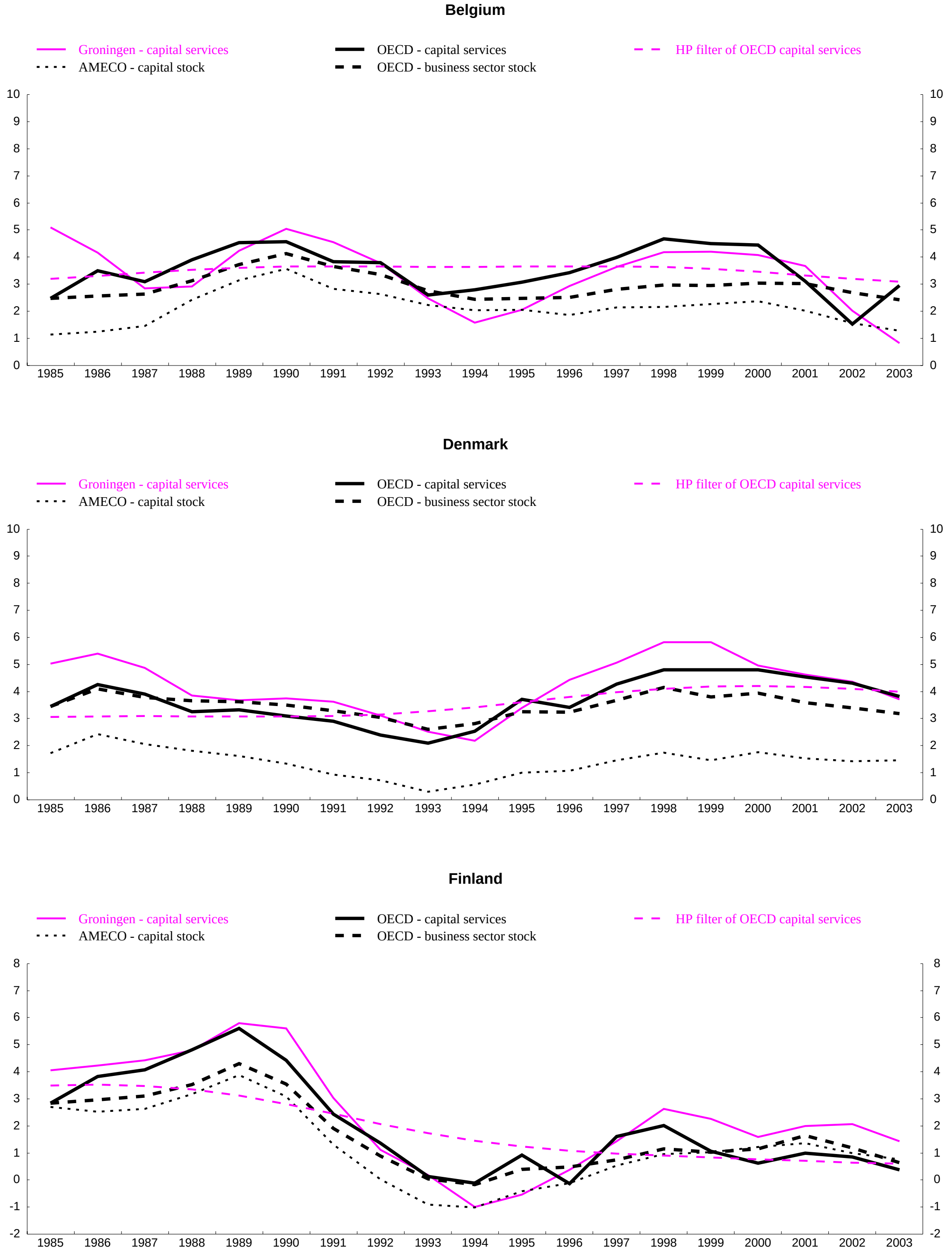


Netherlands



Note: Scales differ in some cases

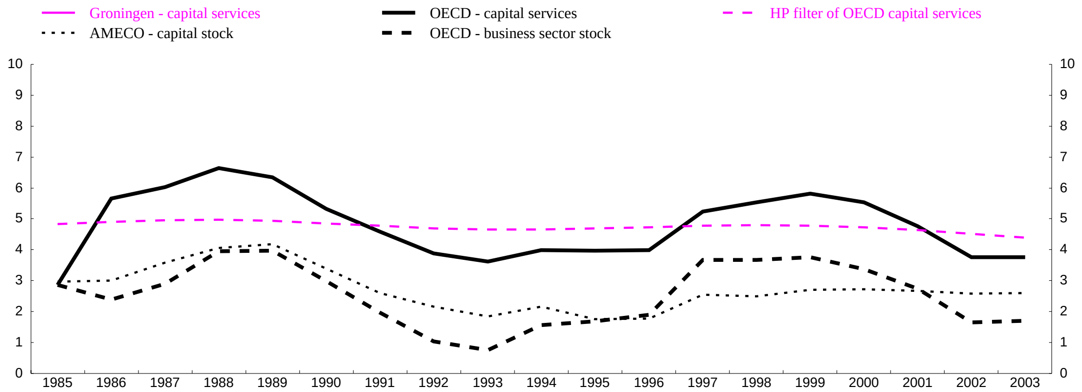
Figure 1
Comparison of capital stock data
(annual rates of growth)



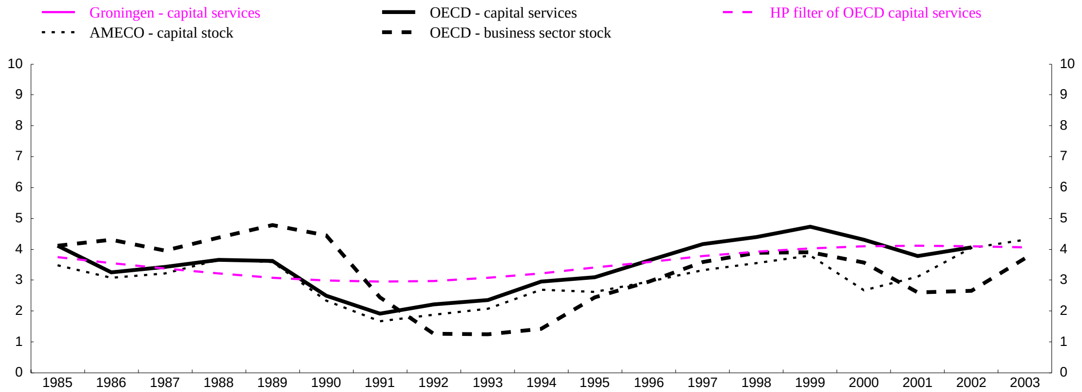
Note: Scales differ in some cases

Figure 1
Comparison of capital stock data
(annual rates of growth)

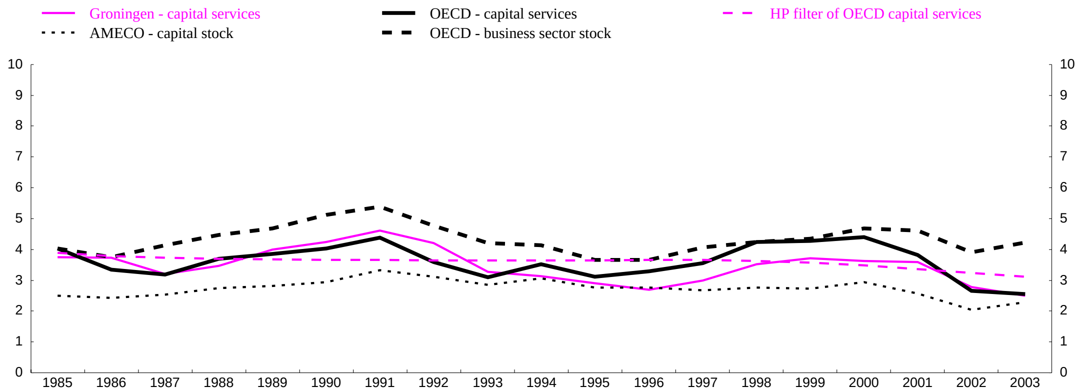
Canada



Australia



Austria



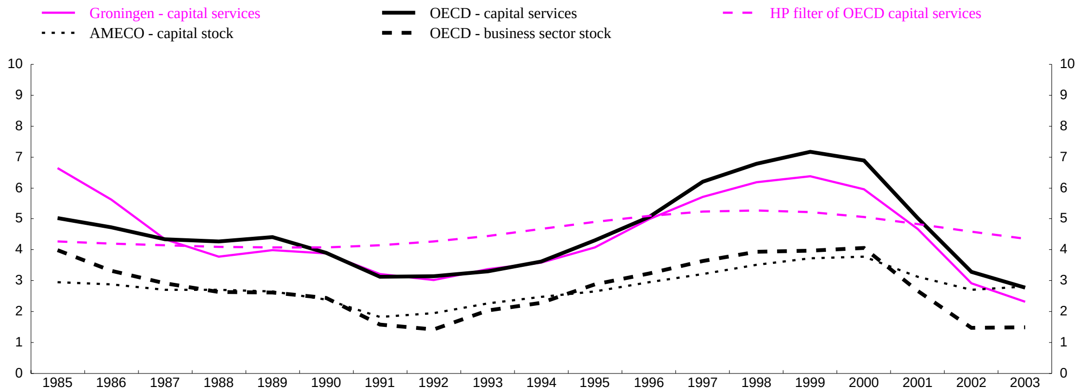
Note: Scales differ in some cases

Figure 1
Comparison of capital stock data
(annual rates of growth)

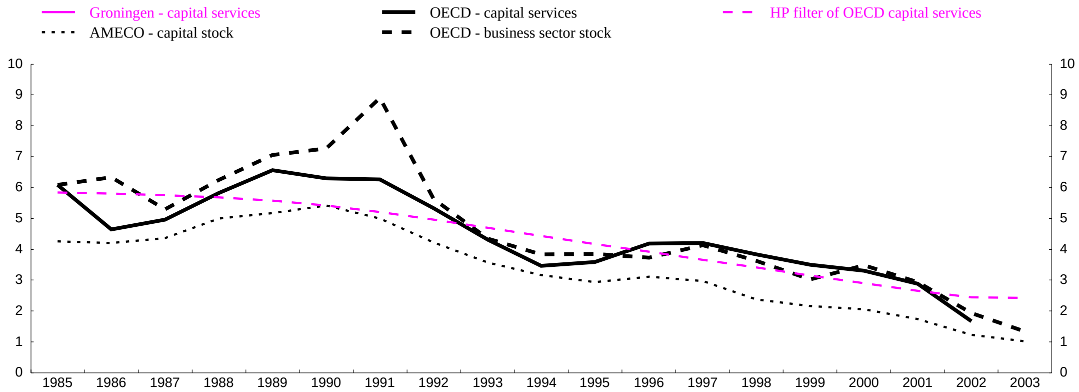
Note: Scales differ in some cases

Figure 1
Comparison of capital stock data
(annual rates of growth)

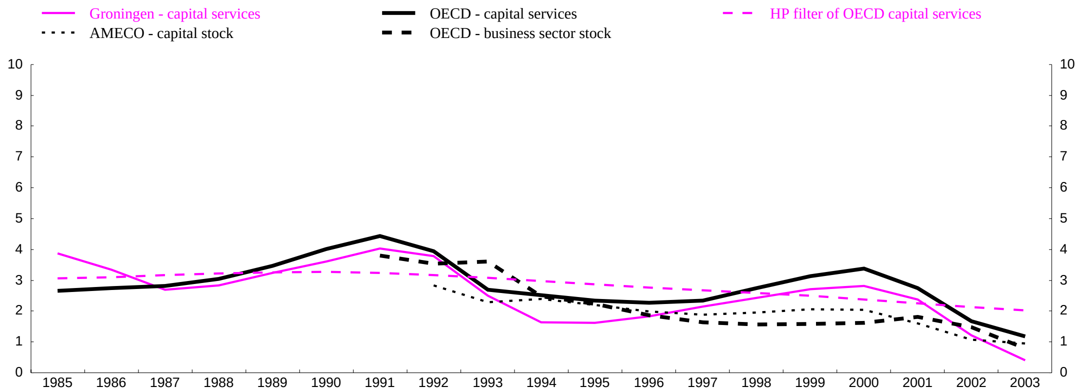
United States



Japan



Germany



Note: Scales differ in some cases

13. The construction of aggregate capital services input measures typically follows three steps:

- The computation of productive capital stock measures by asset, with vintage aggregation within each asset type being done on the basis of specific age/efficiency profile assumptions, to better reflect the flows of services compared with traditional methods;

- The construction of implicit rental prices by asset to reflect shares in capital costs; and

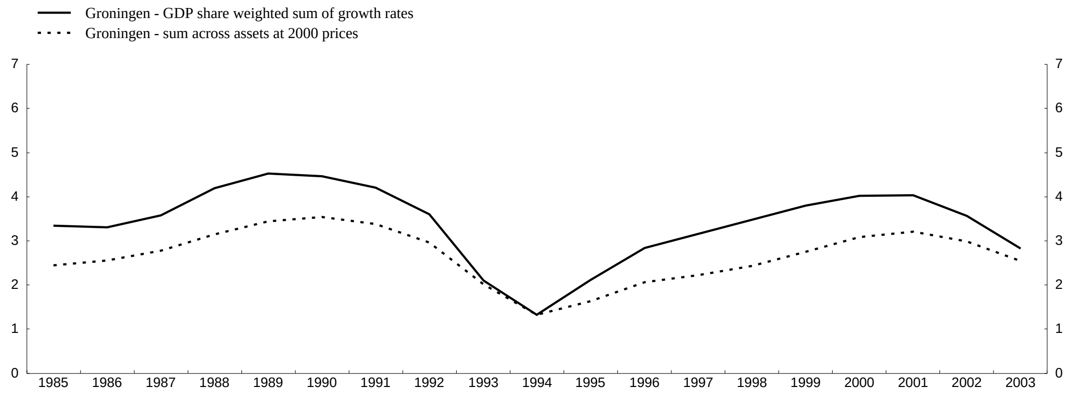
- The chained (Tornqvist) aggregation of productive capital stock measures across individual asset groups into a single aggregated measure of capital services input.

