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An Investment-Function-Based Measure of Capacity Utilisation. Potential Output and Utilised Capacity in the Bank of Italy's Quarterly Model

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SINTESI

Il contenuto di questo lavoro esprime solamente le opinioni degli autori, pertanto esso non rappresenta la posizione ufficiale della Banca d'Italia.

Negli ultimi anni si è andato sempre più diffondendo il ricorso a indicatori sintetici del divario tra il livello effettivo di attività e la massima capacità produttiva possibile (ovvero economicamente conveniente) per rispondere a diverse finalità conoscitive: valutare i rischi di accelerazione dei prezzi derivanti da scostamenti tra la domanda e l'offerta aggregate nel breve periodo; quantificare, in un'ottica di più lungo periodo, quale possa essere il ritmo sostenibile di sviluppo; depurare il saldo di bilancio del settore pubblico della componente associata a oscillazioni cicliche intorno al sentiero di crescita di equilibrio.

L'approccio proposto in questo lavoro per costruire una misura dello scostamento tra output potenziale ed effettivo sfrutta le caratteristiche dell'equazione che descrive le scelte di investimento nell'ambito del modello econometrico trimestrale della Banca d'Italia: poiché la funzione di investimento esprime il tradursi dell'incremento desiderato di capacità produttiva in accumulazione di capitale, eliminando gli effetti del prezzo relativo dei fattori della produzione sulle scelte di investimento è possibile costruire un indicatore della capacità produttiva coerente con lo stock di capitale disponibile e, più in generale, con i comportamenti delle imprese come descritti nell'ambito del modello trimestrale.

I risultati, riferiti al periodo 1970-1997, tracciano un quadro ciclico non dissimile da quello ottenibile con approcci di comune impiego, quali ad esempio il filtro di Hodrick e Prescott o l'interpolazione dei picchi di utilizzo della capacità produttiva (metodo Wharton). L'indicatore proposto risulta correlato, in misura relativamente elevata, sia con il tasso sia con la variazione dell'inflazione (in termini di deflatore dei consumi e di deflatore del valore aggiunto del settore privato); le sue proprietà, in particolare per quel che riguarda l'adeguamento della capacità produttiva a un incremento permanente nel livello della domanda, appaiono nel complesso plausibili.

Il lavoro presenta inoltre un confronto tra alcuni indicatori della capacità produttiva utilizzata e dell'*output gap* disponibili per l'economia italiana, sviluppati da diverse istituzioni italiane (ISAE) e internazionali (FMI, OCSE, CE). Benché le modalità di

costruzione delle diverse misure poste a confronto siano molto differenti tra loro, e diverso sia l’aggregato di riferimento, il quadro ciclico tratteggiato dai vari indicatori è in generale assai simile, con l’unica eccezione della misura pubblicata dall’ISAE, basata sui risultati di indagini campionarie condotte presso le sole imprese manifatturiere.

AN INVESTMENT-FUNCTION-BASED MEASURE OF CAPACITY UTILISATION. POTENTIAL OUTPUT AND UTILISED CAPACITY IN THE BANK OF ITALY'S QUARTERLY MODEL

by Giuseppe Parigi* and Stefano Siviero*

Abstract

Measures of potential output and the output gap are increasingly being developed and used to concisely quantify and monitor the risk of price accelerations stemming from rises in aggregate demand that are not met by a corresponding increase in supply. They often play a prominent role in the price determination mechanisms of macroeconometric models.

In this paper we build a measure of potential private-sector value added for the Italian economy that is consistent with the capital accumulation process in the Banca d'Italia's Quarterly Model — and more generally with the rest of the supply-side block of that model. More specifically, we exploit the fact that the investment function can be thought of as a relationship transforming desired gross additions to capacity output into capital accumulation by means of a conversion factor (the optimal capital/output ratio). Thus, if one removes the component of investment decisions that stems from changes in the relative price of the production factors (i.e., in the optimal capital/output ratio), then a measure of the desired gross addition to capacity may be constructed. The results draw a cyclical picture of the degree of capacity utilisation for the period 1970-1997 that is roughly in line with those produced by the Wharton and Hodrick-Prescott filter approaches, as well as with the pictures resulting from the ISAE, IMF, European Commission and OECD measures of the output gap. Our investment-function-based measure appears to be a promising indicator of the pressure exerted on prices by demand accelerations. Its empirical properties are, on the whole, acceptable and plausible.

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Contents

1. Introduction[1]

Measures of potential output and the output gap are increasingly being developed and used to concisely quantify the risk of price accelerations stemming from rises in aggregate demand that are not met by a corresponding increase in supply. The extensive use of the difference between actual and potential output (the so-called output gap) is based on the intuition, long held in the economic literature, that there exists a (short-run) trade-off between the inflation rate and the growth rate of output.

In the view of the important role of these indicators in signalling demand-driven inflationary pressures, the task of measuring potential output — and hence the output gap — has been tackled from a variety of viewpoints, using a large range of techniques and relying on a variety of different assumptions. Proposed potential output measures range from "engineering" to "economic" ones, and the approaches that have been developed in order to build empirical measures of capacity output range from those that emphasise the statistical aspects to those that, at the opposite end of the spectrum, mostly rely on the relationships postulated by the economic theory. A very extensive, systematic survey can be found in Christiano (1981); a more recent discussion, focusing on the comparison and integration of statistical and economic approaches may be found in St-Amant and van Norden (1996).

In this paper we focus on the role of potential output in structural macroeconometric modelling; more specifically, we address the issue of how consistency may be imposed between capacity utilisation measures and the rest of the supply-side block in the Banca d'Italia's Quarterly Model (henceforth, BIQM).[2]

Estimates of potential output play a prominent role in most macroeconometric models: a level of capacity utilisation above its equilibrium value is usually an important factor in

[1] Helpful comments from Filippo Altissimo, Albert Ando, Andrea Brandolini, Alberto Locarno, Marco Magnani and an anonymous referee are gratefully acknowledged. The usual disclaimer applies. The views expressed in this paper are the authors' own and do not necessarily reflect those of the Bank of Italy.

[2] For a detailed presentation of the Banca d'Italia's Quarterly Model see Banca d'Italia (1986). A discussion of the main features of a more recent version of the model is given in Terlizzese (1994).

causing price and wage inflation, together with gaps in other markets, such as, for instance, the labour market (reflected by the Phillips curve).

The BIQM is no exception: the degree of capacity utilisation is an important driving force in several equations of the model, its most significant role being that of a proxy for the pressure that increases in aggregate demand put on the whole price determination process. Specifically, disequilibria in the goods market signalled by a rise in utilised capacity above its equilibrium level exert their effects through two main channels: first, consistently with the oligopolistic competition scheme adopted in the BIQM, firms apply a mark-up over unit labour costs that is positively correlated with the pressure exerted by aggregate demand (the latter being captured by the divergence between actual and potential value added in the private non-farm, non-energy sector); second, the degree of utilised capacity also plays a role in the Phillips curve — as a proxy for changes in the vacancy rate: an increase in demand above supply raises wages temporarily.

In the BIQM framework, the private-sector potential value added used to be measured by the peak-to-peak interpolation procedure, known as the Wharton method. Potential value added was then modelled as an (unconstrained) distributed lag over past actual value added.

There were a number of reasons for dissatisfaction with that solution. In the first place, the Wharton method is known to be subject to several drawbacks, mostly related to the arbitrary treatment of the starting and ending points of the available sample, where the position of the adjacent peaks must be somehow assumed. Furthermore, such an approach has a clear disadvantage in that potential value added is not guaranteed to be consistent with the rest of the supply side of the BIQM: while the demand of production factors is jointly determined from the first order conditions for cost minimisation within a putty-clay scheme, and the value added deflator is modelled as a mark-up over unit labour costs, potential output is related neither to the putty-clay specification of the production function nor to the available capital and labour inputs.

Several past attempts were made to improve the internal consistency of the supply block, extending the putty-clay structure to cover potential supply as well (see, e.g., Gavosto and Pellegrini (1994)).

This paper documents a simple solution to that issue, based on exploiting the features of the estimated investment function to construct a measure of potential value added and hence of the degree of capacity utilisation.[3]

The paper is organised as follows: Section 2 derives the logarithmic formulation of the investment function equation used to produce the empirical results presented in this paper, and briefly discusses the properties of the estimates of that equation. Section 3 examines, within a stripped-down theoretical framework, how an estimated investment function may be used to compute a measure of capacity utilisation. The basic intuition is that, since capital accumulation is proportional to the desired increase in capacity output for given relative prices of the production factors, the investment function may be used to provide an estimate of the latter once one eliminates the effects due to changes in relative factor prices. It is then shown that the numerical estimate of utilised capacity obtained with the proposed procedure is fairly robust and is not significantly affected by changes in the assumptions. The investment-function-based (IFB hereafter) measure of capacity output is then compared against two measures widely used in the literature: the Hodrick-Prescott filter and the Wharton measure (previously in use in the BIQM). All three indicators draw a roughly similar cyclical picture for the period from 1970 to 1997. Our measure appears to be a promising indicator of the pressure exerted on prices by rises in demand, its correlation with inflation and price acceleration being generally higher than that associated with the other two measures. Section 4 compares several alternative indicators of utilised capacity and the output gap available for the Italian economy. In interpreting the results one should bear in mind that, while the measure constructed in this paper refers to the private non-farm, non-energy-sector, those examined in Section 4 concern either a more narrowly defined sector (as in the case of the ISAE survey-base measure of capacity utilisation for the manufacturing sector) or the whole of GDP (as in the case of the European Commission, IMF and OECD measures). Section 5 concludes.

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[3] A similar method was proposed by Hickman (1964).

