MEASURING POTENTIAL OUTPUT IN THE SEVEN MAJOR OECD COUNTRIES

Raymond Torres and John P. Martin

CONTENTS

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INTRODUCTION

Over the past decade much greater attention has been paid to setting economic policies in a medium-term framework, reflecting a growing concern with structural reform and with the sustainability of imbalances between demand and supply. In this context, potential output can play a useful role as a summary indicator of aggregate supply, as it does in the OECD's medium-term work. A stated aim of structural policies is to improve the supply side of the economy, thereby raising productivity growth in the longer-run and stimulating potential output growth. In addition, the size of the gap between demand and supply is an important indicator of the sustainability of observed output growth and underlying inflationary pressures.

It is important, though, not to exaggerate the role of measures of potential output in policy analysis for several reasons. First, many different concepts of potential output have been proposed in the literature and are in use in OECD countries. Second, a wide variety of empirical methods are used to measure potential, ranging from time-series and trend-type analyses to more elaborate calculations based on production functions and factor demand equations, with the precise answers being sensitive to the chosen methods. Finally, because of these problems, measures of potential are only one of a battery of indicators which policy makers study when trying to make judgements about the current and future path of growth.

The aims of this paper are three-fold:

i) to explain the method used by the OECD to derive a measure of potential output;

ii) to present recent OECD estimates of potential output and the gap between actual and potential output – a measure of capacity utilisation – for the seven major OECD countries; and

iii) to illustrate some of the possible effects of faster productivity and potential output growth on macroeconomic performance.

The OECD is currently developing measures of potential output for most of the other OECD countries, using a similar approach to the one described here. Preliminary results from this work are described in Torres *et al.* (1989).

The structure of this paper is as follows. Section I explains the definition of potential output chosen by the OECD and the method used to derive the estimates. The estimates themselves are reviewed in Section II. Section III compares the OECD and IMF approaches and estimates. Section IV discusses some simulations of the effects of faster productivity and potential output growth using the OECD's INTERLINK model, which embodies the chosen measure of potential in the structure of the major seven country models'. The final section presents some concluding remarks.

I. THE CONCEPT AND ESTIMATION OF POTENTIAL OUTPUT

There are many alternative definitions of potential output and many methods have been used to quantify these concepts, starting with the seminal work by Okun (1962)[2]. The particular concept of potential output which is currently being used by the OECD refers to the level of output that is consistent over the medium-term with stable inflation. As such, this concept is clearly different from one representing the maximum attainable level of output in an engineering sense that could be produced with given factors of production.

This particular concept was chosen in line with the emphasis on control of inflation as a key medium-term priority. In addition, as is shown below, its use ensures consistency between labour market equilibrium and product market equilibrium in INTERLINK.

A. Structure of the supply blocks in INTERLINK

The business-sector supply blocks in INTERLINK play a key role in the determination of the estimates of potential output and capacity utilisation. The general framework for modelling supply is broadly that presented in Helliwell *et* al. (1986) and Jarrett and Torres (1987). The supply blocks for the major seven OECD countries jointly determine factor demands, output supply and producer prices in a consistent framework involving an aggregate three-factor production function of nested CES form[3]. This contains an inner function which combines capital and energy into a single aggregate, referred to as the capital-energy bundle. Specific allowance is made for a vintage element to the capital stock: a flexible ''putty/semi-putty'' structure has been specified which permits an estimated proportion of the capital stock to be adjusted in each period with shifts in relative energy prices, a process known as ''retrofitting''[4]. Failure to endogenise the scrapping rate is typically a major weakness in empirical estimation of production functions. This problem is overcome here to the extent that, for

a given capital stock, the capital-energy bundle is allowed to vary in line with changes in relative energy prices[5]. The capital-energy bundle is then combined with the labour input measured in efficiency units in the "outer" production function. The outer function is characterised by:

i) a constant elasticity of factor substitution;
ii) constant returns to scale: and
iii) Harrod-neutral technical progress, i.e. assumed to be solely labour-augmenting and specified as a labour efficiency index.

This leads to the following overall specification of the production function:

$$QBSV = (\beta * (ETB * ELEFF) ** P + \alpha * KEBSV ** P)** (1/\rho) \quad [1]$$

where QBSV is normal output, which represents the output level that would be supplied if the actual quantities of capital, labour and energy were used at average utilisation rates;

ETB is actual business-sector employment;

ELEFF is the labour efficiency index;

KEBSV is the actual capital-energy bundle;

ρ is equal to $(\tau - 1)/\tau$, where τ is the elasticity of substitution in the outer function between labour and the capital-energy bundle:

and β and α are scale parameters.

The resulting estimates of the elasticity of substitution are shown in Table 1; details of the estimates are described in Jarrett and Torres (1987). The

Table 1. Estimates of the elasticity of substitution"

	Elasticity of substitution between labour and the capital-energy bundle
United States	0.74
Japan	0.32
Germany	0.73
France	0.72
Italy	0.64
United Kingdom	0.77
Canada	0.64

a) For further details on these estimates, see Jarrett and Torres (1987).

unweighted mean elasticity across the seven countries is 0.65 implying that, on average, a 1 per cent increase in the price of labour relative to the cost of the capital-energy bundle leads to a rise in the capital-energy/labour ratio of 0.65 per cent.

B. Technical progress

In general, technical progress increases total factor productivity (TFP), but it may have different effects on the productivity of individual factors. As noted above, technical progress is assumed to affect labour efficiency: in equilibrium (that is, in the absence of changes in relative factor prices), this implies that technical progress augments labour productivity, keeps capital productivity unchanged and therefore increases the capital/labour ratio[6]. Hence, this assumption about the nature of technical progress implies constant profit shares in long-run steady-state growth.

It has proved very difficult to model technical progress and a variety of methods have been used in the literature[7]. Most often, it is proxied by time trends in estimated equations. For the purposes of this work, the labour efficiency index has been proxied by a trend of labour productivity, which has been fitted using the so-called Prescott (1986) method[8]. The implied labour efficiency growth rates are relatively stable and change slowly over time – which seems desirable in any measure of technical progress.

The resulting trend growth rates of labour efficiency are shown in Chart A. Prior to 1973, growth rates of trend labour efficiency ranged from almost 1 per cent per annum in the United States to around 7 per cent in Japan. During the 1970s, technical progress decelerated in all countries. There has been some pick-up again in most countries during the 1980s.