The aggregation method, which is fairly flexible across production function specifications, uses capital cost (property income) share weights to better reflect the marginal products of each type of asset in the production process**.**

14. The main feature of such an aggregation scheme is to place relatively larger weight on assets which depreciate quickly, compared with simple additive aggregation across individual assets. The underlying rationale is that investors typically earn higher returns on short-lived assets in order to compensate for higher depreciation costs. Thus the approach gives more weight in the capital input to each dollars worth of equipment than each dollars worth of structures, reflecting the higher rental values and marginal productivities of equipment. Given that the stock of equipment and (notably) ICT equipment has grown much faster over the sample period relative to other assets, the main effect is that capital services measures tend to grow faster on average than more conventional capital stock measures based on simple additive aggregation methods. This is illustrated in Figure 2, which compares Groningen estimates made on the two different bases. Another important feature of capital services measures is that they are often seen to be more volatile over the cycle than conventional capital stock measures, reflecting the greater weight given to cyclically volatile items with shorter service lives. This is notably the case in the most recent post ICT boom period.

Figure 2
Impact of the aggregation method
(annual rates of growth)

France



Italy

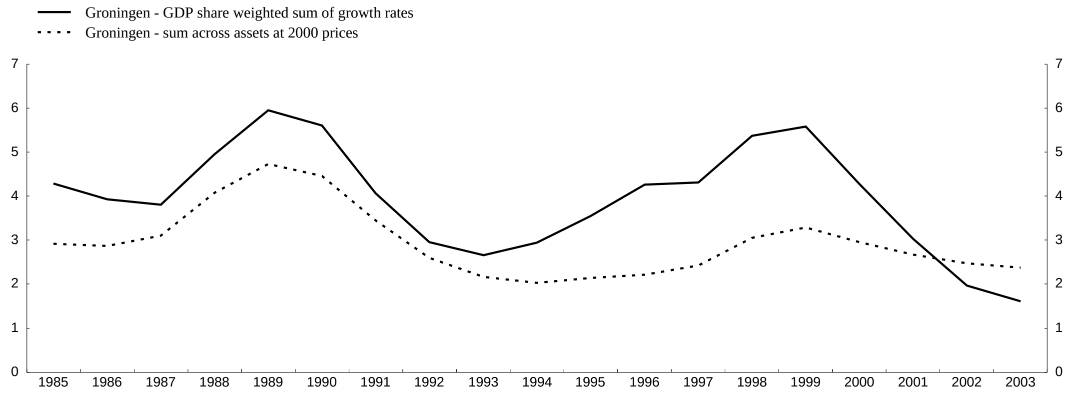
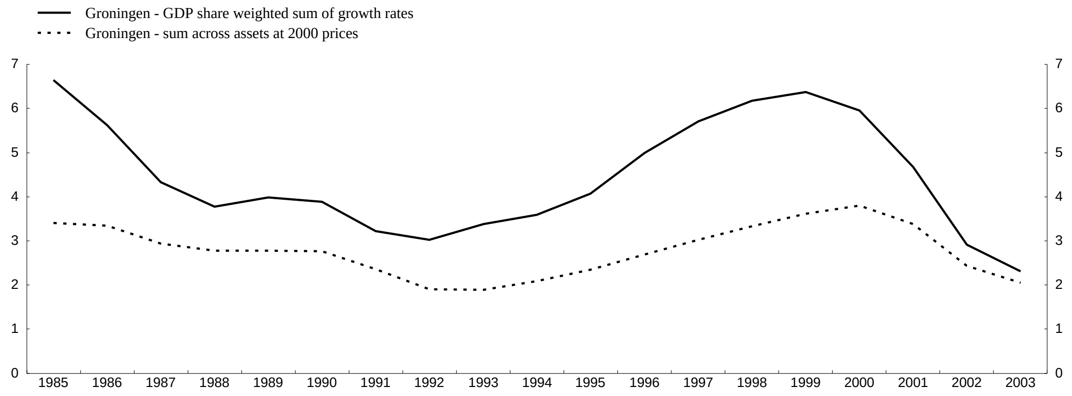
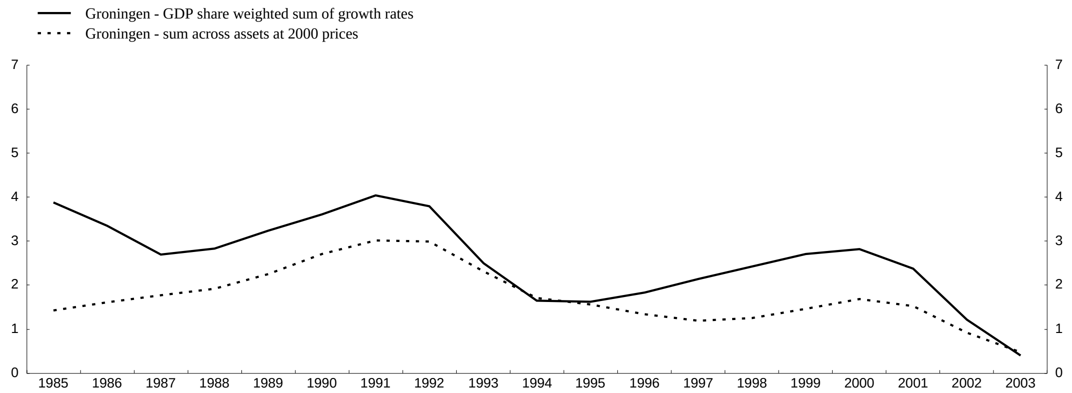


Figure 2
Impact of the aggregation method
(annual rates of growth)

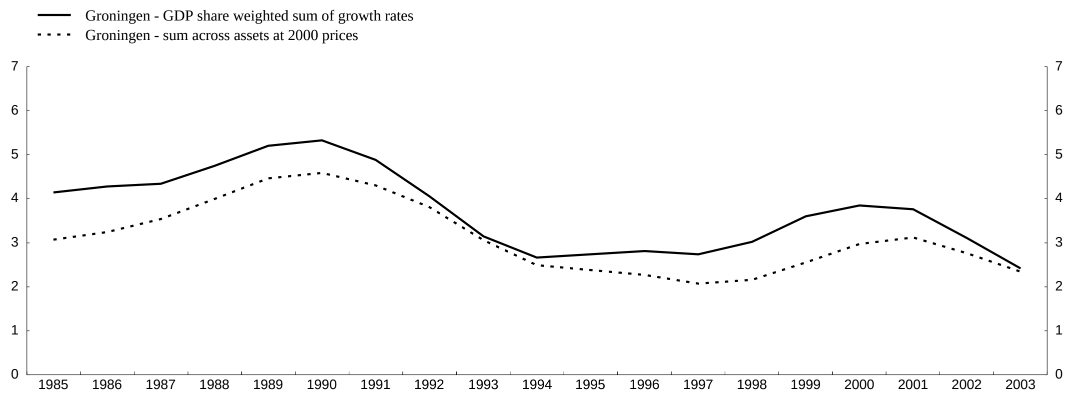
United States



Japan



Germany



15. A number of important considerations favour the use of capital services measures in the production function. Firstly, from an economic theoretic viewpoint the approach is clearly preferable since it takes better account of age-efficiency and retirement profiles of specific asset groups and incorporates a more satisfactory weighting scheme based on marginal the productivity of different assets -- both of which are important in a period of rapid changes in production technologies. Secondly, it provides more transparency, because capital services are derived according to a unified and identifiable method specifically designed to be comparable across countries.[13] It thereby provides both improvements in economic content and greater consistency with other OECD estimates of multi-factor productivity (MFP) at the aggregate level (and implicitly similar measures with a greater degree of industrial disaggregation).

16. In order to use capital services estimates in computations, two practical aspects need to be considered.[14] Firstly they are typically estimated in index form and therefore need to be benchmarked on a given year. For this purpose, benchmark measures of the total economy capital stocks have been used to arbitrarily rescale the capital services measures, with the reference year level taken as the National Accounts base year value of the computed benchmark (see Annex 1 for a description). Secondly, since capital services estimates tend to be updated with a lag, they need to be extended over the recent past. As outlined below, this is done by estimating an average deterioration or depreciation rate for the most recent period and applying this rate to the aggregate non-residential investment flows thereafter.[15,16] A general point to note from Figure 1 is that since the growth rates of business and total economy GDP are generally quite similar, using a total economy capital services measure, which typically grows more faster than previous business sector stock based estimates, often reduces estimated MFP growth relative to former estimates.

2.3 Implementation and comparative results

17. The general method outlined in Box 1 is broadly similar to that used previously for the business sector.[17] The main difference, apart from data specification, is that a two-step approach is now used to more clearly distinguish trend estimation over the historical period from the projection of these trends over short and medium-term horizons. As previously an HP filter is used in estimating historical trends for

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13. With regard to employment, data sources currently vary across countries (as between Labour force survey and National Accounts definitions). However, as employment on a quarterly National Accounts basis become more widely available, the intention would be to switch to this measure, giving more consistency with the definitions and sources for output and capital.

14. In common with most other measures, OECD capital services estimates are annual and therefore need to be interpolated for use in quarterly form.

15. Effectively an implicit deterioration rate for capital services (which is time varying) is derived from the corresponding perpetual inventory equation: $KTV_t = (1-\delta_t)KTV_{t-1} + ITV_t$. The same approach is used in projecting capital services over the forecast period, on the basis of the forecasts of non-residential investment.

16. The only exception is for the United States, where the capital services data are extended on the basis of corresponding BLS estimates, which have a close correlation with the OECD series over the period 1985-2002.

17. OECD capital services estimates are currently available on a consistent basis for 19 OECD countries. For the other countries (the Czech Republic, Hungary, Iceland, Korea, Luxembourg, Mexico, Norway, Poland, the Slovak Republic, Switzerland and Turkey) a framework similar to that outlined below will (data permitting) apply using estimates of total economy capital stocks derived in a manner broadly consistent with the key assumptions underlying the capital services measures. In general this is an improvement on the GDP filtering methods in previous use for these countries.

participation, hours worked and MFP, using the preliminary short-term projections of participation rates, hours worked, GDP and investment to minimise end-point bias.[18] Over the projection horizon, assumptions for the NAIRU, working age population and trend participation and productivity rates are extended exogenously on a judgemental basis.[19] The trend labour participation is calibrated using a method which takes account of underlying demographic changes and cohort effects.[20]

18. As noted earlier, the capital services estimates are in many cases quite variable over the cycle, raising the question of whether such an input should also be smoothed in estimating potential.[21] Indeed, preliminary estimates using the raw capital services data confirmed what seemed to be excessive variability in estimated potential over the cycle, particularly in the near term, reflecting the sharp down-turn in the IT cycle in the early 2000s. On balance, this was considered to be unreasonable and therefore capital services have also been smoothed with an HP filter in obtaining the final estimate.