2. The investment function: specification and estimation

In this section we derive and estimate a logarithmic formulation of the investment function, following closely the approach adopted in Nickell (1979). In that work, the estimated equation was derived as an approximate specification of capital accumulation behaviour around a stationary state equilibrium, given a putty-clay setting. A similar relationship will be shown to hold, except for minor adjustments, along a steady-state growth path too.

While the route followed by Nickell (1979) explicitly assumes that investment installed in period *t* is given by the sum of investments installed by firms facing delivery lags of *i* periods, for $i = 0, 1, ..., n$, the approach we follow does not use that assumption. The distributed lag specification which we derive and estimate may be interpreted as stemming from either the existence of delivery lags or from the process of expectations formation, or from a combination of the two.

From first-order conditions for cost minimisation (with a Cobb-Douglas production function and assuming a putty-clay nature of technology), gross investment in period *t* is proportional to the desired gross additional capacity output that, given the information available as of the beginning of period *t* (output of period *t* is assumed not to be known at the beginning of the period), is planned to be produced between periods *t* and *t*+1 ($(Y^d_{t+1|t} - (1-\delta)Y^d_{t|t})$, where δ is the depreciation rate, Y denotes output and $t+i|t$ denotes expectations as of the beginning of period *t*). The factor of proportionality is given by the optimal capital / output ratio associated with the labour and capital costs that are expected to prevail for the time span during which those capital goods will be in use ($k_{t+1|t}$). Hence we may write:[4]

(2.1) $$I_t = k_{t+1|t}[Y^d_{t+1|t} - (1-\delta)Y^d_{t|t}].$$

Denoting the steady-state rate of growth of output with *g*, eq. (2.1) gives the following expression for the level of investment along the steady-state growth path:

[4] Note that we assume that investment in period *t* will contribute to the production process starting with the following period.

(2.2) $$I_t^{ss} = k^{ss} Y_{t+1}^{ss} \left(\frac{g+\delta}{1+g} \right)$$

where '*ss*' denotes steady-state values. The optimal capital / output ratio, k^{ss}, is obviously constant along any steady-state equilibrium growth path.

We next postulate that, given the existence of delivery lags and under the hypothesis that the process of expectations formation is adaptive, the desired gross capacity output and the expected optimal capital / output ratio may be written as:

(2.3) $$k_{t+1|t} = \sum_{i=0}^{m} \chi_i k_{t-i}$$

(2.4) $$Y_{t|t}^d = \sum_{j=0}^{m} \eta_j Y_{t-j} (1+g)^j , \qquad \eta_0 = 0 .$$

We further formulate the simplifying assumption that expectations concerning desired capacity output in period *t*+1 are generated under the assumption that output resumes growing at its steady-state growth rate, and hence $Y_{t+1|t}^d = Y_{t|t}^d (1+g)$.[5]

In order for eq. (2.1) above to hold, the following constraints must be imposed:

(2.5) $$\sum_{i=0}^{m} \chi_i = 1$$

(2.6) $$\sum_{j=0}^{m} \eta_j = 1 .$$

Taken together, eqs. (2.5) and (2.6) imply that $\sum_{i=0}^{m} \sum_{j=0}^{m} \chi_i \eta_j = 1$. Substituting eqs. (2.3) and (2.4) into eq. (2.1), the following expression is obtained:

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[5] Should one assume that $Y_{t+1|t}^d$ is generated similarly to $Y_{t|t}^d$, by means of eq. (2.4) (where Y_t has to be replaced by $Y_{t|t}^d$), then an equation similar to eq. (2.10) is obtained, except that the expression for the constant term is somewhat different.

$$(2.7)\qquad I_t = \sum_{i=0}^{m}\sum_{j=0}^{m}\chi_i\eta_j k_{t-i}[Y_{t-j}(1+g)^{j+1} - (1-\delta)Y_{t-j}(1+g)^{j}].$$

The expedient exploited in Nickell (1979) in order to arrive at a logarithmic formulation of the investment equation requires expressing eq. (2.7) in terms of deviations from the steady-state growth-path level of investment. To that end, subtract I_t^{ss} (as defined in eq. (2.2)) from both sides of eq. (2.7) and then divide the resulting expression by I_t^{ss}:

$$(2.8)\qquad \frac{I_t}{I_t^{ss}} - 1 = \sum_{j=0}^{m}\ \sum_{i=0}^{m}\chi_i\eta_j\left[\frac{k_{t-i}Y_{t-j}(1+g)^{j+1}}{k^{ss}Y_{t+1}^{ss}}\left(\frac{1+g}{g+\delta}\right) - (1-\delta)\frac{k_{t-i}Y_{t-j}(1+g)^{j}}{k^{ss}Y_{t+1}^{ss}}\frac{(1+g)}{(g+\delta)} - 1\right].$$

Since $\left(\frac{1+g}{g+\delta}\right) - \left(\frac{1-\delta}{g+\delta}\right) = 1$, eq. (2.8) simplifies to:

$$(2.9)\qquad \frac{I_t}{I_t^{ss}} - 1 = \sum_{j=0}^{m}\ \sum_{i=0}^{m}\chi_i\eta_j\left[\left(\frac{k_{t-i}Y_{t-j}(1+g)^{j+1}}{k^{ss}Y_{t+1}^{ss}} - 1\right)\right].$$

Using the approximation $\frac{x_t}{x_t^*} - 1 \approx \ln(\frac{x_t}{x_t^*})$, which holds if x_t is close enough to x_t^*, and solving for $\ln(I_t)$, eq. (2.9) may be written as follows (recall eq. (2.2) above):

$$(2.10)\qquad \ln(I_t) = \ln\left(\frac{g+\delta}{1+g}\right) + \sum_{j=0}^{m}\eta_j\ln(1+g)^{j+1} + \sum_{i=0}^{m}\chi_i\ln(k_{t-i}) + \sum_{i=0}^{m}\eta_j\ln(Y_{t-j})\ .$$

The coefficients in both ln(k) and ln(Y) sum to unity, so that investment is homogeneous of degree one with respect to both output and the optimal capital / output ratio. The steady-state solution for investment in eq. (2.10) can be verified to be the same as in eq. (2.2). In addition, note that for g = 0 the constant term becomes the same as in Nickell (1979); for $g \neq 0$, the constant does not depend solely on the rate of depreciation but is also a (complicated) function of the steady-state rate of growth of output.

For estimation, an ECM specification consistent with eq. (2.10) above was formulated (see Parigi (1998) for more details about the relationships between the two formulations; see also Section 3 below):[6]

(2.11) $$\Delta \ln I_t = \vartheta + \sum_{i=1}^{16} \nu_i \Delta \ln k_{t-i} + \sum_{i=1}^{16} \pi_i \Delta \ln Y_{t-i} - \gamma\left(\ln I_{t-1} - \ln Y_{t-1} - \ln k_{t-1}\right) + \chi f(\Delta bc_t) + \eta dummies + \varepsilon_t \,.$$

Compared with eq. (2.10), eq. (2.11) includes a number of additional regressors: the change in the business confidence index bc_t (which seeks to capture the effects of expectations on accumulation and also proxies for the impact of uncertainty on investment decisions[7]) and dummy variables (including one for periods in which administrative constraints on credit were imposed). For both the distributed lag of the optimal capital / output ratio and for that of output, a maximum lag n=16 was chosen, requiring the coefficients to lie along a 2nd-degree Almon polynomial.

Eq. (2.11) was estimated using data for the period 1974.Q1 to 1995.Q4; observations from 1996.Q1 to 1998.Q1 (for a total of 9 quarters) were used to test for the stability of the estimated relationship. Detailed information on the data used in estimation is given in Appendix A.

The results of OLS estimation are shown in Table 2.1, where IMANEAR is the private non-farm, non-energy sector equipment investment at constant prices, VACNERD is value added at constant prices in the same sector, KSTAR is the optimal capital / output ratio, CLIMA is an index of business confidence, CREDRAT is a measure of credit rationing in periods in which administrative restrictions on credit were imposed, and finally DUTREM is a dummy for fiscal incentives (the so-called “Tremonti Law”, from 1994.Q3 to 1995.Q4).

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[6] For a discussion of the dynamic structure of the logarithmic formulation of the investment equation see also Nickell (1979).

[7] On the role of uncertainty in investment decisions see Guiso-Parigi (1999).