C. Definition of potential output

Potential output in the business sector is defined as the level of output derived from the production function, using as inputs:

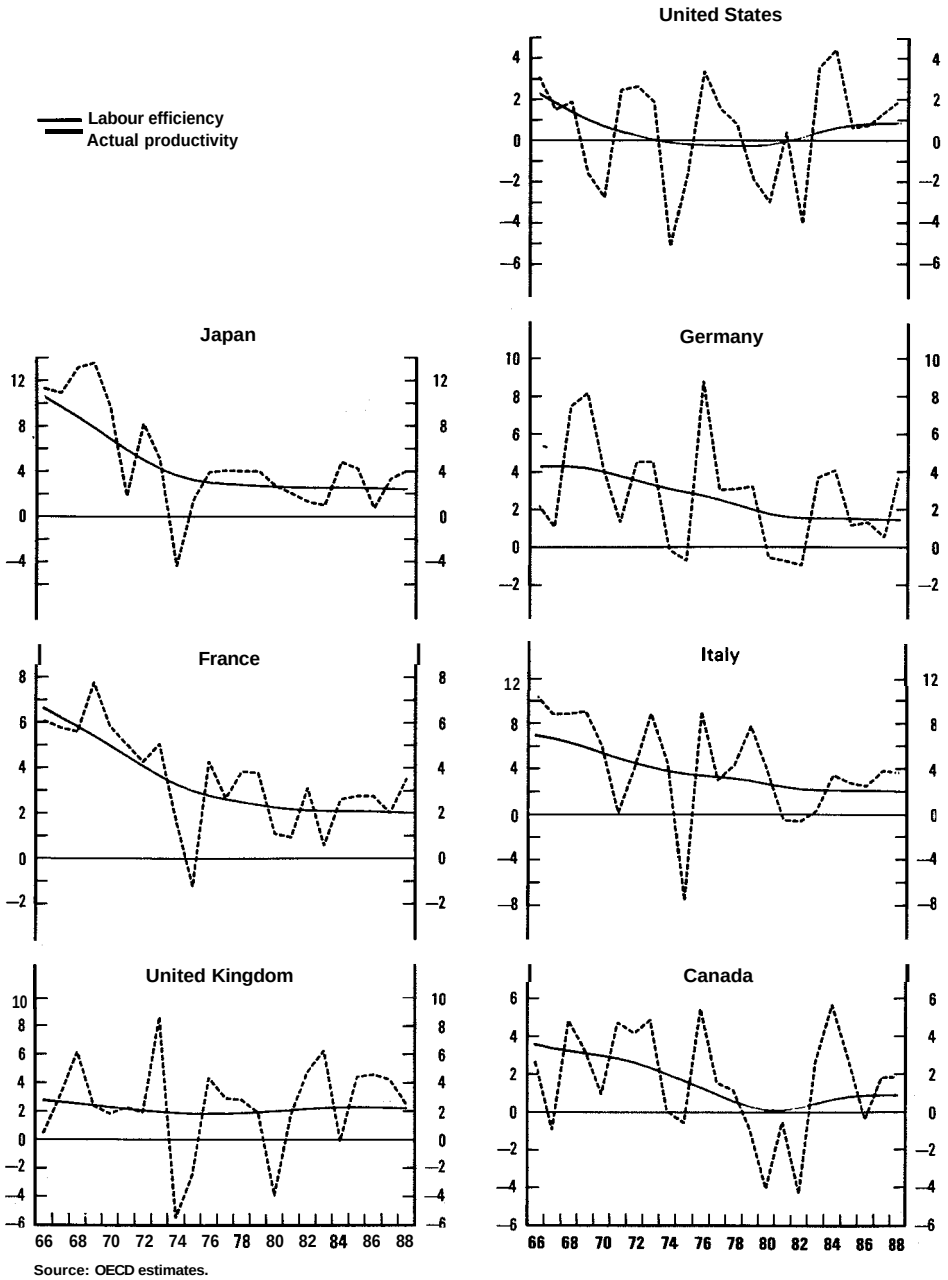
i) the actual level of the capital-energy bundle;
ii) the labour efficiency index; and
iii) potential business-sector employment.

Potential output is defined here as the maximum level of output consistent with stable inflation. The level of the actual capital-energy bundle is used as one input to the calculation, since it represents a relatively binding physical constraint on supply in the short to medium term. In contrast, it is not appropriate to include actual employment in this definition of potential output to the extent that it

CHART A

LABOUR EFFICIENCY AND ACTUAL PRODUCTIVITY

Average annual growth rates in percentage



Source: OECD estimates.

deviates from the level consistent with a stable rate of inflation. Instead a measure of potential employment is used which takes account of the relationship between unemployment and wage/price inflation, as embodied in recent estimates of the wage-price blocks in INTERLINK.

Such wage-price blocks can basically be represented as follows[9]:

$$\dot{w} = \dot{p}_c^e + a_0 - a_1 \, UNR + a_2 Z \qquad [2]$$

$$\dot{p} = \dot{c}^e - b_1[p(-1) - (c(-1) + m)] + b_2(IFU2-1) \qquad [3]$$

$(\dot{w} = dw/dt$, etc.).

Where w represents the wage rate, p_c the consumer price level, UNR the unemployment rate, Z the set of other variables which shift nominal wages, p the output price, c total unit costs (unit labour costs plus unit capital costs plus unit energy costs), m the "normal". mark-up, and IFU2 the ratio of actual to potential output. In INTERLINK, price and cost expectations (represented by the e superscript) are modelled as moving averages of current and past rates of price and cost inflation.

Equation [3] includes two error-correction terms. The first expression in brackets – [p(-1)-(c(-1)+m)] – is the lagged price-cost margin; this variable is specified in level terms, thereby constraining prices to be equal to total unit costs plus the "normal" mark-up in equilibrium. The second term in equation [3] represents the difference between the ratio of actual to potential output and its average value, which is unity. In such a framework, excess (insufficient) demand will exert an upward (downward) pressure on price inflation.