19. The overall results for potential GDP and corresponding output gap estimates for the 19 countries for which capital services data are available are reported in Figure 3 below, along with comparisons with former estimates based on *Economic Outlook No. 78*. Table 1, in addition provides a decomposition of estimated potential GDP growth over the recent past, into key components. Broadly speaking the method is seen to provide smoother estimates of potential (reflecting in part the smoothing of the capital input). For many countries, the average growth of potential is reduced somewhat, particularly in the early part of the current decade, reflecting in part the deceleration of capital services growth at the end of the IT bubble. Although there are a number of differences compared with the previous measures, these are not particularly large averaged over the period since 2000. Differences in output gap estimates reflect revisions to both potential estimates and actual GDP, which in some cases cumulate over time. Broadly speaking, the overall estimates appear to be plausible and the changes for most countries since *OECD Economic Outlook No. 78* are not unduly large in relation to those which normally occur between consecutive forecasts as a result of revisions to historical data and forecasting assumptions.

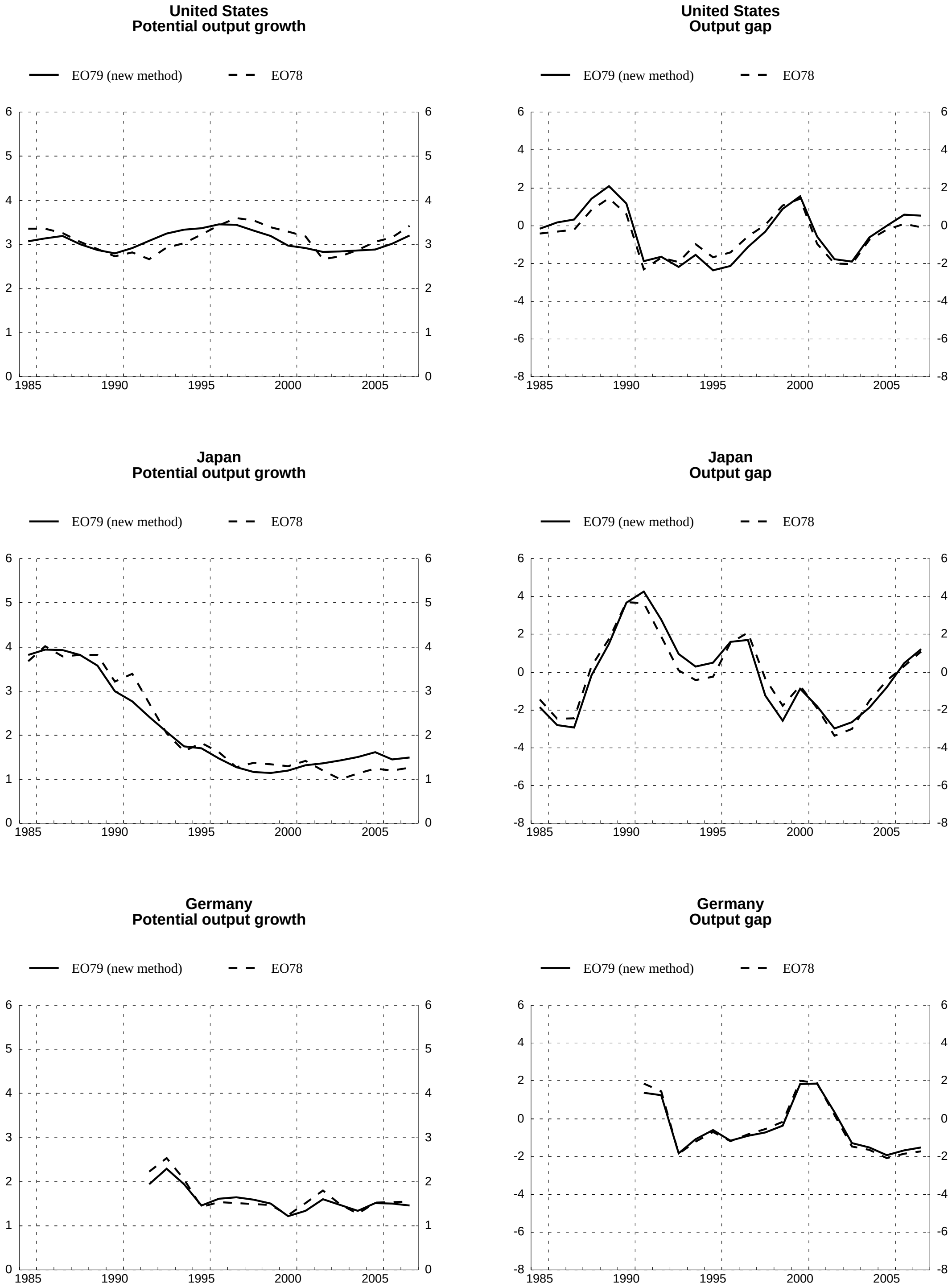
18. Annex 2 provides a discussion of the basic characteristics and use of HP filters in simple and extended forms.

19. Over the medium-term horizon, the assumed path of trend labour productivity also implies a given path for trend MFP, since trend labour productivity is directly related to trend MFP and the investment projection, through capital deepening.

20. The dynamic cohort method used draws on the work of Scherer (2002) and Burniaux *et al.* (2003), using a probabilistic model to calculate labour market exits and entries for each cohort based on labour force survey data, taking into account participation by age and gender.

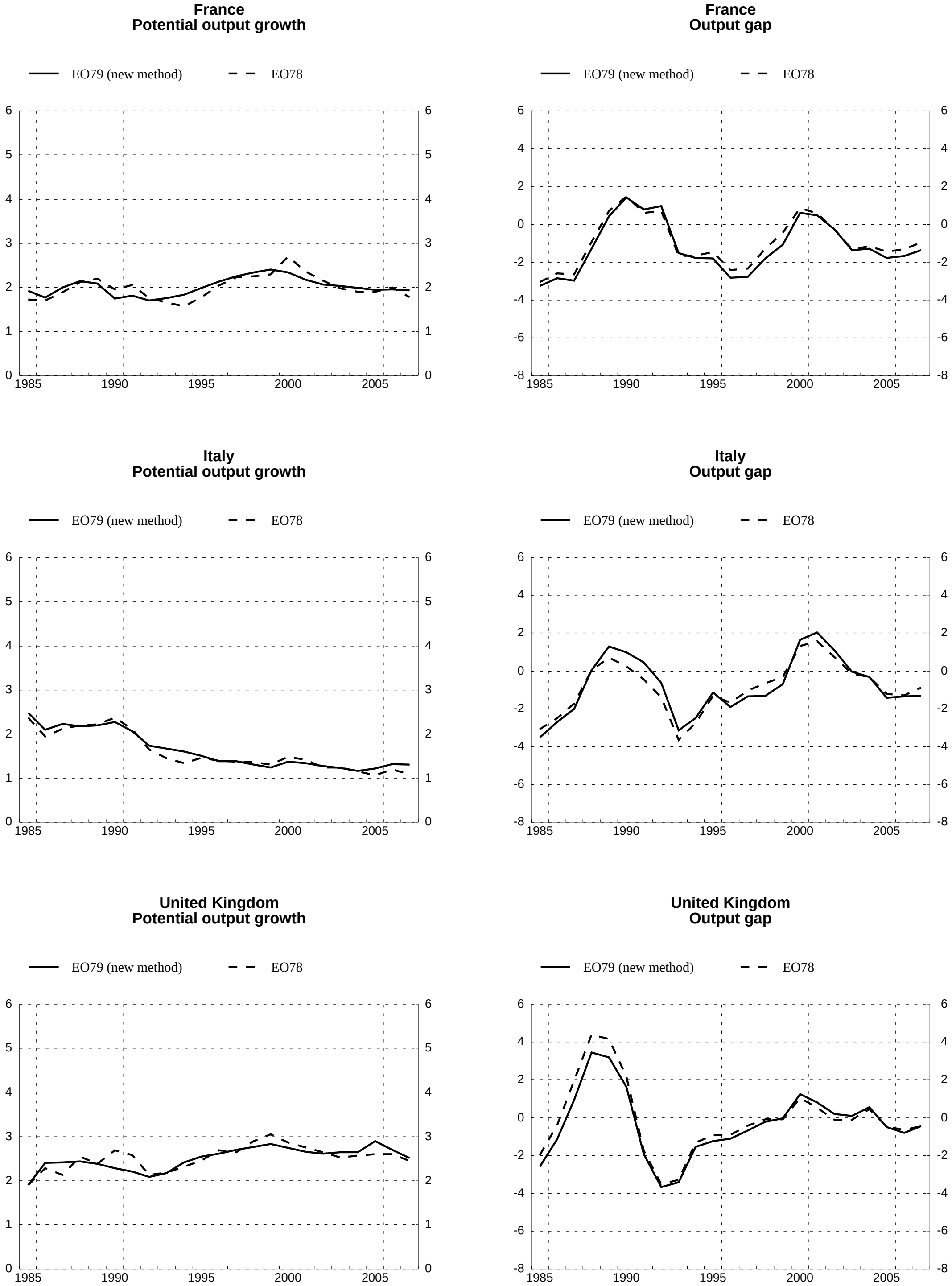
21. Although cyclicality in capital stocks is nothing new, this question has not previously been raised in developing the former method, mainly because it was not seen to be particularly quantitatively significant. Making such an adjustment is akin to adjusting for capacity utilisation or assuming an "equilibrium" path of capital.

Figure 3
Total economy potential and output gaps



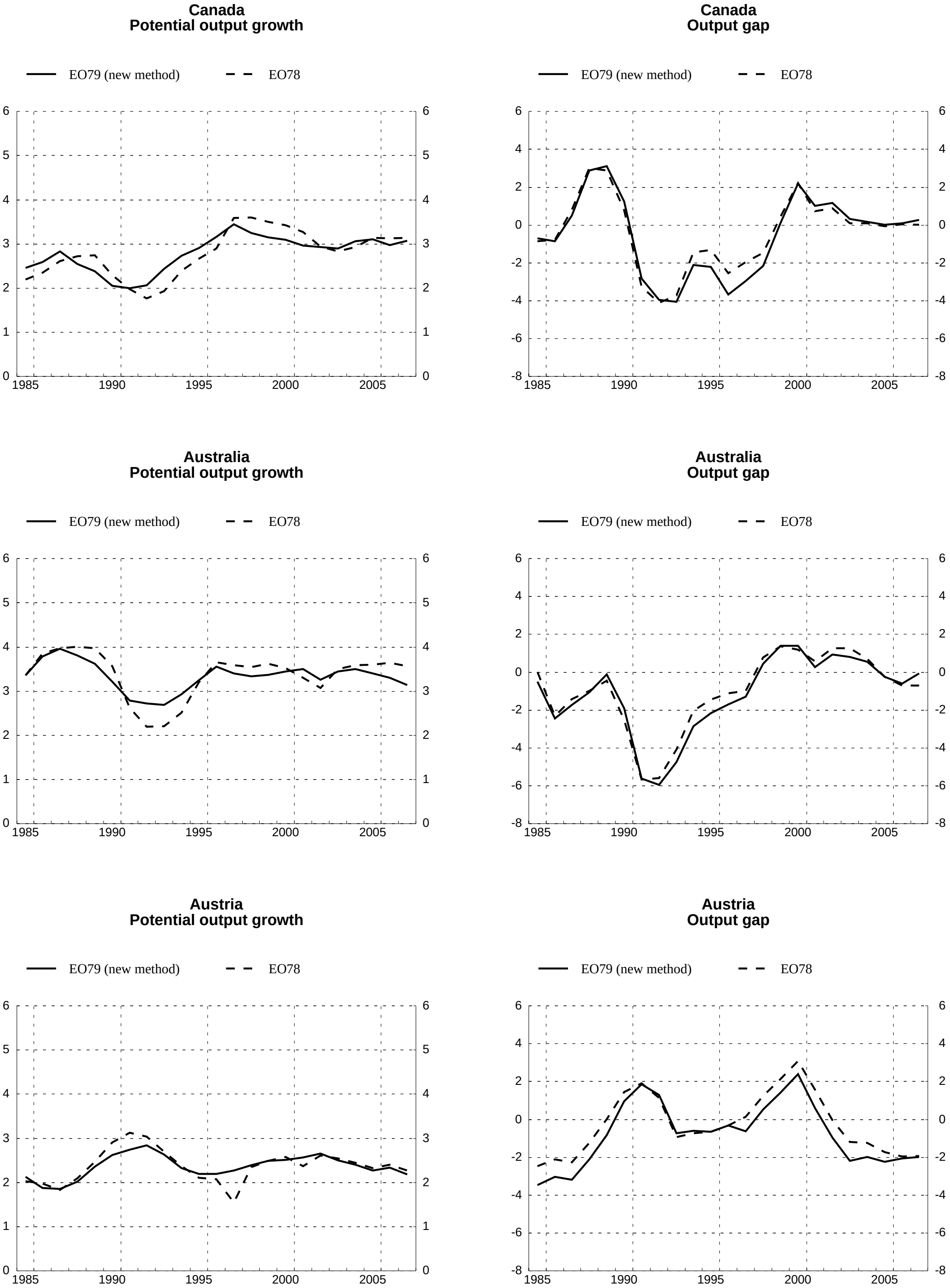
Note: EO79 and EO78 refer to the present and previous Economic Outlook, respectively. Scales differ in some cases