Table 2.1

ESTIMATES OF THE EQUIPMENT INVESTMENT FUNCTION IN THE BIQM
(dependent variable: $\Delta \log IMANEAR$)

Regressor	Coefficient	Coefficient value	t-ratio
Constant	θ	-0.247	4.280
$\ln IMANEAR_{-1}$	γ_1	-0.186	4.245
$\ln KSTAR_{-1}$	γ_2	0.186	4.245
$\ln VACNERD_{-1}$	γ_3	0.186	4.245
$\Delta\ln KSTAR_{-1}$	ν_1	-0.070	1.383
$\Delta\ln KSTAR_{-2}$	ν_2	-0.087	1.915
$\Delta\ln KSTAR_{-3}$	ν_3	-0.101	2.410
$\Delta\ln KSTAR_{-4}$	ν_4	-0.111	2.817
$\Delta\ln KSTAR_{-5}$	ν_5	-0.119	3.112
$\Delta\ln KSTAR_{-6}$	ν_6	-0.124	3.301
$\Delta\ln KSTAR_{-7}$	ν_7	-0.125	3.407
$\Delta\ln KSTAR_{-8}$	ν_8	-0.124	3.456
$\Delta\ln KSTAR_{-9}$	ν_9	-0.119	3.469
$\Delta\ln KSTAR_{-10}$	ν_{10}	-0.111	3.459
$\Delta\ln KSTAR_{-11}$	ν_{11}	-0.101	3.438
$\Delta\ln KSTAR_{-12}$	ν_{12}	-0.087	3.410
$\Delta\ln KSTAR_{-13}$	ν_{13}	-0.070	3.379
$\Delta\ln KSTAR_{-14}$	ν_{14}	-0.050	3.347
$\Delta\ln KSTAR_{-15}$	ν_{15}	-0.026	3.316
$\Delta\ln KSTAR_{-16}$	ν_{16}	0.000	-
	$\Sigma\nu_i$	-1.423	3.249
$\Delta\ln VACNERD_{-1}$	π_1	0.393	3.360
$\Delta\ln VACNERD_{-2}$	π_2	0.406	3.988
$\Delta\ln VACNERD_{-3}$	π_3	0.413	4.422
$\Delta\ln VACNERD_{-4}$	π_4	0.415	4.572
$\Delta\ln VACNERD_{-5}$	π_5	0.411	4.484
$\Delta\ln VACNERD_{-6}$	π_6	0.402	4.271
$\Delta\ln VACNERD_{-7}$	π_7	0.387	4.021
$\Delta\ln VACNERD_{-8}$	π_8	0.366	3.779
$\Delta\ln VACNERD_{-9}$	π_9	0.340	3.563
$\Delta\ln VACNERD_{-10}$	π_{10}	0.308	3.374
$\Delta\ln VACNERD_{-11}$	π_{11}	0.271	3.212
$\Delta\ln VACNERD_{-12}$	π_{12}	0.228	3.073
$\Delta\ln VACNERD_{-13}$	π_{13}	0.179	2.952
$\Delta\ln VACNERD_{-14}$	π_{14}	0.125	2.848
$\Delta\ln VACNERD_{-15}$	π_{15}	0.065	2.757
$\Delta\ln VACNERD_{-16}$	π_{16}	0.000	-
	$\Sigma\pi_i$	4.709	4.349
$\Delta CLIMA_{-1}$	χ	0.326	5.086
CREDRAT	η_1	-0.038	3.758
DU79Q3-DU93Q1-DU93Q2	η_2	0.090	6.602
DUTREM	η_3	0.024	2.255

Sample: 1974.Q2-1995.Q4; $R^2 = 0.722$; $\bar{R}^2 = 0.689$; $\sigma = 0.0215$; $DW = 1.865$; ECM restriction ($\gamma_1 = -\gamma_2; \gamma_1 = -\gamma_3$): $F_{2,75}$ = 1.550 [p-value = 0.22]; Normality: $\chi_3^2 = 2.29$ [p-value = 0.51]; Autocorrelation: Lagrange: $F_{4,73}$ = 1.717 [p-value = 0.16]; Ljung-Box: $\chi_8^2 = 2.29$ [p-value = 0.32]; Stability: Chow (1996.Q1-1998.Q1): $F_{9,86}$ = 0.336 [p-value = 0.97]. Coefficients of both $\Delta\ln KSTAR$ and $\Delta\ln VACNERD$ were estimated as Almon polynomials of degree 2; the coefficient at lag 16 was constrained to be zero in both cases.

All coefficients are significant and have the expected sign and all restrictions are accepted. The estimates do not present signs of mispecification. Specifically, the results of the out-of-sample predictive Chow test over the period 1996.Q1-1998.Q1 are fully satisfactory. Due to the presence of the lagged dependent variable, the adjustment towards equilibrium is clearly much longer than the maximum lag on output and the optimal capital / output ratio. In both cases, the pattern of the adjustment path is consistent with *a priori* expectations.

Further details on the properties of the estimated investment function may be found in Parigi (1998), where particular care is devoted to the issue of constructing the appropriate cost of capital series used to compute the optimal capital / output ratio (specifically, the appropriate treatment of fiscal factors is addressed in detail).

3. Investment-function-based estimates of capacity output for the private non-farm, non-energy sector

In this section we use the empirical estimates of the investment function presented in Section 2 to construct a measure of potential output and hence of utilised capacity. We first present the basic intuition behind our approach, and then show how it may be adapted to fit the actual features of the estimated investment equation and discuss the main properties of the empirical measure of capacity output. Next, we conduct a number of sensitivity analyses to examine how the results are affected by changes in the assumptions. We then compare the new potential output and utilised capacity measures with the Wharton measure previously used in the BIQM, as well as with the results obtained with the Hodrick-Prescott filter. Both the cyclical pictures that emerge from the different measures and their reactions to a shock to actual output are examined. In doing so, some information is provided on the role played by the degree of capacity utilisation within the framework of the BIQM.

3.1 Set-up and main results

Within a putty-clay framework, investment is proportional to the desired increase in output, the factor of proportionality being a function of the relative price of labour and capital (see eq. (2.1)).

Intuitively, then, any gross addition to capacity output desired to take place between any two periods is translated, by means of a conversion factor (the optimal capital / output ratio, corresponding to the relative price expected to prevail at the time when the investment decision is made), into the amount of new gross fixed capital needed to produce the desired gross additional output.

Thus, if one eliminates the effects due to changes in production factor costs from the observed investment series, one can derive an estimate of the (directly unobservable) desired changes in capacity output consistent with the way in which the latter are reflected in investment decisions. It is important to observe that the concept of potential output, and hence capacity, used here is a cost concept. According to Hickman (1964, p. 535), “it is usually defined as that output which can be produced at minimum average cost, given the existing physical plant and organisation of production and the prevailing factor prices”:

Let us first consider a special case in which there is no delivery lag and no adaptive component in expectations, so that there are no distributed lags in the investment equation. In that case one has:

(3.1) $$I_t = k_t \Delta Y_{t,t+1}^d = k_t [Y_{t,t+1} - (1-\delta) Y_t]$$

where $\Delta Y_{t,t+1}^d$ identifies the desired gross addition to capacity between periods t and t+1. The optimal capital / output ratio k_t may thus be interpreted as a conversion factor that transforms $\Delta Y_{t,t+1}^d$ into the amount of new gross physical capital.

This means that if we set $k_t = 1$ we obtain a measure of the desired gross addition to capacity implied by investment behaviour as the latter is modelled in the investment equation:

(3.2) $$\Delta Y_{t,t+1}^d = [Y_{t,t+1} - (1-\delta) Y_t].$$

To adapt this basic intuition to the empirical investment function estimated in Section 2 above, it is convenient to re-write the ECM formulation of eq. (2.11) as an (infinite) distributed lag of all predetermined variables:

(3.3) $$\Delta \ln I_t = \vartheta + \sum_{i=1}^{n} \nu_i \Delta \ln k_{t-i} + \sum_{i=1}^{n} \pi_i \Delta \ln Y_{t-i} - \gamma\left(\ln I_{t-1} - \ln Y_{t-1} - \ln k_{t-1}\right) + \eta x_t + \varepsilon_t$$

where x_t is an (m×1) vector that includes all 'other' predetermined variables (i.e., other than the optimal capital / output ratio and output itself), and thus η is a (1xm) parameter vector.

After some tedious algebra, we can re-write the equation above as follows:

(3.4) $$\ln I_t = \sum_{i=0}^{\infty} \varphi_i \ln k_{t-i} + \sum_{i=0}^{\infty} \psi_i \ln Y_{t-i} + \sum_{i=0}^{\infty} \mu_i x_{t-i} + \sum_{i=0}^{\infty} \lambda_i \varepsilon_{t-i} + \xi$$

where:

$$\begin{aligned}
&\varphi_0 = \nu_0 \\
&\varphi_1 = \nu_0(1-\gamma) + (\nu_1 - \nu_0 + \gamma) \\
&\ldots \\
&\varphi_i = \varphi_{i-1}(1-\gamma) + (\nu_i - \nu_{i-1}) \\
&\ldots \\
&\psi_0 = \pi_0 \\
&\psi_1 = \pi_0(1-\gamma) + (\pi_1 - \pi_0 + \gamma) \\
&\ldots \\
&\psi_i = \psi_{i-1}(1-\gamma) + (\pi_i - \pi_{i-1}) \\
&\ldots \\
&\xi = \vartheta / \gamma \\
&\mu_i = \eta(1-\gamma)^i \\
&\lambda_i = (1-\gamma)^i \\
&\sum_{i=0}^{\infty} \varphi_i = \sum_{i=0}^{\infty} \psi_i = 1.
\end{aligned}$$

In computing the IFB measure of capacity output proposed in this paper, one should perform the infinite sums in eq. (3.4). Since that is obviously not feasible in practice, the cut-off point was set at *r*=40 in all empirical computations below. This choice (whose impact on the final results will be assessed, together with the effects of other assumptions, in Section 3.2 below) was made on the basis of an examination of the estimated coefficients of the investment function: in particular, all coefficients in eq. (3.4) are very close to zero for lags greater than 40 periods, and the 40th coefficient is never greater than 1/60 of the first (and largest) one in all infinite sums. As shown below, a lower cut-off point would probably suffice, in that the empirical results would not be significantly affected. It should be mentioned that the choice made here (*r*=40) is the highest lag compatible with being able to compute the capacity output measure starting from the first quarter of 1970, given the length of the available time series.

One further issue needs to be solved, namely how to handle the ‘other’ predetermined variables (i.e., the vector x_t), which do not appear in the stripped-out basic theoretical approach outlined at the beginning of this section. Two different routes seem to be feasible:

(a) neglect all ‘other’ predetermined variables, as well as the error term, in computing the measure of capacity output. In this case, it would appear sensible to replace them, for each period, by their sample average (the latter would obviously amount to zero for the error terms, given that the equation includes a constant terms and was estimated by means of OLS), so that all factors which, according to the investment equation, had an impact on capital accumulation are allowed to exert only their average effect, period after period, on the series of capacity output;

(b) retain all the variables on the right-hand side of eq. (3.4) in computing the increase in capacity output.