Conditions for long-run equilibrium are two-fold:

i) the mark-up is constant [p(–1) = c(–1) + m]; and

ii) expectations are fulfilled ($\dot{p}^e = \dot{p}_c$ and $\dot{c}^e = \dot{c}$). Under these conditions, real wages grow in line with labour efficiency in long-run equilibrium[10]:

$$\dot{w}\text{-}\dot{p} = \dot{ELEFF} \qquad [4]$$

Combining equation [4] with the wage equation [2] and solving it for the unemployment rate gives a measure of the so-called "non-accelerating wages rate of unemployment" (NAWRU)[11]. Conditions *i)* and *ii)* imply that, in equilibrium, the unemployment rate is equal to the NAWRU and IFU2 is unity. However, IFU2 can be equal to unity only if potential output is equal to actual output, i.e. if potential employment is equal to actual employment[12]. This latter condition holds only if the unemployment rate embodied in the definition of potential employment, the NAWRU, is equal to the actual unemployment rate in long-run equilibrium. Therefore, including the NAWRU in the potential output definition ensures consistency between labour market equilibrium (UNR=NAWRU) and product market equilibrium (actual output=potential output).

This leads to the following definition of business-sector potential employment:

business-sector potential employment = "trend" labour force * (1-NAWRU) - general government employment.

One point to note is that it is the so-called "trend" labour force rather than the actual labour force which enters the definition of potential employment. The "trend" labour force is derived by smoothing the actual labour force using the Prescott method to eliminate, as far as possible, the effects of cyclical fluctuations in labour force participation rates. This procedure avoids introducing undue volatility in the series for both potential employment and potential output.

Business-sector potential output, in turn, is defined as:

business-sector potential output = F (potential employment; ELEFF; actual capital-energy bundle),

where F denotes the outer production function discussed above (equation [1]).

Potential output at market prices for the whole economy is obtained by adding actual value added in the government sector and net indirect taxes to business-sector potential output. Thus, for want of a superior alternative measure, actual value-added of the government sector is taken to be equal to potential output in that sector.

II. ESTIMATES OF POTENTIAL OUTPUT

A. Estimation results

Given the above general framework and current estimates of supply and wage-price block parameters, potential output estimates for the business sector for the major seven countries have been calculated and are presented in Table 2. Estimates of potential output are quite sensitive to the methods used, the exact values of chosen parameters and the assumptions about exogenous variables such as technical progress. Hence, the numerical values presented in Table 2 should be regarded as indicating likely orders of magnitude rather than precise estimates.

Estimates for the NAWRU, which play a key role in the calculation of potential output, are compared with actual unemployment rates in Chart B. Plausible estimates of the NAWRU for Germany and the United Kingdom could not be obtained using the existing wage equations in the model. This reflects the highly non-linear specification of the German wage equation and the presence of a hysteresis term in the U.K. equation. Instead, OECD country experts provided

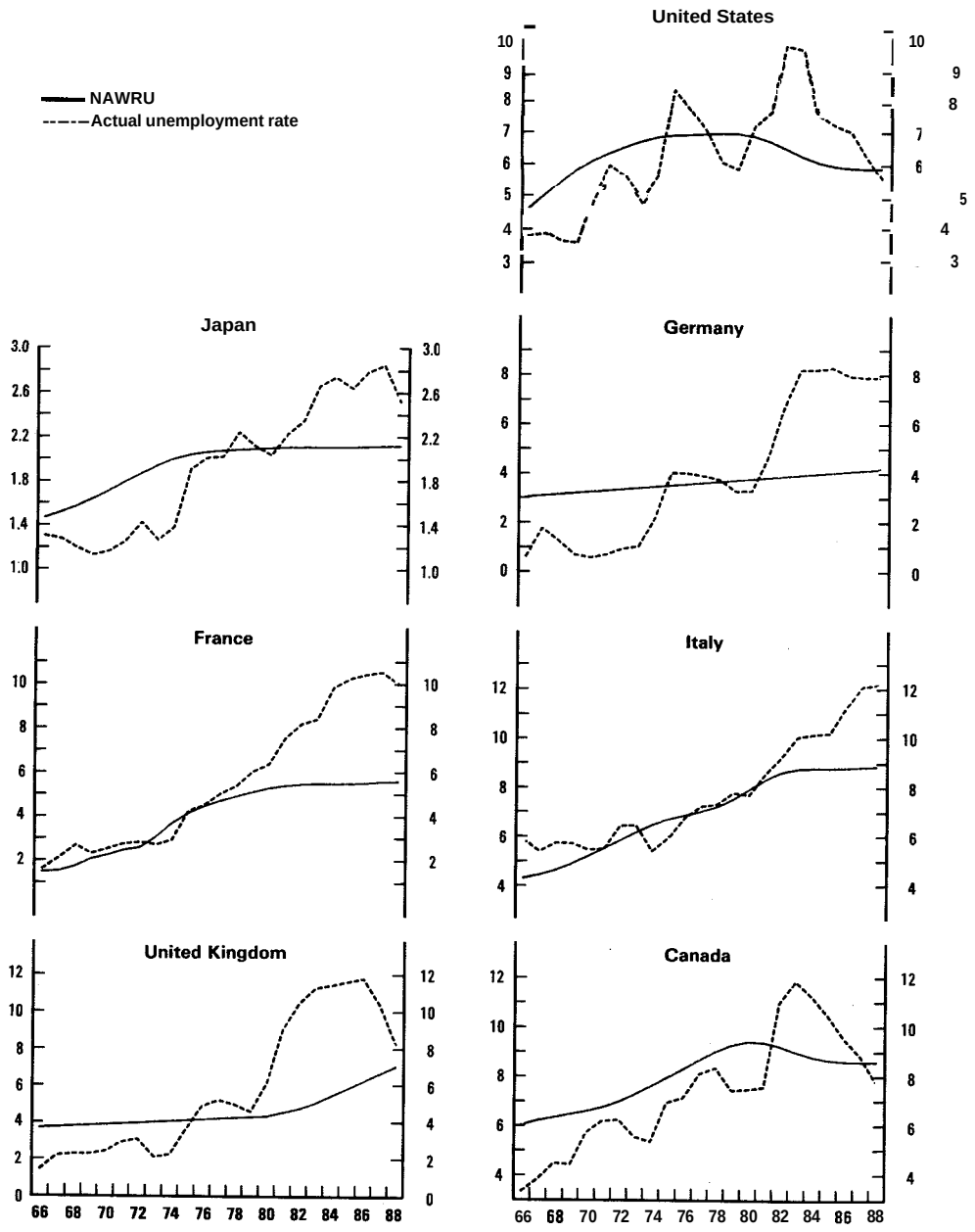
Table 2. Business-sector potential output growth[a]