Figure 3
Total economy potential and output gaps



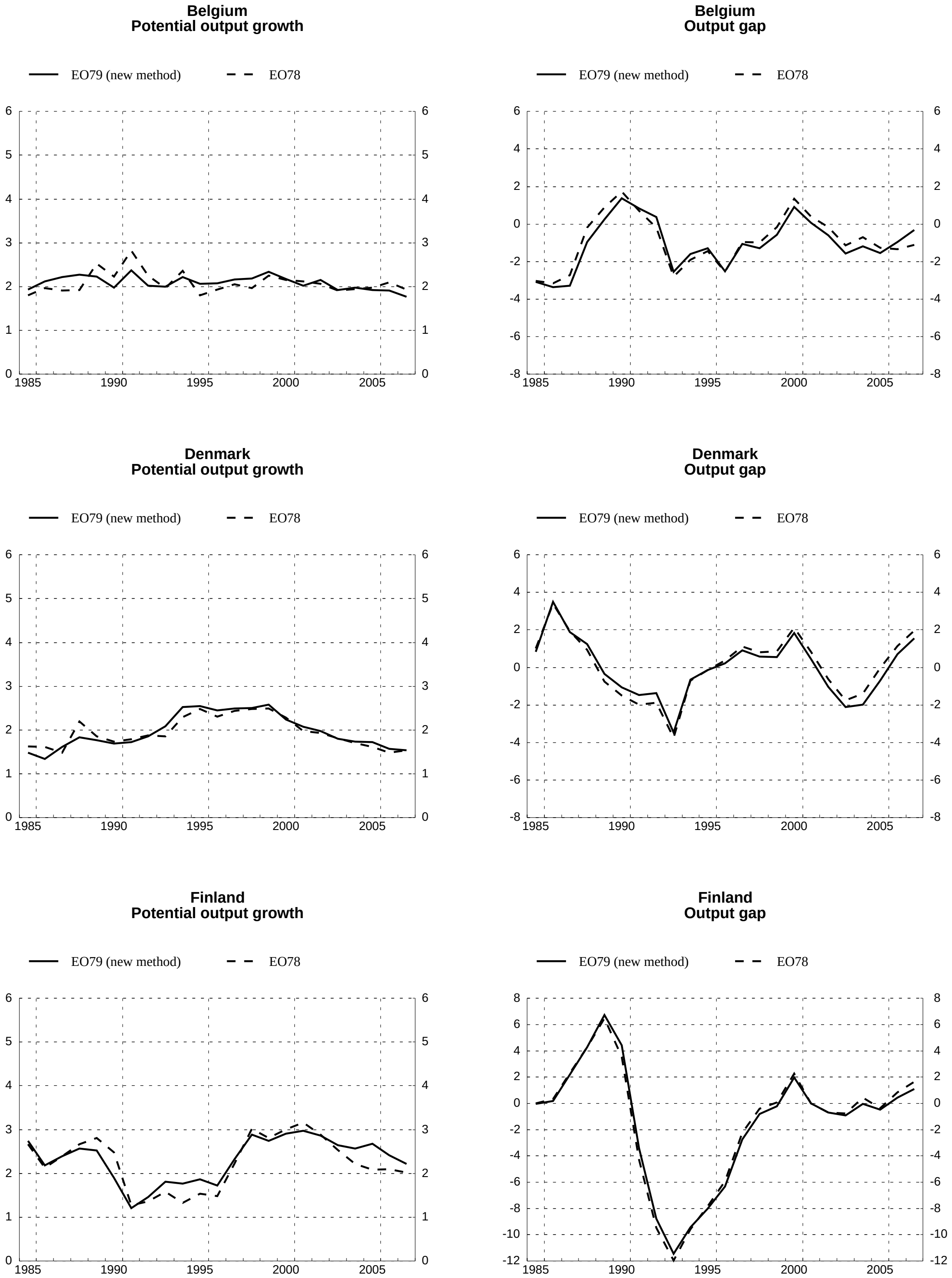
Note: EO79 and EO78 refer to the present and previous Economic Outlook, respectively. Scales differ in some cases

Figure 3
Total economy potential and output gaps



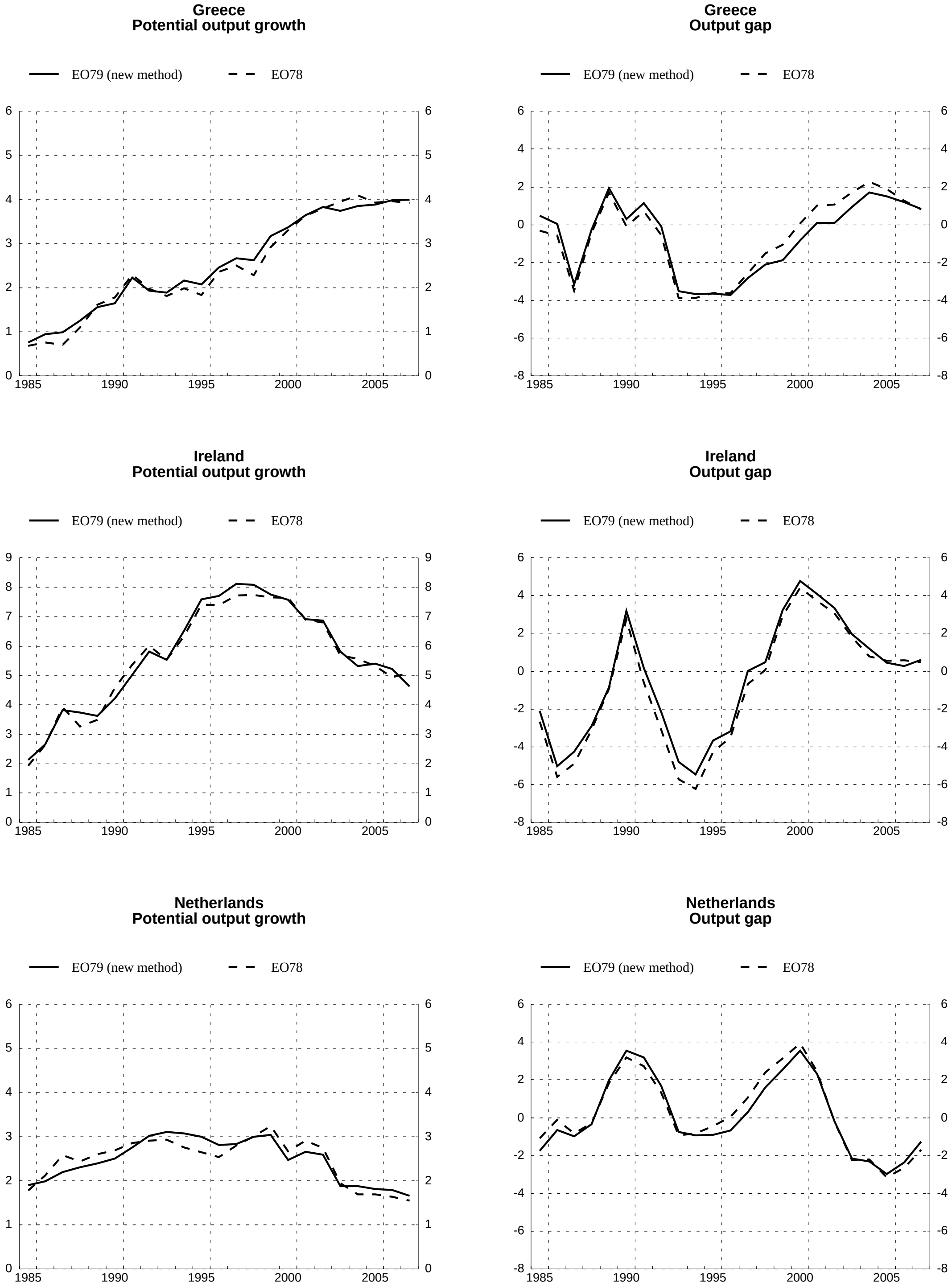
Note: EO79 and EO78 refer to the present and previous Economic Outlook, respectively. Scales differ in some cases

Figure 3
Total economy potential and output gaps



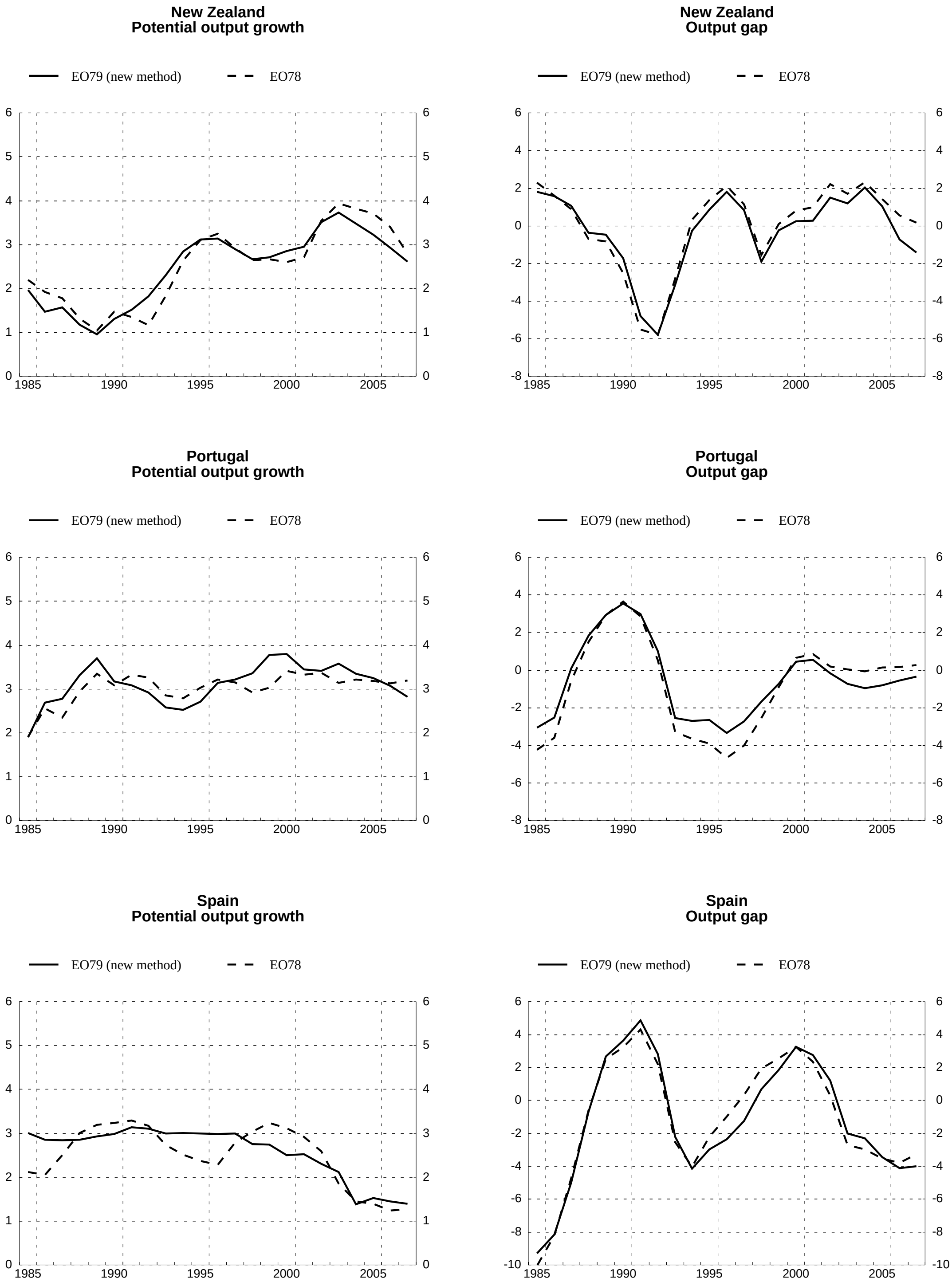
Note: EO79 and EO78 refer to the present and previous Economic Outlook, respectively. Scales differ in some cases

Figure 3
Total economy potential and output gaps



Note: EO79 and EO78 refer to the present and previous Economic Outlook, respectively. Scales differ in some cases

Figure 3
Total economy potential and output gaps



Note: EO79 and EO78 refer to the present and previous Economic Outlook, respectively. Scales differ in some cases