Both options were experimented. In particular, option (b) was assumed in building the benchmark measure of capacity utilisation. Sensitivity analysis was then performed to verify the results that would be produced following option (a).

While the main intuition of our approach is that the increase in capacity output can be computed from the investment equation once the optimal capital / output ratio is set equal to unity in all periods, it should be noted that the numerical value of k depends on a number of variables that are only available as index numbers. Thus, the actual numerical level of k is obviously arbitrary, and therefore it differs from the theoretical concept of the optimal capital / output ratio (k^T). The ratio between the two will in general depend on the base year of the available data.[8]

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[8] To see that the actual value of k is arbitrary, recall, e.g., that the optimal capital / output ratio is an increasing function of the ratio between the (trend) cost of labour per unit of output and the cost of capital. The (trend) cost of labour per unit of output is in turn given by the ratio between compensation per employee and trend productivity; thus, depending on the base year in which the trend is initialised, the entire k series will be scaled either upwards or downwards.

In general, a relationship of the following kind will therefore hold between the two (theoretical and empirical) measures of the optimal capital / output ratio:

(3.5) $$k_t = \omega k_t^T .$$

The parameter ω may be identified by requiring consistency between the steady-state level of investment computed according to eq. (3.4) and the steady-state value that may be derived from the capital accumulation relationship. The latter is given by (see eq. (2.2) above):

(3.6) $$I_t^{ss} = \frac{g+\delta}{1+g} k^{T,ss} Y_t^{ss} .$$

Along a steady-state growth path, substituting k_t with ωk_t^T (see eq. (3.5) above), eq. (3.4) gives the following expression for the steady-state level of investment:

(3.7) $$\ln\left(I_t^{ss}\right) = \xi + \ln\omega + \ln\left(k^{T,ss}\right) + \ln\left(Y_t^{ss}\right) + \ln(1+g)\sum_{i=0}^{\infty}\psi_i \cdot i + \sum_{i=0}^{\infty}\mu_i x^{ss} + \sum_{i=0}^{\infty}\lambda_i \varepsilon^{ss} .$$

Since we require eqs. (3.6) and (3.7) to be consistent in the steady state, we may derive the following expression for the parameter ω:

(3.8) $$\omega = \exp\left\{\ln\left(\frac{g+\delta}{1+g}\right) - \xi - \ln(1+g)\sum_{i=0}^{\infty}\psi_i i - x^{ss}\sum_{i=0}^{\infty}\mu_i - \varepsilon^{ss}\sum_{i=0}^{\infty}\lambda_i\right\}.$$

In other words, setting $k_t = 1$ in the theoretical stripped-down model spelled out at the beginning of this section amounts to setting $k_t = \omega$ in empirically computing the measure of capacity output, in that, for that value of the optimal capital / output ratio, the steady-state value of investment coincides with the value that may be computed from the capital accumulation relationship.

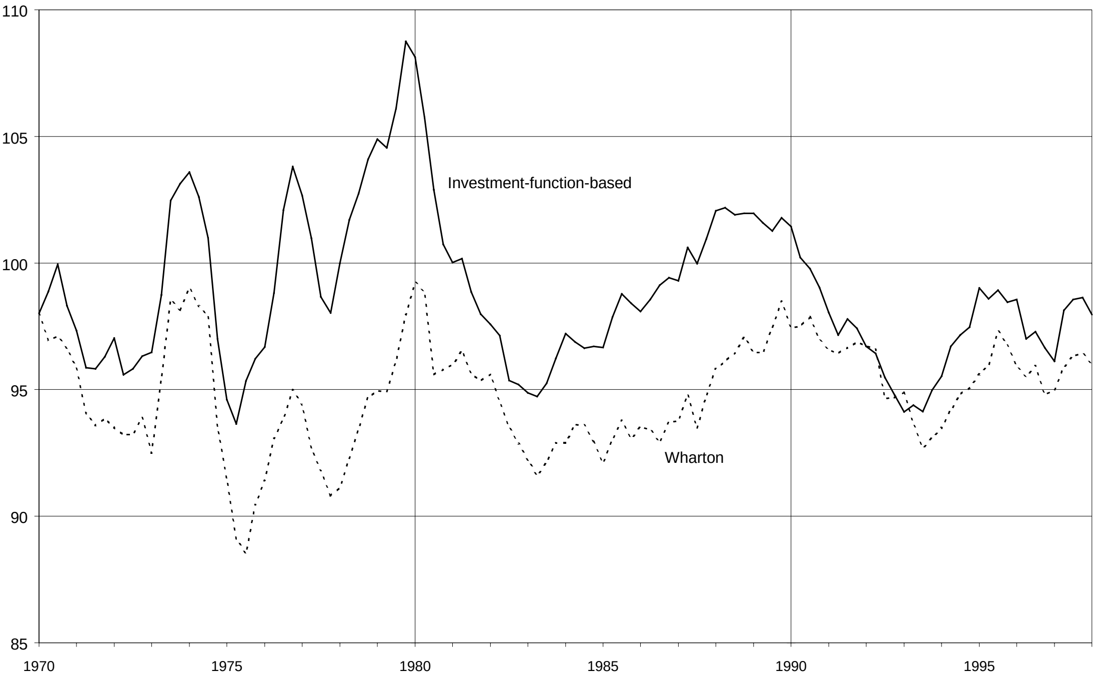
Thus, we may compute the (logarithm of the) gross change in capacity output corresponding to the estimated investment function equation of eq. (3.4) as follows:

(3.9) $$\hat{dy}_t^p = \Delta\ln\hat{Y}_t^p = \omega + \xi + \sum_{i=0}^{40}\psi_i \ln y_{t-i} + \sum_{i=0}^{40}\mu_i x_{t-i} + \sum_{i=0}^{40}\lambda_i \varepsilon_{t-i} .$$

Data were reconstructed for all necessary variables starting from the first quarter of 1960, so that $\hat{dy}_t^p$ can be computed from 1970.Q1 onwards, given the choice made about the maximum lag in eq. (3.9).

Figure 3.1

IFB AND WHARTON MEASURES OF UTILISED CAPACITY



The expression above only gives a measure of the desired gross changes in capacity output corresponding to the observed stream of investment. To convert the former into a measure of the level of capacity output, one must cumulate the changes over time, taking depreciation into account:

(3.10) $$\hat{Y}_t^p = (1-\delta_t)\hat{Y}_{t-1}^p + \exp(\hat{dy}_t^p) .$$

A starting condition must then be selected. In the benchmark measure, the choice was made to cumulate the desired gross changes in capacity output that may be computed according to eq. (3.9) starting with the value of the Wharton measure of potential output in the first quarter of 1970. National accounts estimates of the depreciation rate δ_t were then used in computing $\hat{Y}_t^p$ from eq. (3.10).

The resulting time series for the index of utilised capacity is shown in Figure 3.1, together with the Wharton measure previously used in the BIQM (as to the main characteristics of the latter see Gavosto and Siviero (1995) and the discussion below).

Given our definition of capacity output, it is not surprising that capacity utilisation can be greater than 100: “If optimum capacity is accurately estimated, a utilisation rate in excess of 100 simply means that current output lies in the range between optimum and peak capacity. Unless marginal cost rises quite steeply beyond the point of minimum cost, the range between optimum and peak capacity may be a wide one” (Hickman (1964), p. 544).

It is useful to summarise here all the assumptions underlying the empirical estimate derived in this section:

(i) g=0.0055, i.e., 2.2 per cent annual rate of growth of output in the steady state.[9] The need to make an assumption concerning this variable stems from eq. (3.8) above;

(ii) eq. (3.8) was computed period by period, using the corresponding value of δ_t from national accounts statistics, and the resulting time series was only then averaged out over the whole sample period to provide an estimate of ω;

(iii) while the basic set-up does not explicitly allow a role for any exogenous variables other than the desired increase in capacity output and the optimal capital / output ratio, in computing the measure of capacity output according to eq. (3.9) above, all ‘other’ exogenous variables were left unchanged at their historical values, rather than substituting them with their respective sample averages;

(iv) the (theoretically infinite) sums in eq. (3.9) were approximated by 40-term finite sums;

(v) eq. (3.10) was used to cumulate the desired changes in capacity output starting from the Wharton estimate of potential output available for 1970.Q1.

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9 The value chosen for parameter g coincides with the average growth rate of valued added in the non-farm, non-energy private sector over the period 1980-1997. Should one adopt the average value over the whole sample (1970-1997), the results would not be significantly altered.

3.2 Sensitivity analysis

In this section we examine the sensitivity of the capacity output measure constructed above with respect to the various assumptions that needed to be made in the process and were listed at the end of the previous section.

In short, the results appear to be fairly robust with respect to all assumptions, with the possible exception of the starting condition. More specifically, the following results were obtained:

(i) *Sensitivity with respect to the growth rate assumption (g)*

The assumption concerning the steady-state growth rate of output g affects the estimate of the desired gross change in capacity output through the re-proportioning factor ω computed by means of eq. (3.8).