	1966.73	1974.79	1980-85	1986-90
United States				
Potential output (business sector)	3.1	2.8	2.6	2.7
of which:				
Capital-energy bundle	1.5	1.2	1.1	1.1
Labour	1.1	1.7	1.4	1.0
Total factor productivity[b]	0.5	−0.1	0.1	0.6
Japan				
Potential output (business sector)	9.6	4.1	3.9	4.3
of which:				
Capital-energy bundle	4.0	0.9	0.7	1.0
Labour	0.6	0.7	1.0	1.1
Total factor productivity[b]	4.9	2.5	2.2	2.2
Germany				
Potential output (business sector)	4.2	2.4	2.3	2.5
of which:				
Capital-energy bundle	1.8	1.1	0.9	1.1
labour	−0.2	−0.4	0.3	0.4
Total factor productivity[b]	2.6	1.7	1.2	1.0
France				
Potential output (business sector)	5.3	3.2	2.2	2.7
of which:				
Capital-energy bundle	1.8	1.3	0.8	1.2
Labour	0.3	0.1	0.1	0.2
Total factor productivity[b]	3.2	1.8	1.3	1.3
Italy				
Potential output (business sector)	4.9	3.6	2.6	3.0
of which:				
Capital-energy bundle	2.0	1.2	0.8	1.3
labour	−0.5	0.3	0.4	0.4
Total factor productivity[b]	3.4	2.1	1.4	1.3
United Kingdom				
Potential output (business sector)	2.5	2.3	2.3	2.4
of which:				
Capital-energy bundle	1.4	1.0	0.7	0.9
labour	−0.4	0.1	0.3	0.0
Total factor productivity[b]	1.4	1.2	1.3	1.5
Canada				
Potential output (business sector)	5.2	4.4	3.3	3.5
of which:				
Capital-energy bundle	1.8	2.0	2.0	1.8
labour	1.5	1.8	1.2	1.2
Total factor productivity[b]	1.9	0.6	0.1	0.5

a) The calculations are based on gross output data (including energy consumption).
b) Total factor productivity (TFP) growth is equal to labour efficiency growth multiplied by the labour share in value added.

CHART B

NAWRUs AND ACTUAL UNEMPLOYMENT RATES



Source: OECD estimates

judgmental estimates for the NAWRU for these two countries and these values were used in the calculations.

The contributions of the various inputs to the growth rate of potential are also shown in Table 2. Excepting Canada, the capital-energy bundle's contribution to potential output growth has shown a marked deceleration until the middle of the **1980s.** This reflects in part the rise in real energy prices which curbed the demand for energy. However, the downward trend in the estimated contribution of the capital-energy bundle has been reversed recently, reflecting the investment boom and low real energy prices.

TFP growth in the major seven countries follows a similar pattern to that of the capital-energy bundle. In the United States, TFP provided a positive, though weak, stimulus to potential output growth in the **1980s,** compared with a slight negative contribution in the **1974-79** period. Outside the United States, the contribution of TFP declined steadily until the middle of the **1980s** (except in the United Kingdom). Thereafter the data suggest a break in the downward trend of TFP growth. In the case of the United Kingdom, the contribution of TFP increased appreciably during the **1980s.**

The major European countries have combined weak labour force growth and rising NAWRUs. As a result, the amount of labour input available to the business sector in these countries has only increased marginally since the middle of the **1970s.** By contrast, in North America and, to a lesser extent in Japan, the contribution of a growing labour force to potential output growth has been fairly strong.

Some partial simulations were run in order to assess the sensitivity of these estimates of potential output to:

i) a fall in the NAWRU by 1 percentage point;
ii) a rise in the underlying rate of technical progress – proxied by an increase in the labour efficiency index by **1** percentage point;
iii) an upward shift in the level of the capital stock by **1** percentage point;
iv) a rise in the trend labour force by **1** percentage point; and
v) a 50 per cent rise in energy prices.

The effects on potential output of these exogenous shocks appear to be fairly similar for each of the seven country models. On average, the semi-elasticity of potential output to the NAWRU is **0.9** (that is, a reduction of **1** percentage point in the NAWRU leads, on average, to a rise of **0.9** per cent in potential output). The elasticity of potential output is very similar with respect to changes in both technical progress and trend labour force – averaging **0.7** over all the seven countries. The average elasticity with respect to changes in the capital stock is around 0.3. Finally, a 50 per cent increase in energy prices – which roughly corresponds to the actual rise in relative energy prices after the two oil prices shocks – leads, on average, to a **1** per cent fall in the level of potential output.

B. Price and quantity responses to excess demand

Chart C shows the ratios of actual to potential output which, by proxying the gap between aggregate demand and supply, represent a measure of inflationary pressures. A value of such a ratio in excess of unity means that the economy is operating above potential and a value below unity that there is slack in the economy. In general, estimates of the gap fell substantially below the 1973 peak in the middle of the 1970s. They then increased until the late 1970s. In the early 1980s, the gap variable fell below unity in all countries but Japan, thereby providing support to the disinflationary process over this period. In the late 1980s, the estimated gaps have tended to exceed unity for all countries except Germany and France, suggesting some renewal of inflationary pressures.

For given values of demand, a divergence between actual and potential output may be expected to produce two different effects. First, it should exert pressures on price inflation. Empirical evidence to this effect is provided by Stiehler (1987) in his re-estimation of the price equations for the major seven country models in INTERLINK. However, Stiehler's estimates suggest a very slow response of prices to the gap term. This is in line with other empirical studies on price determination (see Encaoua and Geroski, 1986, for a survey).

Second, the gap should also influence the split of demand between domestic and foreign supply. At present, INTERLINK, like some other macroeconomic models (e.g. the Metric model of the French economy), allows for some spillover effects from the goods market in the determination of import volumes and prices[13].