Table 1. **Potential output growth decomposition**

(Average growth rates 2000 to 2005)

	Potential output growth	Potential employment	Potential labour productivity growth	Contribution from:		
				Trend hours	Capital deepening	Trend TFP
United States	2.9	0.7	2.1	-0.2	1.1	1.1
Japan	1.4	-0.1	1.5	-0.3	0.6	1.1
Germany	1.4	0.2	1.2	-0.3	0.6	0.8
France	2.1	0.9	1.2	-0.5	0.6	1.1
Italy	1.3	0.5	0.8	-0.1	1.0	0.0
United Kingdom	2.7	0.8	1.9	-0.3	0.8	1.3
Canada	3.0	1.6	1.3	-0.1	0.8	0.6
Australia	3.4	1.8	1.6	-0.2	0.7	1.1
Austria	2.5	0.8	1.7	-	0.5	1.1
Belgium	2.0	0.7	1.3	-0.2	0.7	0.7
Denmark	1.9	0.1	1.8	0.2	1.2	0.5
Spain	3.5	3.1	0.4	-0.1	0.9	-0.3
Finland	2.8	0.8	2.0	-0.1	-0.1	2.2
Greece	3.7	0.9	2.8	0.0	1.6	1.4
Ireland	6.3	3.3	2.9	-0.7	0.8	2.9
Netherlands	2.2	1.1	1.1	0.0	0.4	0.6
New Zealand	3.3	2.2	1.1	0.0	0.9	0.4
Portugal	2.1	0.8	1.2	-	0.7	0.4
Sweden	2.6	0.4	2.2	0.0	0.6	1.4

Source: *OECD Economic Outlook No.79.*

3. A streamlined modelling system for medium-term scenarios

3.1 General background to OECD medium-term scenarios

20. In parallel with its short-term economic assessment and forecasting exercises, the OECD routinely constructs medium-term scenarios extending beyond the normal short-term forecast period, usually over an additional five years.[22] The main purpose of the medium-term baseline (MTB) is to provide a basis for comparisons with other scenarios based on alternative assumptions and to provide insights on the possible build-up or unwinding of specific imbalances and tensions in the world economy beyond the normal short-term forecasting horizon. The MTB does not however embody a specific view about the nature or timing of future cyclical events but is highly conditional on number of stylised assumptions for the period beyond the short-term projection horizon. Typically these include:

- That the gaps between actual and potential GDP are eliminated over the projection period for all OECD countries so that the level and growth of GDP return to estimated potential (as defined by the underlying supply-side assumptions).

- Unemployment returns to its estimated structural rate (the NAIRU).

22. Summary details of OECD medium-term baseline/reference scenarios are typically published in the June editions of the *OECD Economic Outlook*, see for example Appendix 1.2 to "General Assessment of the Macroeconomic Situation", *OECD Economic Outlook No.79*, June 2006.

- Commodity prices remain unchanged in real terms, apart from oil prices which are frequently assumed to follow specific profiles (for example *OECD Economic Outlook No.79* assumes that oil prices remain unchanged at $70 per barrel for Brent crude).

- Exchange rates remain unchanged in nominal terms.

- Monetary policies are directed at keeping inflation low, or bringing inflation in line with medium-term objectives.

- Fiscal policies are assumed to remain broadly unchanged, with the cyclically-adjusted primary budget deficit/surplus held approximately constant from one year to the next, subject to the OECD's assessment of specific influences implicit in currently legislated tax and expenditure measures.

The combination of these assumptions therefore abstract from the short-term cyclical positions of key variables in the short-term projection and thereby provide a stylised view of the evolution of underlying or cyclically adjusted imbalances over the projection period on the broad assumption of no additional policy changes. Given the restrictive nature of these assumptions, it must be stressed that such scenarios are not intended to be central forecasts.

21. Against this background, the new MTB system was designed to give an efficient means of producing and updating a set of quarterly projections over a five-year period (or beyond) for all OECD countries using the short-term *Economic Outlook* projections as a starting point. The underlying model comprises about 130 equations per country, most of them being accounting identities, but also econometric estimates of a number of key behavioral relationships.[23] The accounting framework used is relatively standardised across countries and consistent with that of the *Economic Outlook*, but focuses specifically on variables of central importance to the medium term.[24]

22. More specifically, the system includes:

- Behavioural equations for trade volumes and prices and pcore inflation as well as rules for core exogenous variables (the accumulation rate, the wage share, fiscal assumptions etc.).

- Fully linked country projections including trade identities with consistent determination of import and export volumes and values.

Starting from a given set of short-term projections, baseline numbers can be produced under a set of transparent rules/assumptions by setting relatively few key identified variables/parameters (the speed of gap closure, target rates of accumulation and wage shares etc.) and key residuals. The tool is also relatively flexible so that the MTB can be fine-tuned by adjusting relatively few exogenous variables or by changing key add-factors whilst preserving the overall consistency of the scenario. In practise, this means that revisions and variants based on alternative judgements can be produce relatively quickly.

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23. The system is simpler for those countries currently having incomplete supply side information (Hungary, Luxembourg, Mexico, Slovakia and Turkey). It also includes equations which determine trade volumes, prices, values and current account balances for six main non-OECD regions (China, Dynamic Asia , Other Asia, Latin America, Africa and the Middle East and Central and Eastern Europe).

24. Technically the system runs from within an MS Excel spreadsheet "front-end", with a TROLL-based model solution programme running in background mode.

23. The following section describes the broad structure and behavioral parts of the MTB system in more detail and discusses some remaining issues and the scope for possible improvements. Various supporting information are provided in Annexes 3 and 4.

3.2 The main features of the MTB model framework

24. The structure of the MTB model is standardised across countries, with an accounting framework based on a streamlined version of that used in the *Economic Outlook* projections. The system is made up of five main blocks:

- A supply side block based on the aggregate Cobb Douglas production function framework (as described previously in Part 2), which also determines employment and unemployment.
- A wage-price block.
- A trade and balance of payments block.
- A household account (distribution and use of income).
- A government account (uses, resources and debt).

The overall model structure is necessarily limited insofar as it relies on key assumptions in order to make projections, for example with respect to the path of GDP. It is therefore not a "full" simulation model in the normal sense, although as outlined below, for given assumptions, its analytical properties are well determined (see Annex 4 for a more detailed account of main model relationships and for the analytical derivation of its longer-term properties).

25. Before describing model structure and properties in more detail, it is useful to recall the basic assumptions involved and the implications they have on the projection paths:

- The variables which determine potential output are based on supply-side assumptions and estimates which are largely predetermined, as outlined in Part 2 of this paper.
- From a starting position given by the short-term forecasts, the total economy output gap is assumed to close over the projection horizon. The economy wide gap can be decomposed into four component gaps, namely participation rate, unemployment rate, hours worked and total factor productivity gaps (see equation [A4-9] of Annex 4), and the choice is made to close each component gap separately.[25]
- Cyclically-adjusted government net lending is normally assumed to remain a constant share of potential GDP, the level being, in the absence of other specific policy assumptions, that of the last year of the short-term projections.[26]

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25. Closing each individual gap is a sufficient but not a necessary condition to close the economy-wide gap which might be achieved by any number of positive/negative combinations of individual gaps. But this appears to be the most sensible way to proceed, carried out simultaneously with the adjustment of demand to supply potential. The system allows each gap to be closed according to alternative exponential, linear or manual adjustment rules.

26. More precisely, this assumption implies that changes in the primary cyclically-adjusted position compensate for movements in interest payments. In practice, the primary cyclically-adjusted deficit is

26. The first and the second assumptions imply that the model solution is largely driven by predetermined supply-side considerations with the demand side adjusting in order to meet the goods and services balance. Typically, potential output growth is determined by given trends in production factors (population, hours worked, NAIRU, participation rate and multi-factor productivity) and from assumed paths of accumulation and depreciation rates, which in turn determine the capital stock and investment. This latter assumption is necessary to obtain a level of potential output through the production function.[27]

27. By assumption, the output gap is closed within the five-year horizon through the closure of the four gaps defining the whole economy output gap. International trade volumes are determined by the set of behavioural equations relating import and export volumes to activity and price competitiveness, as described in Pain *et al*. (2005).[28] Then, for given trade volumes, the balance between supply and known demand components (trade volumes, investment and public consumption) determines household consumption and, thereby, the saving rate.[29]

28. Prices and wages are given by the solution of a wage-price block. The core price inflation equation is taken from Pain and Mourougane (2004) and is primarily driven by the unemployment gap and trade prices.[30] The trade prices relationships are also those reported in Pain *et al.* (2005), used to monitor trade prices in the short-term forecasts. The GDP deflator is defined as a weighted average of domestic and import prices,[31] with the investment deflator assumed to grow in line with the GDP deflator.[32] Wages are derived from an exogenous wage share assumption.[33] With the exchange rate assumed to be constant and in the absence of excess demand or supply, domestic prices grow in the long run at the same rate as foreign prices. Assuming a stable wage share in the long run implies that real wages move in line with trend labour

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assumed to remain constant (as a share of potential GDP) and interest payments are projected to evolve in line with nominal potential GDP.

27. Such a mechanism is somewhat different from a model-based determination in which the capital output ratio is ultimately determined by the demand for capital which, in the Cobb-Douglas case, depends on the real cost of capital, the capital share and a mark-up on demand.

28. The core trade model is identical to that used in the production of the short-term forecasts as described in "The new OECD international trade model", Pain *et al.* (2005).

29. In a full model with the usual set of structural equations, the balance between demand and supply would normally be achieved through price adjustment.

30. These are based on recent updates of the inflation relationships in Richardson *et al.* (2000) and Turner *et al*. (2001).

31. As the GDP deflator is projected by means of an equation, nominal GDP is computed in the system as the product of real GDP times the GDP deflator. This does not ensure that the usual demand side identity (nominal GDP equal to the sum of all demand components) is verified. The residual item in the system therefore has to be checked so that it does not produce movements that depart significantly from those occurring over the historical period.

32. Under such an assumption, on a balanced growth path (*i.e.* with a stable capital to output ratio), the growth rate of real GDP is the sum of total factor productivity and the growth rate of employment. If a drift between both deflators were to be postulated (typically the GDP deflator increases more rapidly than the investment deflator), then potential output growth would be the sum of total factor productivity plus employment growth plus the difference between the growth rate of the GDP deflator and the investment deflator.

33. Alternative paths can be assumed for this core exogenous variable. An enriched version might for example include a structural wage share equation including terms in the unemployment gap, the tax wedge and real interest rates. See for example Cotis and Rignol (1998) and Mihoubi (1999).

productivity. Thus there is no change in profit margins (measured as the GDP deflator minus unit labour costs).

29. The fiscal assumptions and the relationship between the output gap and cyclically-adjusted receipts and spending (see equation [A4-19] of Annex 4) drive the path of the public deficit. Nominal short-term interest rates are set to follow a Taylor rule and long-term interest rates are defined relative to short-term interest rates.