Figure 3.2

SENSITIVITY OF THE IFB MEASURE OF UTILISED CAPACITY WITH RESPECT TO THE GROWTH RATE ASSUMPTION

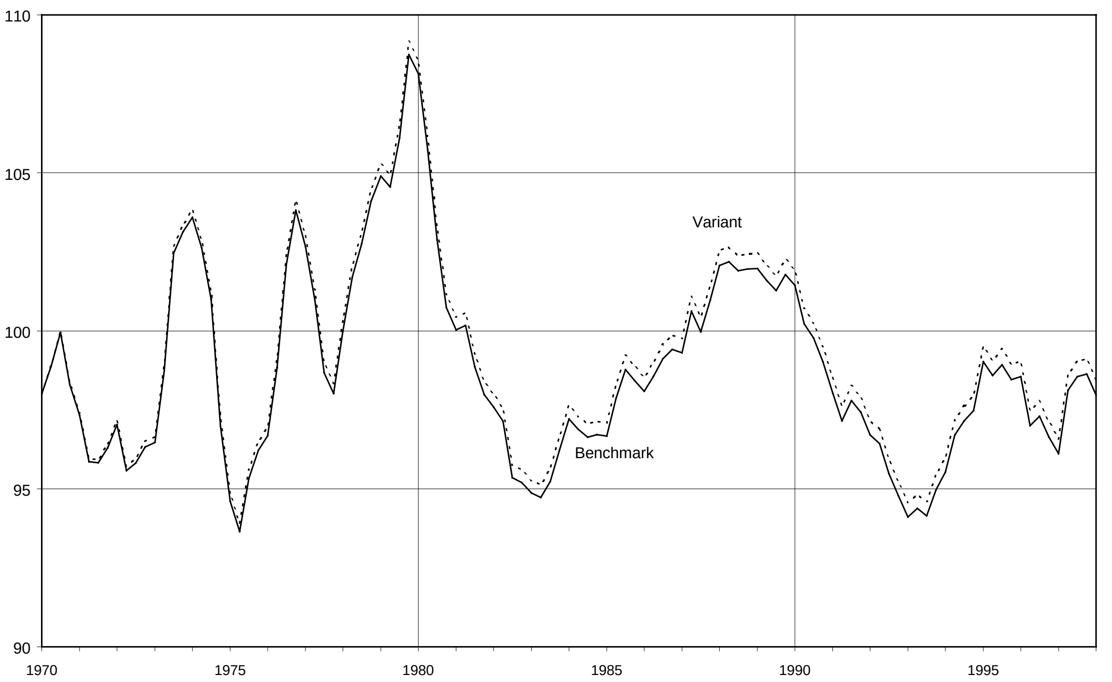


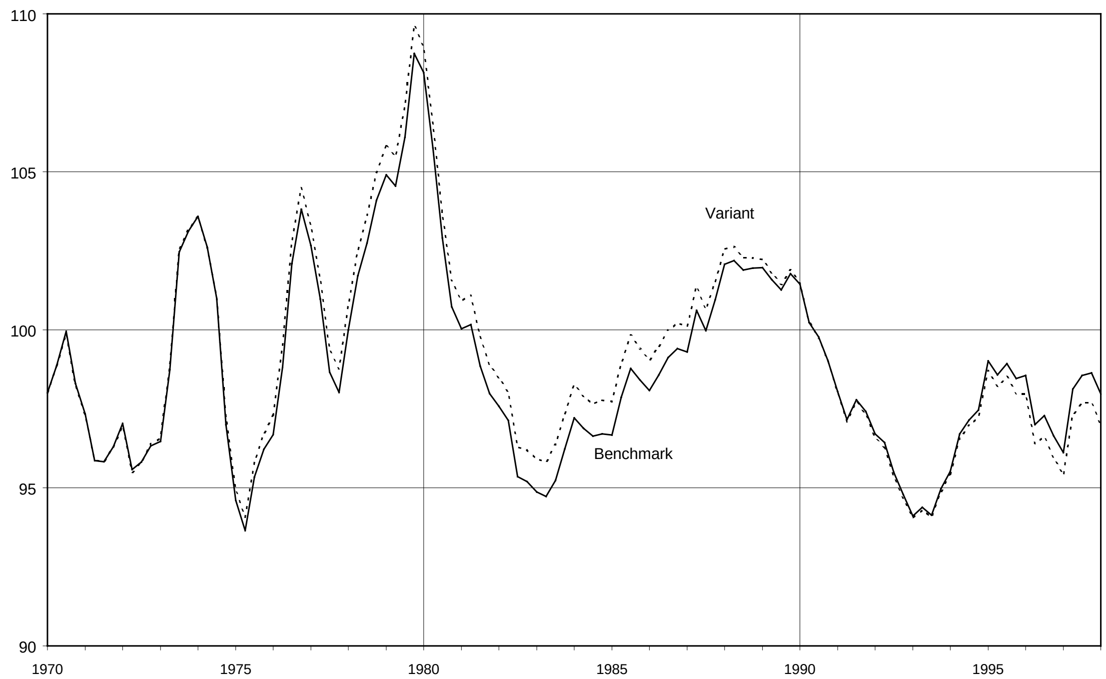
Figure 3.2 compares the benchmark estimate of the index of utilised capacity against the outcome resulting from assuming g=0.005 (rather than g=0.0055 as in the basic

measure; the alternative output growth estimate corresponds to a 2 per cent annual rate of growth of output, 0.2 points lower than in the benchmark).

Similar results to those depicted in Fig. 3.2 obtain if *g*=0.006 is assumed. Thus, the measure of utilised capacity appears to be basically unaffected by the assumption concerning the rate of growth of output in the steady state, as long as the latter takes values within the plausible range (steady-state annual rates of growth of economic activity between 2 and 2.5 per cent; the average annual rate of growth of the non-farm, non-energy private sector value added — the variable used in our empirical computations — was 2.1 per cent between 1980 and 1997).

Figure 3.3

SENSITIVITY OF THE IFB MEASURE OF UTILISED CAPACITY WITH RESPECT TO THE DEPRECIATION RATE ASSUMPTION, 1



(ii) *Sensitivity with respect to the depreciation rate assumption* (δ_t):

Instead of computing eq. (3.8) using, period by period, the historical δ_t taken from national accounts statistics, an average value of δ_t was first computed ($\overline{\delta} = 0.028$, corresponding to a depreciation rate of about 11.5 per cent per year) and then used in eq. (3.8) to solve for ω. Figure 3.3 shows that the measure of capacity output is not significantly sensitive to this assumption.