Table 3 shows correlation coefficients between the gap (or the change in the gap) and changes in consumer price inflation and import penetration growth. In all

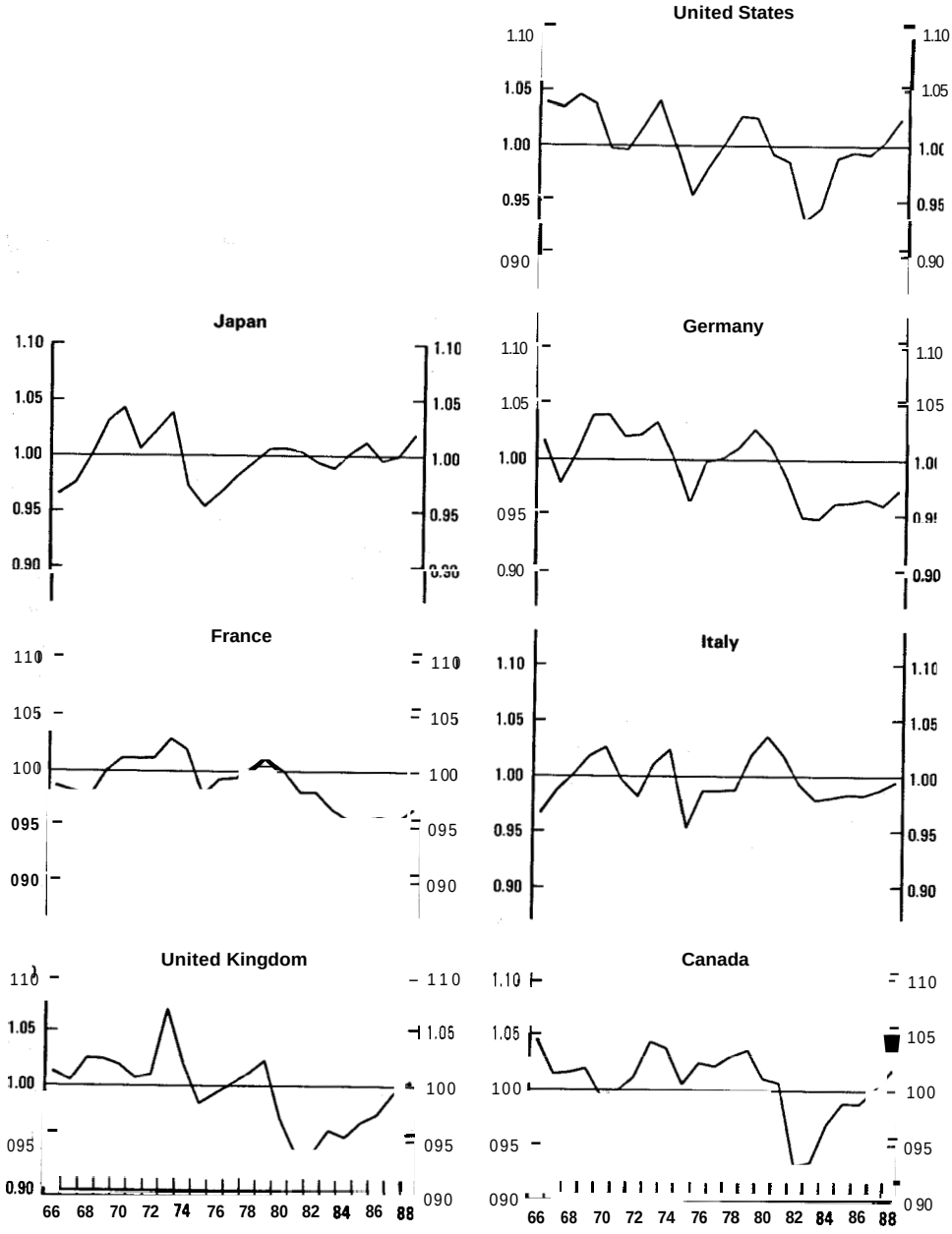
Table 3. Correlation coefficients between the gap[a], inflation and import penetration, 1971-87

	United States	Japan	Germany	France	Italy	United Kingdom	Canada
Correlation between the gap and:							
Change in price inflation	**0.53**	**0.44**	0.27	0.40	0.42	**0.31**	0.47
Import penetration growth[b]	**0.10**	**0.05**	**0.03**	**0.33**	**0.21**	**0.29**	**0.02**
Correlation between the change in the gap (GAP-GAP(-1)) and import penetration growth	0.67	0.17	**0.59**	0.64	0.80	**0.23**	0.81

a) The gap is defined as the ratio of actual to potential output.
b) Growth in the ratio of manufacturing imports to domestic demand, both in real terms.

CHART C

RATIO OF ACTUAL TO POTENTIAL OUTPUT



Source OECD estimates

cases except Germany and the United Kingdom, the correlation between the gap and changes in inflation is positive and close to 0.5, suggesting that an above-average gap is associated with an acceleration of inflation. By contrast, there appears to be only a weak correlation between excess demand and import penetration growth. However, the growth of import penetration appears to be much more strongly correlated with the change in the gap.

III. COMPARISON WITH IMF ESTIMATES

The IMF has recently published its own estimates of potential output, using a similar methodology to the one presented here – see Adams et al. (1987) and IMF (1988). In both cases, a production function approach is used and some measure of unemployment consistent with stable inflation is estimated[14]. In addition, the IMF study makes use of the OECD business-sector data base.

However, there are important differences between the two methodologies. First, the IMF study includes only two factor inputs – labour and capital – in the aggregate production function whereas this study also takes account of energy. Second, the IMF estimates a non-accelerating inflation rate of unemployment (NAIRU) from an unemployment equation which includes several structural factors as explanatory variables. In contrast, the NAWRU estimates used here are generally derived from a Phillips-curve type of nominal wage equation. Third, the labour input in the OECD estimates is the trend labour force times one minus the NAWRU. The IMF method uses an equation linking the dependent variable, actual employment, to some demographic variables and to the gap between the actual unemployment rate and the NAIRU.

The latest IMF and OECD estimates of potential output growth for the total economy are compared in Table 4[15]. For the pre-1973 period, the IMF estimates are, on average, higher than those of the OECD. This reflects different estimates of TFP. In contrast, the OECD figures for the period 1973-79 show stronger potential output growth for all countries compared with IMF estimates. In the IMF study, an arbitrary rise in the scrapping rate was imposed for 1974, thereby reducing substantially capital stock growth. One advantage of the OECD approach is that it takes explicit account of the effects of energy price changes on the capital stock. For the 1980-87 period, the two sets of estimates are very similar. In general, both institutions give similar estimates for potential output growth for the projection period. However, in the case of Canada, the divergence is important, reflecting primarily differences in the estimated contributions of projected growth in the capital stock. The OECD projections also show stronger potential output growth in Germany, reflecting the positive effects on the labour force of the recent wave of immigration from Eastern Europe.