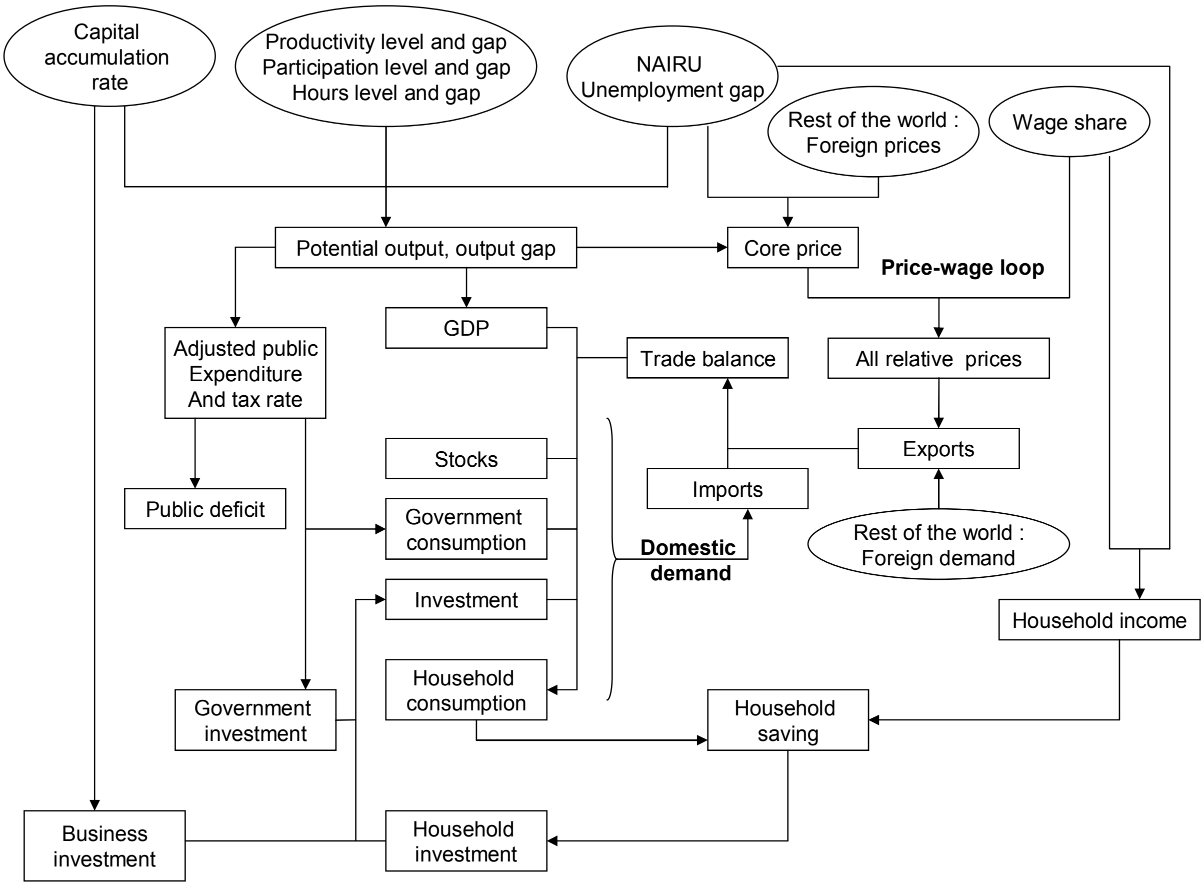
30. Figure 4 describes the main features of an individual country model and its solution, assuming foreign prices and demand are taken as exogenous. In solution, once individual country add factors are set a fully linked solution is obtained with individual trade volume and price linkages computed simultaneously with the country models. The convergence process also includes an algorithm which ensures the consistency of total world exports and imports in volume and value terms. Given the specific structure of the trade blocks, designed to maintain reasonable international consistency in world trade volumes and prices, individual country projections are only marginally affected by this additional consistency adjustment.[34]

31. Although the current form of the MTB system brings transparency, consistency and efficiency compared with earlier spreadsheet based versions, a variety of issues remain and hence there may be scope for further improvements. With respect to model structure, equations such as those defining the accumulation rate and the wage share could be added. The system would also benefit from inclusion of equations to determine interest payments (public and foreign sector), asset prices and stocks. Monitoring equations, in the spirit of those currently incorporated for trade or inflation, would also be useful for checking the implicit add-factoring embedded in some essentially targeted variables such as consumption. With regard to developing richer behavioural content and full simulation capabilities, this is planned to take place in the context of a more regionally compact global model drawing on the same broad accounting framework but focusing more specifically on global trade and finance linkages between major OECD and non-OECD countries and regions.[35]

34. Once trade add-factors are set for every country, the system is solved and automatically adjusts export volumes and import prices: the correction is designed to ensure that total export volumes grow at the same rate as total import volumes and that average world import prices grow at the same rate as average world export prices. As a consequence, trade discrepancies for trade volumes and trade values remain constant in share of world demand, which is fundamental requirement for global consistency over the projection period.

35. The prototype version of the new global model, currently in development, focuses on the United States, Japan, the euro area, the rest of the OECD, China and other non-OECD regions.

Figure 4. **The MTB maquette for a single country**



ANNEX 1. ESTIMATED BENCHMARK CAPITAL STOCK AGGREGATES

In order to benchmark the capital services measures and derive a national accounts base year level of non residential capital stock, benchmark estimates have been derived based on the usual business and government sector investment decomposition, both of which are generally available back to 1955 or 1960. Prior to these dates, the investment to GDP ratio has been back-cast and investment levels derived using GDP estimates taken from Maddison (2001). The capital stock benchmark series is estimated as a "pseudo" capital services measure using a retirement law and a concave age-efficiency profile (see Box 2 for the definitional differences in measures of capital stock). The average life span of business investment is assumed to be 18 years and government investment 60 years (assuming that most of public investment is infrastructure). Basically over the first six years (one-third of the life span), there is no retirement. Afterwards, the retirement is assumed to be linear. The overall age efficiency profile is a concave function (the efficiency does not diminish at the beginning of the life but occurs latter more and more rapidly). Such a profile is equivalent to a convex age-price profile (*i.e.* machines lose most of their acquisition value at the beginning of their lives) using a function of the following form:

$$e_t = \frac{T-(t-1)}{T-\beta(t-1)} \text{ with } \beta = 0.8$$

The product of the retirement law and the age efficiency profile imply an essentially endogenous deterioration rate.

ANNEX 2. THE HP AND EXTENDED HP FILTERS

This Annex provides a detailed description of the mechanics of the Hodrick-Prescot (HP) filter, with particular emphasis on end-point bias and ways to overcome it, notably by imposing end-point restrictions.

The HP filter is the solution of the following minimisation programme:

$$\underset{\mathrm{T_t}}{Min}\ \ell = \sum_{t=1}^{T} y_t - T_t + \lambda \sum_{t=3}^{T} \left[(T_t - T_{t-1}) - (T_{t-1} - T_{t-2}) \right]^2 \qquad [A2\text{-}1]$$

In terms of matrix notation, [A2-1] can be rewritten as:

$$\underset{\mathrm{T}}{Min}\ \ell = (Y - \mathrm{T})' (Y - \mathrm{T}) + \lambda T' \Delta_2 ' \Delta_2 T \qquad [A2\text{-}2]$$

where Δ_2 is a $t, t-2$ matrix that second difference T :

$$\Delta_2 = \begin{matrix} 1 & -2 & 1 & 0 & 0 & \cdots & 0 \\ 0 & 1 & -2 & 1 & 0 & \cdots & 0 \\ \vdots & & & & & & \vdots \\ 0 & 0 & 0 & \cdots & 1 & -2 & 1 \end{matrix}$$

The first order condition of [A2-2] is given by:

$$\frac{\partial \ell}{\partial T} = 0 \Leftrightarrow -2(Y - T) + 2\lambda \Delta_2 ' \Delta_2 T = 0 \qquad [A2\text{-}3]$$

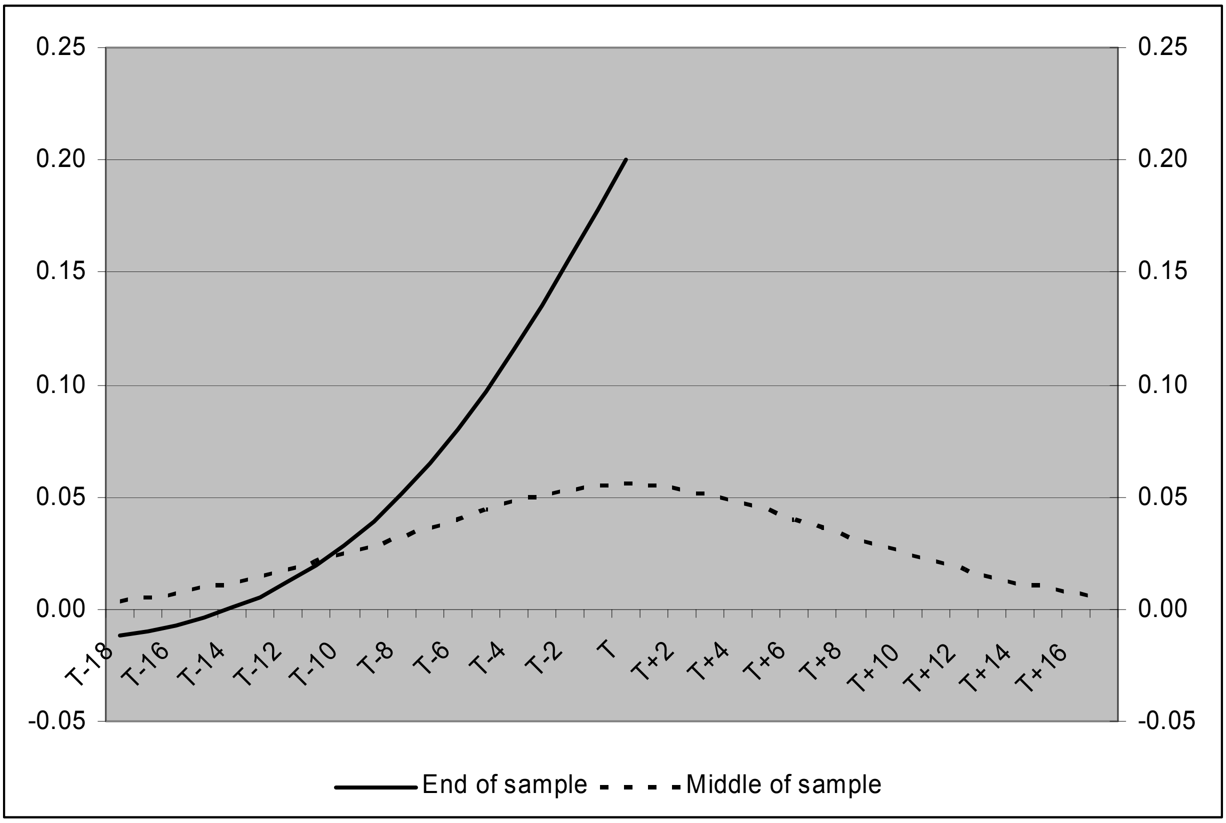
Or equivalently, [A2-3] yields:

$$T = (I + \lambda \Delta_2 ' \Delta_2)^{-1} Y \qquad [A2\text{-}4]$$

The inverse of the matrix $I + \lambda \Delta_2 ' \Delta_2$ gives the weight of each observation in the trend determination. Figure A2.1 provides an example of such weights with $\lambda = 1600$. It can be seen that over the middle of the sample these weights exhibits a bell shape. Furthermore, because 1600 corresponds to a cycle of eight years, there are four years (16 quarters) each side of quarter T. One of the well documented drawbacks of the HP filter is that as the end (or the beginning of the sample) approaches, the filters becomes one-sided and the contemporaneous data are given a weight that is much greater than in the middle of the sample. Formula [A2-4] has other interesting features. When lambda increases, the weights are lower but more past and future values of actual data affect the trend.

Figure A2.1 **Weights of the HP filter**

(lambda=1600)



The extended HP filter is a generalisation of the minimisation problem [A2-1]. The use of such filer is well documented in Laxton and Tetlow (1992) or Butler (1996). The idea is to add additional variables that can potentially have an effect on the trend determination. For instance, Conway and Drew (1997) apply this filter to determine potential output in New Zealand using capacity utilisation constraint as an additional variable. In the current case, these additional restrictions are end point constraints or/and imposed long-term growth rates. The trended variable is the result of the following minimisation problem:

$$\underset{\mathrm{T}}{Min}\ \ell = (Y - \mathrm{T})'(Y - \mathrm{T}) + \lambda T'\Delta_2{}'\Delta_2 T + (\mathrm{T} - \mathrm{X})'\Delta' W \Delta(\mathrm{T} - \mathrm{X}) \qquad \text{[A2-5]}$$

where W given weighting matrix, X a vector containing the explanatory series and Δ matrix which can either be the identity in case X is a level series or that first differentiate in case we want to impose a growth rate constraint:

$$\Delta = I \text{ or } \Delta = \begin{matrix} 1 & 1 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 1 & -1 & 0 & 0 & \cdots & 0 \\ \vdots & & & & & & \vdots \\ 0 & 0 & 0 & \cdots & 0 & 1 & -1 \end{matrix}$$