Figure 3.4

SENSITIVITY OF THE IFB MEASURE OF UTILISED CAPACITY WITH RESPECT TO THE DEPRECIATION RATE ASSUMPTION, 2

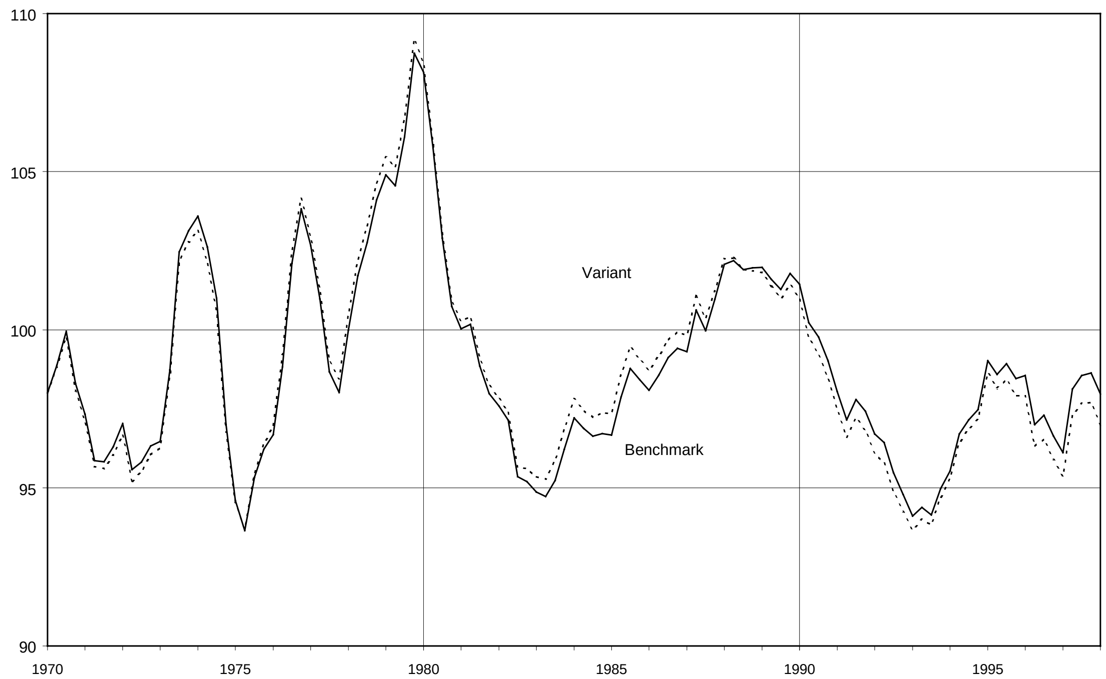


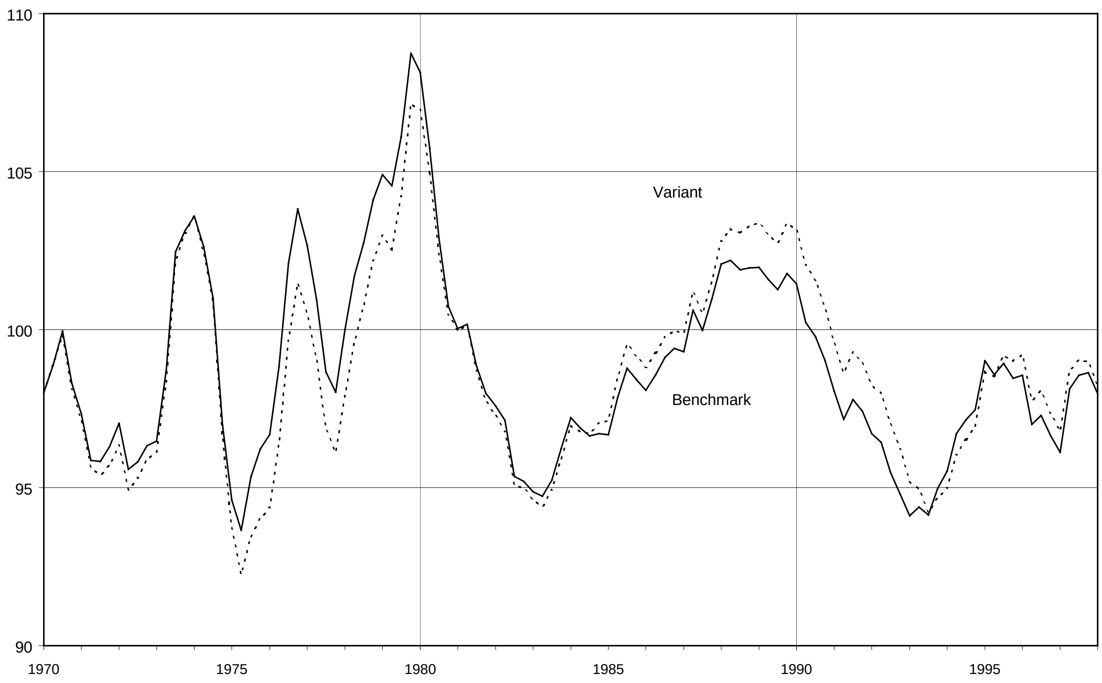
Figure 3.4 further shows that if $\overline{\delta}$ is raised by 100 basis points on an annual basis the results, although somewhat more visibly affected, do not produce any significant change in the overall picture, in that the timing and size of peaks and troughs as well as the timing of turning points do not change. A similar result obtains if the depreciation rate is lowered by 100 basis points.

(iii) *Sensitivity with respect to the treatment of the 'other' exogenous variables (x_t)*:

In using eq. (3.9) to compute the desired addition to capacity output, the historical values of all 'other' exogenous variables (which, incidentally, are all zero in the steady state) were replaced by their respective sample means (which are either zero or very close to zero in all instances). The results (see Fig. 3.5) show once again very little sensitivity of the results with respect to the assumption made in the benchmark computations.

Figure 3.5

SENSITIVITY OF THE IFB MEASURE OF UTILISED CAPACITY WITH RESPECT TO THE TREATMENT OF THE 'OTHER' EXOGENOUS VARIABLES

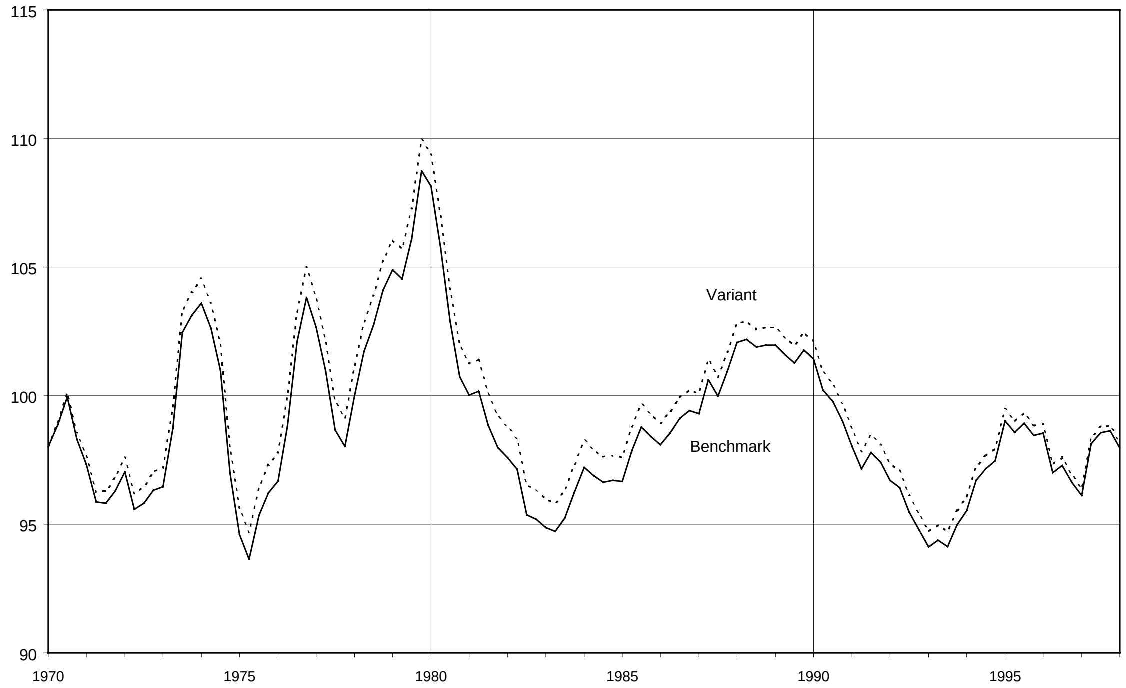


(iv) *Sensitivity with respect to the cut-off point of the infinite sums in eq. (3.9):*

The cut-off point of the (theoretically infinite) sums in eq. (3.9) was set at 30 lags, rather than at 40 as in the benchmark procedure. Figure 3.6 shows that the results are basically unaffected.

Figure 3.6

SENSITIVITY OF THE IFB MEASURE OF UTILISED CAPACITY WITH RESPECT TO THE CUT-OFF POINT OF THE INFINITE SUMS IN EQ. (3.7)



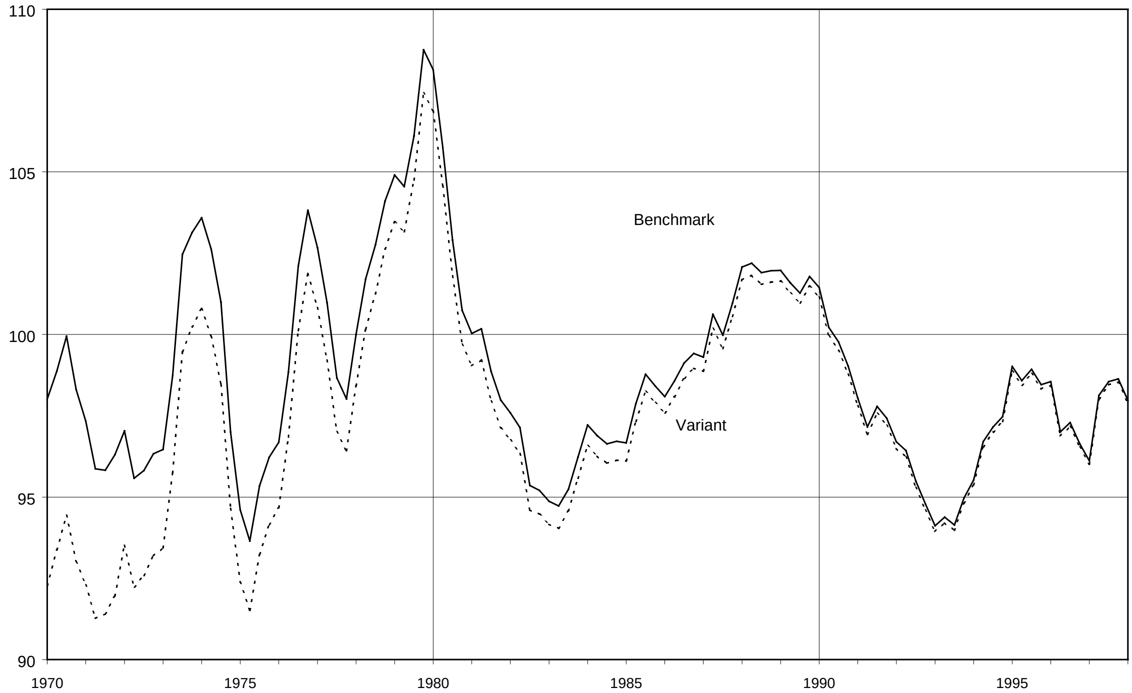
(v) *Sensitivity with respect to the initial conditions:*

Rather than cumulating the desired gross changes in capacity output starting from the Wharton measure of potential output for 1970.Q1, the level of the latter in 1972.Q1 was picked as the starting condition. For the periods before that date, eq. (3.10) was used backwards. Figure 3.7 shows that the results are affected more than in previous cases, although they remain unchanged from a qualitative viewpoint.

To summarise, the preferred measure of capacity output is not particularly sensitive to any of the assumptions that needed to be made in the process of estimating that measure, although minor differences may sometimes emerge. The proposed measure thus appears to be satisfactorily robust.

Figure 3.7

SENSITIVITY OF THE IFB MEASURE OF UTILISED CAPACITY WITH RESPECT TO THE INITIAL CONDITIONS



3.3 Properties of estimated capacity: a comparison with other measures

As mentioned in the Introduction, the degree of capacity utilisation plays a prominent role in several structural relationships of the BIQM. More specifically, it appears in three of the main equations that contribute to the determination of domestic prices:[10] first, it is used in the main domestic price equation (the non-farm, non-energy private sector value added deflator), to capture the effects that demand pressures exert on profit margins, since in an oligopolistic competition framework the mark-up is a function of, among others, market

[10] The degree of capacity utilisation also plays a role in other relationships within the BIQM: e.g., it is a proxy for non-price effects which may arise in foreign trade behaviour as a result of domestic demand moving asymmetrically with respect to domestic supply.

conditions. This is the main channel through which demand pressures affect final good prices. Second, the Phillips curve embedded in the BIQM depends not only on the unemployment rate but also on the degree of capacity utilisation, which is meant to capture firms' ability to pay, and only has a short-lived effect. Third, an increase in capacity utilisation worsens inflation expectations. The latter are endogenously modelled in the BIQM using quantitative measures computed on the basis of largely qualitative inflation expectations surveys. The assumption is made that the expectations formation process can be modelled as a sort of reduced form of the actual price determination block in the BIQM.