Table 4. IMF and OECD estimates of total-economy potential output growth[a]

	1966-73		1974-79		1980-87		1988-90[b]	
	IMF	OECD	IMF	OECD	IMF	OECD	IMF	OECD
United States								
Potential output	3.6	3.1	2.0	2.8	2.8	2.6	2.8	2.6
of which:								
Capital[c]	0.8	1.2	0.5	1.0	0.8	1.0	0.8	1.0
Labour	1.0	1.1	1.3	1.6	0.7	1.3	0.7	0.9
TFP	1.1	0.5	0.1	−0.2	1.0	0.2	1.0	0.5
Public sector	0.7	0.3	0.1	0.3	0.3	0.1	0.3	0.2
Japan								
Potential output	8.6	8.6	3.5	4.2	3.9	4.0	3.9	4.1
of which:								
Capital[c]	2.3	2.8	1.0	0.8	1.3	0.7	1.6	0.6
Labour	−0.3	0.6	0.7	0.7	0.3	1.0	−0.1	1.3
TFP	5.9	4.5	1.4	2.5	2.0	2.1	2.0	2.1
Public sector	0.7	0.7	0.2	0.3	0.3	0.2	0.4	0.1
Germany								
Potential output	4.5	4.0	1.5	2.4	2.2	2.3	2.1	2.5
of which:								
Capital[c]	1.0	1.4	0.5	0.9	0.7	0.9	0.7	1.0
Labour	−0.8	−0.2	−0.8	−0.4	−0.2	0.3	−0.8	0.5
TFP	3.7	2.4	1.5	1.6	1.4	1.0	1.9	0.9
Public sector	0.6	0.4	0.3	0.3	0.3	0.1	0.3	0.1
France								
Potential output	5.5	4.6	2.3	3.1	2.3	2.3	2.5	2.5
of which:								
Capital[c]	1.1	1.1	0.7	1.1	0.8	0.8	0.9	0.9
Labour	−0.1	0.2	−1.0	0.1	−0.6	0.1	−0.5	0.3
TFP	3.9	2.8	2.3	1.6	1.8	1.3	1.8	1.2
Public sector	0.6	0.4	0.3	0.3	0.3	0.2	0.3	0.0
Italy								
Potential output	5.1	4.6	1.4	3.6	3.0	2.7	2.6	2.9
of which:								
Capital[c]	1.0	1.5	0.6	1.0	0.8	0.8	0.6	1.1
Labour	−1.3	−0.4	−0.3	0.3	−0.1	0.3	−0.4	0.4
TFP	4.9	3.1	0.9	2.0	1.8	1.3	1.5	1.2
Public sector	0.5	0.4	0.2	0.3	0.5	0.2	0.5	0.2
United Kingdom								
Potential output	2.7	2.5	1.0	1.8	2.5	2.2	2.6	2.8
of which:								
Capital[c]	0.7	1.1	0.4	0.9	0.6	0.6	0.6	0.8
Labour	−0.9	−0.5	−0.8	−0.3	-0.3	0.2	−0.2	0.2
TFP	2.2	1.3	0.8	0.8	1.6	1.5	1.7	1.7
Public sector	0.7	0.6	0.6	0.3	0.6	−0.1	0.5	0.1
Canada								
Potential output	4.9	5.1	3.6	4.3	3.5	3.3	2.8	3.4
of which:								
Capital[c]	0.9	1.3	0.7	1.6	0.9	1.7	0.9	1.6
Labour	1.1	1.4	1.4	1.6	1.0	1.1	0.8	1.1
TFP	1.7	1.6	0.9	0.6	1.1	0.3	0.7	0.5
Public sector	1.2	0.8	0.6	0.5	0.5	0.3	0.4	0.2

a) The calculations are based on value-added data not gross output data as in Table 2.
b) 1988-92 for the IMF.
c) In order to make the two sets of estimates comparable. the contribution of the capital-energy bundle in the OECD calculations has been adjusted to exclude the effect of enerov.