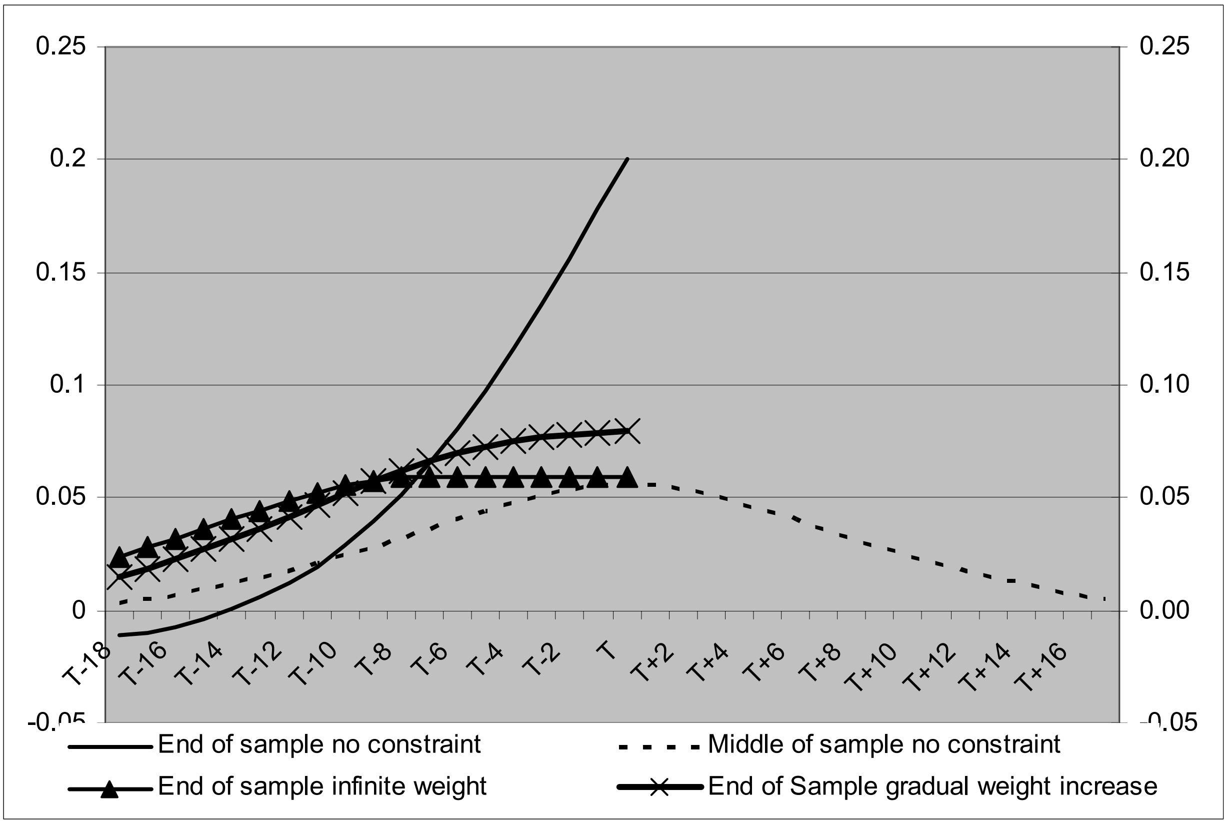
The solution to this generalised version of the HP filter is given by:

$$T = \left(\Delta' W \Delta * \left(\Delta' W \Delta\right)' + I + \lambda \Delta_2{}' \Delta_2\right)^{-1}\left(\Delta' W \Delta X + Y\right) \quad \text{[A2-6]}$$

It is worth noting that when both X and W are equal to zero, the minimisation problem yields exactly the standard HP filter. The usefulness of such an approach relies in its flexibility. This filter is capable of addressing all specific medium term projection issues, such as endpoint, minimizing the revision compared with the previous round, dealing with broken trends, imposing long run growth rates. Typically, imposing an endpoint at the end of the projection period, amounts to filling the vector X with zeros except for its last row. The weights attached to this row then have to be large to make the constraint binding rapidly. As shown in Figure A2.2, the weighting scheme has implications on the resulting trends. Typically, the higher the weight, the larger will be the differences from an unconstrained HP filter at the end of the sample period.

Figure A2.2. **Weights comparisons: unconstrained/constrained HP filter**

(lambda=1600)



ANNEX 3. THE MTB ACCOUNTING FRAMEWORK

This annex and Tables A3.1 to A3.6, describe the underlying accounting framework of the MTB system. This is essentially a simplified form of that used for the short-term projections with some details removed, new composite variables (tax rates for example) added and some accounts explicitly linked. The variable codes are those of the *OECD Economic Outlook* data base, with variable types flagged as being an identity (I), a forecast (F) or the result of a behavioural equation (B). All historical data (series up to the end of the short-term projection period) come from the standard quarterly database used for short-term projections. The formulas shown in the relevant tables show any data transformation involved in the specification of individual variables.

The expenditure account (see Table A3.1) is fairly standard with GDP calculated as the product of the GDP gap and potential GDP (in the model the usual GDP identity $GDPV = TDDV + XGSV - MGSV$ holds). Consumption, inventories and housing investment are defined as a residual. Productive investment (investment consistent with the capital service approach, *i.e.* total economy minus housing) is the product of the accumulation rate c and the capital stock. Public sector variables in volume are defined by identities with government consumption and government investment assumed to be constant as shares of potential nominal GDP.

Table A3.1 **Expenditure account**

	Code	Type	Formula
Private consumption	CPV	I	
Public consumption	CGV	I	CG/PCG
Productive investment	IPV	B / I	$c*KBV_{-1}$
Business investment	IBV	I	IPV-IGV
Housing investment	IHV	FI	
Public investment	IGV	I	IG/PIG
Stockbuilding [+statistical discrepancy]	ISKV	I	
Exports of goods and services	XGSV	B	
Import of goods and services	MGSV	B	
GDP total economy	GDPV	B / I	GAP*GDPVTR
Investment total economy	ITV	I	IBV+IHV+IGV (or IPV+IHV)
Domestic demand	TDDV	I	CPV+CGV+ITV+ISKV
Net exports	FBGSV	I	XGSV-MGSV

The household account (see Table A3.2) is somewhat different from that used in the Economic Outlook, although all the key aggregates are the same. Notably, three tax rates with different bases are defined as: the employers' social security contribution rate ($T\_TRPBSH = TRPBSH/WAGE$), the employees' social security contribution rate ($T\_TRPESH = TRPESH/WAGE$) and the direct tax rate ($T\_TYH = TYH/(WAGE + SSPG + OTHER)$. Two further residuals items gather miscellaneous not essential variables: other income ($OTHERH$) and other saving $OTHERS$. Over the historical period, other income is defined by: $OTHERH = YDH - [WSSS - TRPBSH - TRPESH + SSPG - TYH]$ and other saving is defined as $OTHERS = SAVH - CP$. These residuals are generated by two exogenous variables: T_OTHERH and T_OTHERS. There is a full consistency with the public sector account. Social security contributions are a receipt for the public sector and an outlay for the household. The functioning is similar for direct taxes and current transfers paid by the government. Overall, the household account is almost constituted by identities with only two variables (the residuals) being forecast. Thus, public sector related variables are set to meet the constraint that the cyclically adjusted deficit is constant in share of GDP while wages and consumption are determined in the other accounts (expenditures, prices and wage/employment).

Table A3.2 **Households account**

	Code	Type	Formula
Wage bill private sector	WAGEB	I	$WR * ETB$
Wage bill public sector	WAGEG	I	$WRG * EG$
Wage received by households	WAGE	I	$WAGEB + WAGEG$
Employers social security contribution	TRPBSH	I	$TRPBSHA * IFU^{a4}$
Employers social security contribution rate	T_TRPBSH	I	$TRPBSH/WAGE$
Employees social security contribution	TRPESH	I	$TRPESHA * IFU^{a4}$
Employees social security contribution rate	T_TRPESH	I	$TRPESH/WAGE$
Wage bill including social security contribution	WSSS	I	$WAGE + TRPBSH$
Current transfers paid by government	SSPG	I	$T\_SSPGA * GDPTR$
Direct taxes paid by households	TYH	I	$TYHA * IFU^{a2}$
Direct tax rate	T_TYH	I	$(WAGE + SSPG + OTHERH)/TYH$
Other income (residual)	OTHERH	I	$T\_OTHERH * OTHERH$
Other income ratio	T_OTHERH	F	Constant
Disposable income	YDG	I	WSSS-TRPBSH-TRPESH+SSPG-TYH+OTHERH
Consumption in value	CP	I	$CPV * PCP$
Other saving	OTHERS	I	$T\_OTHERS * YDH$
Other saving ratio	T_OTHERS	F	Constant
Saving	SAVH	I	$YDH - CP + OTHERS$
Saving ratio	SRATIO	I	$SAVH/YDH$

The current account balance (Table A3.3) is the same as for the short-term forecasts. Trade prices and volumes give the trade balance in values (national account definition). Factor incomes and net transfers are projected as a constant share of exports or imports. The current account residual is maintained at its average for the short term projection period.

Table A3.3 **Current account**

	Code	Type	Formula
Import of goods and services values	MGS	I	MGSV*PMGS
Exports of goods and services values	XGS	I	XGSV*PXGS
Factor income from abroad	XSII	F	
Factor income to abroad	MSII	F	
Net transfer payments	NTR	F	
Residual BOP item	CBR	F	
Current account balance	CB	I	XGS-MGS+XSII –MSII+NTR

The government account (Table A3.4) involves some streamlining by introducing a number of residual items (*OTHERCT, OTHERGO, OTHERGR*) respectively defined as YPG-[CG-SSPG-YPEG], CAPOG-IG+CFKG and YRG-[TYH+TYB+SSRG+TIND+YPERG]. Two additional tax rates are included: the business tax rate *T_TYB*=TYB/(PGDPB*GDPVTR) and the indirect tax rate T_TIND=TIND/(CP-TIND). The functioning of the account is relatively straightforward. Given the constraint of a constant cyclically adjusted balance, taxes and expenditures are assumed to remain constant in terms of potential GDP, the current value being derived through the path of the output gap.

Table A3.4 **Government account**

	Code	Type	Formula
Outlays			
Wage consumption	CGW	I	WG*EG
Non wage consumption	CGNW	I	CG-CGW
Total public consumption	CG	F	Constant in share of potential GDP
Current transfers to households	SSPG	I	T_SSPGA*GDPVTR
Ratio of current transfers to household	T_SSPGA	F	Constant
Property income paid by government	YPEG (or GGINTP)	F	Constant share of potential
Other income (residual)	OTHERGO	F	Constant share of potential
Government current disbursement	YPG	I	CG+SSPG+YPEG (or GGINTP)+OTHERGO
Government primary cyclically-adjusted disbursement	YPGXA	I	(YPG-GGINTP)*IFU^{A1}
Government cyclically-adjusted disbursement	YPGA	I	YPGXA+GGINTP
Public investment	IG	F	Constant in share of potential GDP
Fixed capital consumption (needed for potential)	CFKG	F	Constant share of potential
Other capital transfers	OTHERCT	F	Constant share of potential
Net capital outlays	CAPOG	I	IG+OTHERCT-CFKG
Receipts			
Household direct taxes	TYH	I	TYHA*IFU^{a2}
Cyclically-adjusted direct taxes	TYHA	F	Constant share of potential GDP
Business direct taxes	TYB	I	TYB*IFU^{a3}
Tax rate business direct taxes	T_TYB	I	TYB/(PGDPB*GDPVTR)
Cyclically-adjusted business direct taxes	TYBA	F	Constant share of potential GDP
Employers'+employees' social security contribution	SSRG	I	TRPBSHA*IFU^{A4}+TRPESHA*IFU^{a4}
Cyclically-adjusted social security contribution	SSRGA	F	TRPBSHA+TRPESHA constant share of potential
Indirect taxes	TIND	I	TINDA*IFU^{a5}
Indirect tax rate	T_TIND	I	TIND/CP
Cyclically-adjusted indirect taxes direct taxes	TINDA	F	Constant share of potential
Property income received	YPERG or GGINTR	F	Constant share of potential
Other receipts	OTHERGR	F	Constant share of potential
Government current receipts	YRG	I	TYH+TYB+SSRG+TIND+YPRG+OTHRGR
Government primary cyclically-adjusted receipts	YRGXA	I	TYHA+TYBA+SSRGA+TINDA+OTHERGR
Government cyclically-adjusted receipts	YRGA	I	TYHA+TYBA+SSRGA+TINDA+YPERG+OTHERGR
Balance			
Government net lending	NLG	I	YRG-YPG-CAPOG
Government cyclically primary adjusted balance	NLGXA	I	YRGA-YPGA-CAPOG+GGINTP-GGINTR
Government cyclically-adjusted balance	NLGA	I	YRGA-YPGA-CAPOG

Table A3.5. **Labour and prices**

	Code	Type	Formula
Government employment	EG	F	Constant share of ET
Private sector employment	ETB	I	*ETNIA-EG*
Total employment national account definition	ETNIA	I	*ET*CLF*
Ratio allowing to compute total employment LFS	CLF	I	$gapclfs+CLF_{-1}$
Total employment LFS definition	ET	I	*LF-UN*
Working age population	POPT	F	Supply-side assumption
Participation rate	LFPR	I	$LFPR_{-1}+gaplfpr$
Labour force	LF	I	LFPR*POPT
Unemployment rate	UNR	I	$gapunr+UNR_{-1}$
Unemployment	UN	I	*UNR*LF*
Business wage rate par head	WR	I	*wageshare*pgdp*GDPV/ETB*
Public sector wage rate per head	WG	F	Growth rate in line with WR
Whole economy wage rate per head	WT	I	(WR*ETNIA+WG*EG)/(ETNIA+EG)
Unit labour cost whole economy	ULC	I	WSSS/GDPV
Core inflation	PCORE	B	
Consumption deflator	PCP	I	
Public investment deflator	PIG	I	
Public consumption deflator	PCG	I	
Price of imports	PMGS	B	
Price of exports	PXGS	B	
GDP deflator	PGDP	I	
Business GDP deflator	PGDPB	I	

Table A3.6 **Supply side**

	Code	Type	Formula
Potential output total economy	GDPVTR	I	See equation A4-5
Output gap total economy	GAP	I	See equation A4-9
Ratio potential over real GDP	IFU	I	GDPVTR/GDPV

ANNEX 4. ANALYTICAL SOLUTION OF THE MTB SYSTEM

This Annex describes the analytical solution of the MTB system for a single country. For simplicity and without loss of generality, some accounting details are omitted. Because of the particular nature of the assumptions on which the MTB is based, a country model solution can be completed through three iterative steps: price and wage determination, real side determination and saving-investment balance closure. It is worth highlighting that this is different from a full model solution in which key supply-side levels are determined through factor demand equations.