Measuring potential output and the output gap thus evidently plays a crucial role in shaping the outcome of model simulations. In the literature, several procedures have been proposed for the purpose of measuring potential output, from more theory-based approaches to purely statistical ones (see Christiano (1981) for a comprehensive, albeit not up-to-date, survey and St-Amant and Van Norden (1996)). In a nutshell, methods based on the "production function" approach attempt to measure in a statistical sense the "normal" relations between inputs and outputs, taking account of the fact that inputs are sometimes under-utilised (see Artus (1977)). In general, the production function approach consists in estimating a two-factor (usually Cobb-Douglas) production function, with capital and labour and exogenous technical progress measured by total factor productivity. The estimated coefficients are then used to compute potential output, replacing production inputs by some measure of their respective "normal" degree of utilisation.

The advantage of the production function approach lies in the fact that it provides a broad and consistent assessment of the economic outlook. It highlights how the various factor inputs and technical progress contribute to potential growth and the output gap. Among its drawbacks, this approach requires a fair amount of economic data and econometric expertise. More crucially, it relies on a number of very restrictive assumptions which are generally not tested and above all exogenously imposed (that is, there is no relationship between the model and the hypotheses about the evolution of factor inputs): this is particularly true for the labour force and the estimation of the NAIRU (see Appendix II for a more detailed description of the procedures production-function-based approaches applied by the IMF, the OECD and the EC).

Our procedure may well be deemed to belong to the class of production function methods, in that it is derived from the solution of the cost minimisation problem of the firm subject to the constraint given by the production function. The main difference with respect to the approach outlined above is that it does not need a direct estimate of the production function; potential output, as shown above, is directly obtained from the estimated capital demand equation. This method greatly reduces data requirements and limits any subjective intervention.

Alternatives to these proposals are purely statistical techniques, such as the Wharton peak-to-peak interpolation method and various smoothing techniques. The Wharton procedure tries to measure the output attainable if all inputs are fully utilised, while smoothing techniques provide a measure of the average trend of output. One drawback of these procedures is that they are univariate, in that they only use data on output while ignoring those on the situation in the labour market and on the inflation rate, which may contain valuable information to estimate potential output or the output gap. More recently, new techniques have been proposed that combine elements from both the structural and statistical approaches. Specifically, time-series methods are used to arrive at a specification for the process determining actual output; data for other economic variables related (from a theoretical viewpoint) to potential output are then combined with the results of the time-series analysis to produce a specification of the output gap. Examples of these techniques are the multivariate extension of the Hodrick-Prescott filter in Laxton and Tetlow (1992) and the unobserved components methods (see Gerlach and Smets (1997) and (1999) for an application to the G7 and euro area countries, respectively).

All these methods have different implications for the related measure of the output gap. In our case, as potential output refers to what may be produced at the minimum average cost, there may be periods when the output gap is positive (i.e., actual output exceeds potential output). However, some degree of asymmetry around zero has to be expected, since negative output gaps should generally prevail. Smoothing techniques should at least in principle provide a perfectly symmetrical measure of the output gap: given a set of regular cycles, the overall output gap should sum to zero. By contrast, peak-to-peak methods necessarily result in asymmetrical output gaps, because the latter is by construction lower than zero.[11]

In the remainder of the section we compare our investment-based measure of potential output with those obtained with the Wharton method, previously used in the BIQM, and with the results obtained by applying the Hodrick-Prescott filter to the series of private sector value added. In the first case, potential value added, constructed by means of peak-to-peak interpolation, was endogenised in the BIQM as an unconstrained 12-term distributed lag over actual value added. In the second case, the Hodrick-Prescott filter was applied to actual private sector value added, setting λ=1600.[12] In order to alleviate the end-of-sample problems emphasised in Maravall (1995), an AR model for actual value added was estimated, and projections were generated with it for 40 quarters after the last available observation (1997.Q4). The Hodrick-Prescott filter was then applied to the whole (actual plus projected) series of value added, generating a filtered series up to 1997.Q4.

The rates of change of the IFB, Wharton and Hodrick-Prescott filter measures of potential private sector value added are shown in Figure 3.8. On the basis of the IFB measure, the average growth rate of potential output has declined progressively in the last three decades, reflecting the slowdown in the capital accumulation process: while it was about 3.5 per cent (on an annual basis) in the 1970s, it decreased to 2.5 per cent in the 1980s and to less than 2 per cent from 1990 to 1997. A similar pattern emerges from the other two indicators (the decline in the average growth rate of potential output between the 1970s and the 1980s is more pronounced if the Wharton measure is used).

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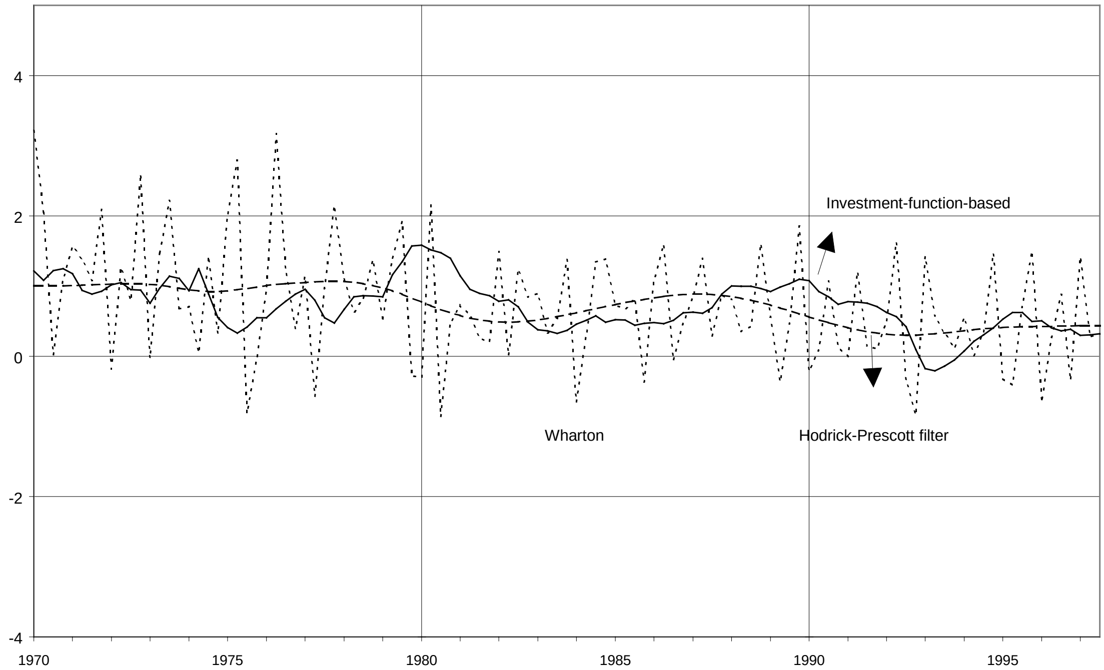
[11] Most countries in Europe tend to compute potential output and the output gap with the production function approach. Only a few countries rely exclusively on purely statistical methods such as the HP filter. However, given the uncertainty surrounding the measurement problem, almost all countries compute estimates of potential output and the output gap with a range of alternative approaches, in order to assess the robustness of results.

[12] The parameter λ determines to what extent high frequency cycles are eliminated from the data: a value of λ=1600 dampens cyclical components up to about 8 years. In the case of the European Commission estimates based on yearly data, λ=100, so that the potential output indicator retains all cyclical components with a frequency lower than about 16 years.

Figure 3.8

RATES OF CHANGE OF THREE DIFFERENT MEASURES OF POTENTIAL OUTPUT, 1970.Q1-1997.Q4



The three resulting measures of capacity utilisation are given in Figure 3.9. Some descriptive statistics are presented in Tables 3.1, 3.2, 3.3 and 3.4; the latter also shows the simple correlation of the three indicators of the degree of utilised capacity with two measures of domestic inflation and with changes in the latter.

Several differences are apparent. In the first place, while in the historical period the Wharton measure never exceeds 100 by definition,[13] this is obviously not the case for either of the other two (in particular, the Hodrick-Prescott series is, by construction, centred around 100). Aside from scale factors, the three series appear to provide roughly the same cyclical

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[13] Note, however, that given the way in which potential output was modelled in the previous version of the BIQM, there was no guarantee that the simulated values of capacity utilisation lie between 0 and 100, even if the estimated equation is based on the Wharton measure of potential value added.

picture, as peaks and troughs largely coincide (Fig. 3.9). As one would expect *a priori*, the rates of change of potential value added constructed according to the three approaches described above are appreciably less volatile than those of the actual series. The Hodrick-Prescott filter series is clearly smoother than either of the other two. The Wharton series is comparatively more affected by short-run variations in actual value added, as confirmed also by the descriptive statistics in Table 3.1. The IFB measure is an intermediate case: while it is not as smooth as the Hodrick-Prescott filter one, it does not display as much short-term variability as the Wharton one. As expected, the correlation between the rate of change of the Wharton measure and that of actual value added is the highest (Table 3.2), both over the entire available sample (1970.Q2-1997.Q4) and in two of the three sub-samples considered (roughly corresponding to the 1970s, 1980s and 1990s; results not shown). The IFB measure, by contrast, is the one with lowest correlation with the historical series of value added. On the whole, the correlations between the three available series are not particularly high, ranging from 0.11 to 0.47, thus showing that significant differences are present.