CHART D

OUTPUT GAPS

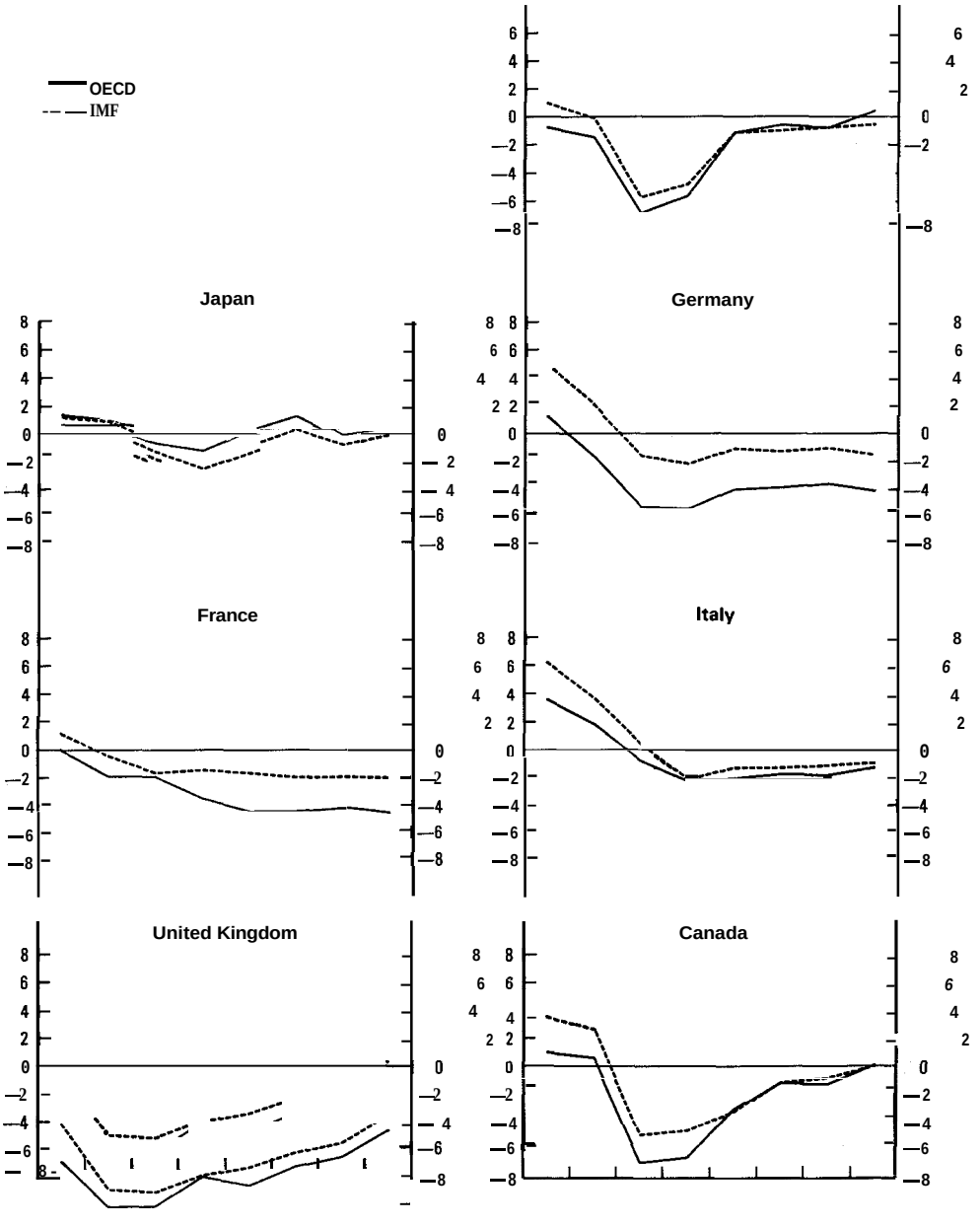


Chart D compares the IMF and OECD estimates of the gap variables over the period 1980-87. For all countries except Germany and France, both the levels and the fluctuations of the two series are very similar. For these two countries, the OECD series indicates a wider gap throughout the 1980s, owing to the fact that their NAWRUs are relatively low.

IV. SIMULATIONS OF TECHNICAL CHANGE AND PRODUCTIVITY GROWTH

In this section, the possible effects of changes in technical progress on macroeconomic performance are illustrated by means of an INTERLINK simulation of the outcomes of an exogenous increase in labour efficiency gains, a key determinant of potential output. Two main conclusions emerge from the simulation: first, faster technical progress increases output growth and yields employment gains in all major seven countries. Second, the responses of nominal wages and prices to increased productivity are key factors in explaining inter-country differences.

A. Channels of transmission from a change in technical progress to output, prices and employment

A rise in technical progress relative to baseline enhances labour efficiency and, for a given level of output, results in less labour input. However, this negative substitution effect on employment is offset by positive output effects which operate through two main channels:

i) Profitability increases relative to baseline to the extent that higher wages do not absorb all the gains in labour productivity[16]. Improved profitability leads to an increase in the desired level of output which firms wish to supply. It can also have positive effects on aggregate demand through the stimulus it gives to investment.

ii) Increased productivity serves to lower prices through two effects. First, it lowers unit labour costs directly. Second, as the rate of technical progress increases, the gap between actual and potential output widens, thereby exerting downward pressure on prices relative to baseline. These favourable effects on inflation in turn generate positive effects on consumption demand. Competitiveness also improves in relative terms in those countries where the productivity shock is strongest.

The magnitude of these positive output effects depends crucially upon the extent to which the benefits of higher productivity growth lead to lower price inflation relative to baseline rates, instead of being immediately absorbed by higher nominal wages.

B. Simulation results of faster technical progress in all countries

Table 5 shows the effects of a sustained rise in the labour efficiency index by 1 percentage point in each country. Real public expenditure is kept constant so as to ensure that there is no impact from fiscal policy compared with the baseline. Also, monetary policy is assumed to be non-accommodating (i.e. constant money supply, which could allow interest rates to fall) and the simulation was carried out in linked mode, but with fixed exchange rates.

The overall results show that increased labour efficiency leads to significant output and employment gains. This reflects on the one hand the positive effects of the rise in profitability on output supply and business investment and, on the other hand, the demand stimulus arising from price deflation. Below-average improvements in profitability occur in the United States and Canada, countries where the wage responses to increased productivity are relatively large. However, due to strong demand reactions to the fall in the price level, employment gains in these two countries are only slightly below average. By contrast, France shows the largest employment increases in line with the moderate response of real wages. In the goods market France is also an outlier: despite real-wage moderation, the price level falls less than in most of the other countries.

V. CONCLUDING REMARKS

This paper has outlined the concepts and methods used by the OECD to derive estimates of potential output for the major seven countries. It has also contrasted the OECD approach and estimates with those published recently by the IMF. The following broad conclusions emerge from this study:

- The OECD has developed a method which includes the major determinants of potential output in a consistent way, based on an aggregate three-factor production function. However, the method is sufficiently flexible to allow for judgement of country specialists about several key determinants of potential, in particular the path of technical progress and the measure of labour market equilibrium, as represented by the NAWRU.

Table 5. Effects of a labour efficiency growth increase (by 1 p.p.) in all countries