Price and wage determination

The reduced form of the wage price block incorporates five prices: core inflation $pcore$, import prices $pmgs$, export prices $pxgs$, an investment deflator pi and the GDP deflator $pgdp$ (where a lower script denotes variables expressed in logs)[36]:

$$\begin{aligned}
&\Delta(\Delta(pcore)) = \gamma(u-\bar{u}) + \theta(\Delta pimp - \Delta pgdp)\\
&\Delta pgdp = \psi\,\Delta pcore + (1-\psi)\Delta pmgs\\
&\Delta pmgs = \varepsilon\,\Delta\bar{p} + (1-\varepsilon)\Delta pgdp\\
&\Delta pxgs = \kappa\Delta\bar{p} + (1-\kappa)\Delta pgdp\\
&\Delta\bar{p} = \eta\Delta pcom + (1-\eta)\Delta p_f\\
&\Delta pi = \Delta pgdp
\end{aligned} \qquad [A4\text{-}1]$$

These equations are fairly standard. Import prices are a weighted average of domestic, foreign export and commodities prices (including oil). Similarly export prices are a weighted average of domestic, foreign import and commodities prices. All other demand prices (investment deflator) are indexed on the GDP price in the long-run to maintain constant relative prices. On a balanced growth path, a stable inflation rate implies that:

$$\Delta pmgs = \Delta pxgs = \Delta pgdp = \Delta pcore = \Delta pi = \Delta\bar{p} \qquad [A4\text{-}2]$$

Thus, in the long run, all prices are indexed on foreign prices and all relative prices are constant. It is nonetheless possible to relax this hypothesis, for example in the short run, inflation may deviate from such a path because the unemployment gap is not zero, although the values of this gap are essentially predetermined by assumption (the rate of gap closure). The price level is recomputed iteratively from the last known value from the end of short-term projections. Overall, this first step to solve out an MTB model is relatively straightforward with only two exogenous variables required: the unemployment gap and foreign prices.

36. The equations presented here are a simplified version of those involved. Typically, the long run of the trade prices equations are expressed in level terms and the dynamics of the pcore equations are much richer, but this does not alter the long-run properties derived in this Annex.

The wage share (ws) is another key variable in the MTB process, which is assumed exogenously so that nominal and real wages are fully given by solving equation [A4-3].

$$ws = \frac{w * L}{pgdp * GDPV} \quad \text{[A4-3]}$$

With a constant wage share, real wages grow in line with productivity, or equivalently unit labour costs and the GDP deflator increase at identical rates, consistent with stable profit margins. The wage share variable also has an important influence on the path of the household saving rate.

Real side determination

The supply side of the economy is described by Cobb Douglas technology with a Harrod neutral labour augmenting progress:

$$Y_t = (E_t L_t HRS_t)^{\alpha} (K_t)^{1-\alpha} \quad \text{[A4-4]}$$

where E_t is labour efficiency, L_t is employment, HRS_t hours worked and K_t the capital stock. Using similar notation, the level of potential output $\overline{Y_t}$ is given by:

$$\overline{Y_t} = \left(\overline{E_t}\,\overline{L_t}\,\overline{HRS_t}\right)^{\alpha} (K_t)^{1-\alpha} \quad \text{[A4-5]}$$

The trend employment grows at rate n , trend labour efficiency at rate g and trend hours worked at rate h . All these growth rates are exogenous, stemming from the underlying supply-side assumptions. The long-run levels of both labour utilization and total factor productivity are also given. The output gap is defined by the log difference between actual and potential GDP, thus:

$$GAP_t = y_t - \overline{y}_t \quad \text{[A4-6]}$$

Combining equations [A4-4] and [A4-5], taking their log and substituting into [A4-6] yields:

$$gap_t = \alpha\left[\left(e_t - \overline{e_t}\right) + \left(l_t - \overline{l_t}\right) + \left(hrs_t - \overline{hrs_t}\right)\right] \quad \text{[A4-7]}$$

Equation [A4-7] confirms that the path of the capital stock is not required for producing the path of the output gap. Since potential employment, potential labour efficiency and potential hours worked are exogenous, the path of each gap component (employment, hours and productivity gaps), which are known by assumption, determine the path of the output gap. The employment gap can be decomposed further into a labour force participation and unemployment rate gaps. Employment and potential employment can be rewritten as a function of working age population $popt$, labour force participation pr and the unemployment rate unr :

$$L_t = POPT_t * pr_t * (1 - u_t) \text{ and } \overline{L_t} = POPT_t * \overline{pr_t} * (1 - \overline{u_t}) \quad \text{[A4-8]}$$

Taking the log and substituting into [A2-7] gives:

$$GAP_t = \alpha\left[\left(pr_t - \overline{pr}_t\right) + \left(h_t - \overline{h}_t\right) + \left(\overline{u_t} - u_t\right) + \left(e_t - \overline{e}_t\right)\right] \quad \text{[A4-9]}$$

so that the assumed path of gap closure implies that the paths of unemployment rate and the labour force and then employment are fully determined.

The capital accumulation is described by the following identity:

$$K_t = (1-\delta)K_{t-1} + I_t \qquad \text{[A4-10]}$$

where I_t denotes investment and δ the rate of depreciation. The accumulation rate (the investment to capital ratio) is a key parameter, defining the path of the capital stock and the level of potential, and hence the level of actual GDP.

Dividing both side of [A4-10] by K_{t-1} yields:

$$g_{k\,t} = c_t - \delta \qquad \text{[A4-11]}$$

where c_t is the accumulation rate and g_{kt} the growth rate of capital stock. It is worth noting that in the long-run (i.e. beyond the usual MTB horizon), the "equilibrium" accumulation rate, *i.e.* the accumulation rate ensuring a stable capital to output ratio (or the capital stock grows like potential output) is the sum of four terms:

$$c^* = n + g + h + \delta \qquad \text{[A4-12]}$$

At this equilibrium level, the economy is on a path where the growth rate of labour productivity is that of labour efficiency, potential increases as employment plus labour efficiency plus trend hours, and capital stock rises like potential output. When the capital accumulation rate is below its long-run equilibrium value, the capital stock growth is below potential growth and vice versa, with implications on the private saving ratio (see below). The long-run level of the capital output ratio depends on the starting point and the path of the accumulation rate and is not determined by a structural equation. In the system, there is a steady state (that can eventually be reached beyond the MTB horizon) because the model is constrained so that capital stock and potential output grow at the same path.

To close the model and to ensure that supply equals demand, the usual demand identity has to hold. With investment is given by the accumulation rate three unknown remain: consumption, public expenditure and net trade volumes.

$$Y_t = C_t + I_t + G_t + X_t - M_t \qquad \text{[A4-13]}$$

Of these, public expenditures G are predetermined and net trade is determined by the standard equation specifications:

$$X_t = F_{dt}\left(\frac{P_{xt}}{\overline{P}_t}\right)^{\eta} \quad \text{and} \quad M_t = DD_{dt}\left(\frac{P_{mt}}{\overline{P}_t}\right)^{\gamma} \qquad \text{[A4-14]}$$

where F_{dt} denotes foreign demand, DD_t domestic demand and $\overline{P}_t$ foreign prices. As domestic prices, foreign prices and foreign demand are known, equations [A4-14] yield trade volumes. Hence, real private consumption C_t is used as the adjustment variable ensuring that equation [A4-13] is verified.[37] Overall, the path of real GDP is given by the accumulation rate and the speed at which the output gap is closed. The assumed accumulation rate determines real investment. Because real public expenditures are exogenous and trade volumes are given by equation [A4-14], consumption adjusts so that equation [A4-13] holds.

Saving-investment closure

In this highly simplified framework, private saving is given by the following accounting identity:

$$S_{pt} = -S_{publict} + \left(P_{xt} X_t - P_{mt} M_t\right)_t + P_{it} I_t \qquad \text{[A4-15]}$$

where S_{pt} stands for private saving, $-S_{publict}$ the public deficit, $P_{xt} X_t - P_{mt} M_t$ the current account and $p_{it} I_{p_t}$ private investment. Dividing [A4-15] by nominal GDP gives:

$$s_{pt} = -s_{publict} + ca_t + \frac{P_{it} I_t}{P_{gdpt} Y_t} \qquad \text{[A4-16]}$$

The path of the current account balance is known through the solution for trade volumes and prices. The path of public deficit is given by the assumption that that the cyclically adjusted deficit is constant in share of GDP. In a stylized government account where the government does not pay interest payment, both the cyclically adjusted deficit and the primary cyclically adjusted deficit would coincide. The public expenditure are denoted by G (supposed to be exogenous) and taxes by T. It is further assumed that taxes represent a constant share of potential GDP and that government expenditures have no cyclical components (thus $G_t = GA_t$). The stable tax rate assumption is required to ensure that at each period of the MTB, structural tax revenues are a constant share of nominal GDP.

The actual government budget balance is given by:

$$D_t = G_t - T_t \qquad \text{[A4-17]}$$

With the tax rate expressed in terms of potential GDP, the cyclically adjusted taxes receipts TCA are given by:

$$TCA_t = t * pgdp_t * \overline{Y}_t \qquad \text{[A4-18]}$$

and current receipts are given by the following equation:

$$T_t = \left(gap_t\right)^{\sigma} TCA_t \qquad \text{[A4-19]}$$

The cyclically adjusted deficit DCA is defined as:

$$DCA_t = G_t - TCA_t \qquad \text{[A4-20]}$$

37. In reality, this is a little bit more complicated, with domestic demand and import volumes being determined simultaneously.

As both tax rates and nominal potential GDP are known, cyclically adjusted revenues are fully determined. At the end of the MTB horizon, when the gap is closed, both cyclically and actual receipts coincide (see equation [A4-19]). Under these assumptions, the primary cyclically adjusted deficit is kept constant and thus the current actual deficit is the adjustment variable which gradually moves back toward its structural level. This implies that the current receipts expressed in share of GDP are not constant over the MTB horizon. Combining [A4-18] and [A4-19] yields:

$$\frac{T_t}{pgdp_t Y_t} = t * gap_t^{1-\sigma_T} \qquad \text{[A4-21]}$$

If σ_T equals 1, the cyclically adjusted taxes to GDP ratio coincides with current taxes to GDP ratio (see equation [A4-21]). Usually σ_T is greater than 1 for taxes. Thus σ_T contains the information about tax base effects which influences the effective tax rates. In the model, the government expenditures are determined by the same method, but σ_E is typically less than 1.

Starting from an initial private saving ratio, [A4-16] can be rewritten as:

$$\Delta s_{pt} = -\Delta s_{publict} + \Delta ca_t + \frac{P_{it} I_t}{P_{gdpt} Y_t}\left(g_{kt} - g_{yt} + g_{pit} - g_{pgdpt}\right) \qquad \text{[A4-22]}$$

Overall, the path of the private saving rate is given by the difference between the growth rate of the nominal capital stock and the growth rate of nominal potential output. If the investment deflator and the GDP deflator grow at the same rate ($g_{pit} = g_{pgdpt}$), then the evolution of the saving ratio is fully given by the difference between the growth rate of capital stock in volume and the growth rate of real potential output. Thus when the accumulation rate is at its "equilibrium value", changes in the private saving rate follow the evolution of the current account and the public sector deficit. The implications for the MTB is that assuming a constant accumulation rate does not ensure a constant private saving ratio. For instance, if the accumulation rate is below $n + g + h + \delta$, then, potential output grows faster than the capital stock (the capital to output ratio diminishes) and everything else being equal, the private saving decrease. Such an assumption can not hold in the long-run and at some point (not over the MTB horizon which is too short), adjustments will occur.

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