Deviations from baseline in per cent

	Years					
	1	3	5	1	3	5
	output			Private consumption		
United States	0.7	2.0	2.6	0.2	1.1	1.7
Japan	0.7	2.0	3.1	0.4	1.4	2.2
Germany	0.6	1.9	2.6	0.3	1.2	1.9
France	0.8	3.1	4.9	0.2	1.1	2.0
Italy	0.3	0.8	1.4	0.1	0.8	1.5
United Kingdom	0.5	1.1	2.2	0.2	0.9	2.0
Canada	0.3	1.3	2.3	0.2	1.0	1.8
	Prices			Private investment		
United States	−0.1	−0.5	−0.7	1.6	6.3	8.1
Japan	−0.4	−1.4	−2.6	0.5	2.7	4.7
Germany	−0.2	−1.4	−3.5	1.0	2.5	2.5
France	−0.3	−1.3	−1.7	1.2	6.0	9.7
Italy	−0.3	−1.5	−2.3	−0.2	−0.1	0.5
United Kingdom	−0.3	−1.9	−3.7	0.5	1.5	3.9
Canada	−0.2	−1.1	−2.0	0.2	1.6	4.2
	Employment			Real foreign balance		
United States	0.3	0.7	0.7	−0.0	−0.1	−0.4
Japan	0.2	0.5	1.0	0.0	0.2	0.3
Germany	0.1	0.7	0.7	−0.0	0.2	0.7
France	0.2	0.9	1.8	−0.1	−0.4	−0.7
Italy	0.1	0.4	0.6	0.0	0.2	0.2
United Kingdom	0.1	0.4	0.7	−0.1	0.2	0.2
Canada	0.2	0.6	0.8	0.0	0.2	0.3
	Real wages			Profitability		
United States	0.3	1.7	3.1	0.3	0.4	0.4
Japan	0.4	1.3	2.2	0.1	0.6	1.1
Germany	0.2	0.8	1.5	0.3	0.8	1.2
France	0.1	0.5	1.0	0.4	1.2	1.9
Italy	0.2	1.1	2.1	0.3	0.8	1.1
United Kingdom	0.2	0.9	1.7	0.2	0.8	1.4
Canada	0.2	1.3	2.4	0.3	0.6	0.7
	Labour efficiency index					
All countries	0.7	2.7	4.8			
	Productivity of labour					
United States	0.4	1.3	2.0			
Japan	0.5	1.5	2.1			
Germany	0.5	1.2	1.9			
France	0.6	2.1	3.0			
Italy	0.2	0.4	0.8			
United Kingdom	0.5	0.7	1.5			
Canada	0.1	0.7	1.5			

- Applying this methodology provides a set of estimates of potential output which are consistent with stable inflation over the medium term.
- The ratio between actual and potential output of the business sector, a measure of capacity utilisation, is found to be positively correlated with price inflation and enters significantly into the price equations in INTERLINK. While the gap is only weakly correlated with the growth of import penetration, there appears to be a much stronger association with changes in the gap.
- The OECD and IMF estimates of potential output growth and capacity utilisation are similar.

NOTES

1. See Richardson (1988) for a recent review of the structure and properties of OECD's world macroeconomic model INTERLINK.
2. See Christiano (1981) for an extensive review of the various concepts and methods of measurement. See also many of the articles in Bosworth and Heathfield (1987).
3. The supply blocks for the smaller countries in INTERLINK are somewhat simpler, being based on a two-factor – capital and labour – aggregate production function. See Torres et *al.* (1989) for details.
4. The exact definition of the capital-energy bundle (KEBSV) can be found in Helliwell et al. (1986). KEBSV can be expressed as follows:

   KEBSV = g [KEBSV(-1); IBV; KBV(-1); PENB/UCC; retrofitting parameter: inner elasticity of substitution]

   where IBV is business fixed investment, KBV is business capital stock, and PENB/UCC is the price of energy relative to the user cost of capital. The partial derivatives of KEBSV with respect to its arguments are all positive except for PENB/UCC and KBV(-1). The partial derivative with respect to relative energy prices is negative. The partial derivative with respect to the lagged capital stock is positive if the retrofitting parameter is non-zero; there is no effect if the retrofitting parameter is zero.
5. If relative energy prices rise (fall), energy requirements fall (rise) relative to a given capital stock input; therefore a change in the relative price of energy produces a change in the opposite direction in the capital-energy bundle. In that sense, the "putty/semi-putty" structure is equivalent to a production structure without energy but with a capital stock whose scrapping [ate would vary with relative energy prices.
6. Total factor productivity (TFP) growth is defined as that portion of real output growth which is not accounted for by increases in the capital/energy bundle and labour inputs. Because technical progress is assumed to be labour-augmenting, TFP growth is approximately equal to labour efficiency growth times the labour share. TFP growth is defined as:

   $\dot{TFP} = \dot{QBSV} - [a\ \dot{ETB} + (1-a)\ \dot{KEBSV}]$

   where a represents approximately the labour share: and a "dot" over a variable denotes a growth rate. Substituting equation [1] in the text into the above definition and then totally differentiating yields:

   $\dot{TFP} = a\ \dot{ELEFF}.$
7. In previous work on the supply blocks, technical progress was treated differently. Given that the United States has the highest level of TFP (measured at purchasing power parities) among the OECD countries, a "catch-up" hypothesis, with reference to technical progress in the other countries, was incorporated in the estimation of the supply blocks. Specifically, the rates of growth of labour efficiency in the other countries were assumed

to converge eventually to the U.S. rate, which was taken to be exogenous. There is a detailed discussion of the "catch-up" hypothesis in Helliwell *et* a/. (1986). This approach was abandoned because it was found to give unsatisfactory results in practice.

8. The Prescott method selects the trend path which minimises the sum of the squared deviations from the series in question subject to the constraint that the sum of the squared second differences is not larger than a certain factor. For further details, see Prescott (1986).

9. See Chan-Lee *et* a/. (1987) for a summary of the empirical work underlying the model's wage equations, and Stiehler (1987) for the price equations.

10. This holds under the assumption that real interest rates and real energy prices are constant in long-run equilibrium.

11. Combining equations [2] and [4], assuming $\dot{p}_c^e = p$, and solving it for the unemployment rate consistent with stable wage inflation gives the NAWRU as follows:

NAWRU $= -(ELEFF - a_0 - a_2 \bar{Z}) / a_1$,

where $\bar{Z}$ represents the equilibrium values taken by the Z variables.

12. An additional condition is that capital stock be fully utilised in long-run equilibrium.

13. INTERLINK's import volume equations include the ratio of current total domestic demand to a moving-average of current and past total domestic demand. Such a variable is used as a proxy for capacity utilisation.

14. Adams and Coe (1989) have extended the IMF methodology recently in research applied to U.S. data. In this approach, the natural rate of unemployment and potential output are estimated jointly via a set of simultaneous equations. Their estimated growth rates of potential output and the gap are very similar to those presented here.

15. The contribution of changes in the energy input has been subtracted from the capital-energy bundle in the OECD calculation. Therefore, Table 4 shows the specific contribution of the capital stock alone for both sets of estimates.

16. Profitability is proxied in the model by the ratio of business sector output prices (PQB) to the dual cost of the production function (CKEL). CKEL is approximately equal to a weighted average of input prices minus total factor productivity (the labour efficiency index times the labour share). Hence, when real factor prices remain constant, a rise in technical progress leads to an increase in PQB/CKEL.

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