Figure 3.9

IFB, WHARTON AND HODRICK-PRESCOTT FILTER MEASURES OF UTILISED CAPACITY, 1970.Q1-1997.Q4

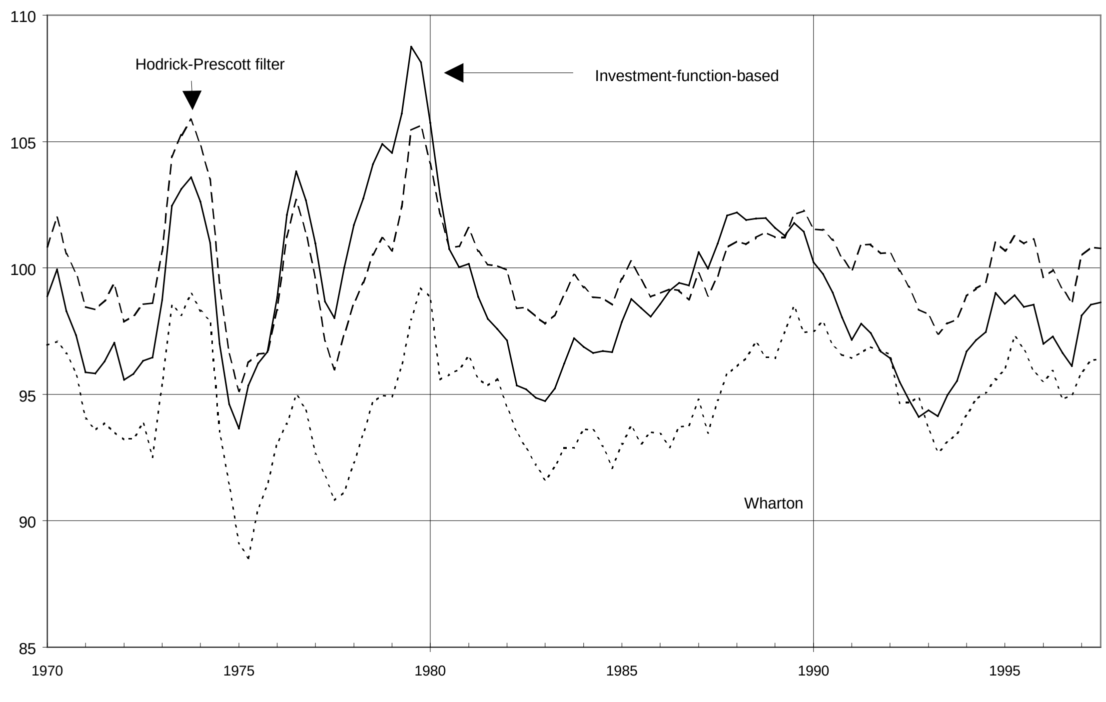


Table 3.1

DESCRIPTIVE STATISTICS OF THE RATES OF CHANGE OF ACTUAL PRIVATE SECTOR VALUE ADDED AND OF POTENTIAL OUTPUT MEASURES

	Average (1)	Standard deviation (2)	(2)/(1)	Max-min
Private sector value added	0.73	1.20	1.63%	7.88
IFB potential value added	0.72	0.36	0.50%	1.79
Wharton potential value added	0.75	0.84	1.13%	4.01
Hodrick-Prescott filter potential value added	0.72	0.26	0.36%	0.77

Table 3.2

CORRELATION BETWEEN THE RATE OF CHANGE OF ACTUAL PRIVATE SECTOR VALUE ADDED AND OF DIFFERENT POTENTIAL OUTPUT MEASURES

	Private sector value added	IFB	Wharton	Hodrick-Prescott filter
Private sector value added	1.00	0.04	0.41	0.31
IFB	-	1.00	0.11	0.47
Wharton	-	-	1.00	0.33
Hodrick-Prescott filter	-	-	-	1.00

Not surprisingly in light of the discussion above, the index of utilised capacity developed in Section 3.1 displays the highest variability (Table 3.3), a feature that also emerges from visual inspection of Figure 3.9. In particular, the IFB measure of potential value added is much less sensitive to changes in actual value added than the one previously in use, so that a change in the latter has a stronger impact on the degree of utilised capacity than it does in the case of the Wharton approach.

Table 3.3

DESCRIPTIVE STATISTICS OF DIFFERENT UTILISED CAPACITY MEASURES

	Average (1)	Standard deviation (2)	(2)/(1)	Max-min
IFB measure of capacity utilisation	98.84	3.08	3.12%	15.10
Wharton measure of capacity utilisation	94.83	2.16	2.27%	10.69
Hodrick-Prescott measure of capacity utilisation	100.02	2.01	2.01%	10.75

Table 3.4

CORRELATION BETWEEN THREE DIFFERENT MEASURES OF UTILISED CAPACITY AND THE INFLATION RATE

	IFB	Wharton	Hodrick-Prescott filter	Δ_1% Cons. defl.	Δ_1% Private v.a. defl.	Δ(Δ_1% Cons. defl.)	Δ(Δ_1% Private v.a. defl.)
IFB	1.00	0.56	0.77	0.41	0.38	0.16	0.14
Wharton	-	1.00	0.89	0.01	0.01	0.15	0.20
Hodrick-Prescott	-	-	1.00	0.30	0.30	0.16	0.16

Table 3.4 shows that the correlations among the three indicators of capacity utilisation are fairly high, ranging from 0.56 to 0.89 over the whole sample (1970.Q1-1997.Q4). Concerning their correlation with quarter-on-quarter inflation, the Wharton measure appears to be basically uncorrelated with the change in prices, while the measure proposed here shows the highest correlation; on the other hand, the correlations of those three measures with the change in inflation (last two columns of Table 3.4) are very similar (around 0.15).

Let us now turn to investigating the properties of the potential output sub-block of the BIQM in the new (i.e., with the IFB measure of potential value added) and in the old (i.e., with the Wharton measure) versions of the model.

Both measures are homogenous with respect to actual output (homogeneity of the measure proposed in this paper may be verified to hold looking at eq. (2.14)); however, neither of the two is super-homogenous (for a discussion of super-homogeneity see Nickell (1979)): in other words, while the degree of capacity utilisation is a constant along any steady-state growth path, it changes across steady-states. Different equilibrium rates of growth of output imply different degrees of utilised capacity. In particular, the following relationship holds between the IFB measure of capacity utilisation and the quarterly rate of growth of value added:

(3.11) $$CU^{IFB} = 95.1 \cdot \exp(10.6 \cdot \log(1+g)).$$

For the Wharton measure the relationship between utilised capacity and the rate of growth of value added is the following:

(3.12) $$CU^{W} = 92.3 \cdot \exp(4.6 \cdot \log(1+g)).$$

Table 3.5

SENSITIVITY OF IFB AND WHARTON MEASURES OF UTILISED CAPACITY WITH RESPECT TO THE STEADY-STATE GROWTH RATE OF OUTPUT

Annual rate of growth of output	IFB	Wharton
0.0	95.13	92.33
1.0	98.28	93.40
2.0	100.89	94.48
3.0	103.02	95.57

The resulting capacity utilisation rates corresponding to a grid of rates of growth of value added in the steady-state are shown in Table 3.5. While super-homogeneity is known not to hold, neither measure appears to be overly sensitive to the rate of growth of output, at least as long as the latter falls within a plausible range.

Figure 3.10

IMPACT OF A 1 PER CENT INCREASE IN PRIVATE SECTOR VALUE ADDED ON THE IFB AND WHARTON MEASURES OF POTENTIAL OUTPUT

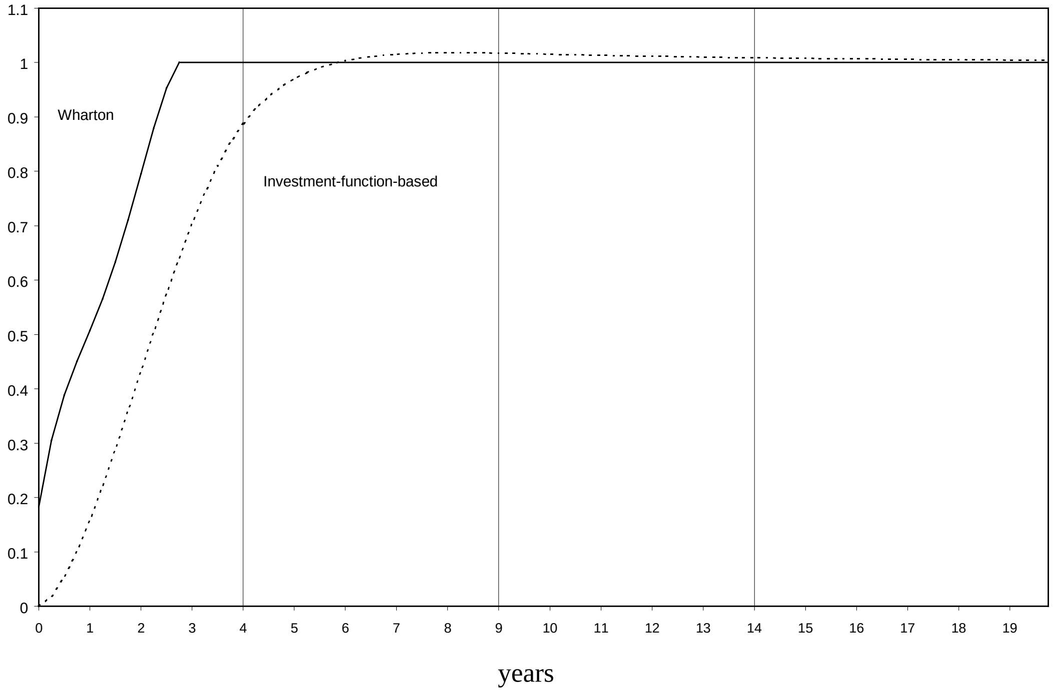
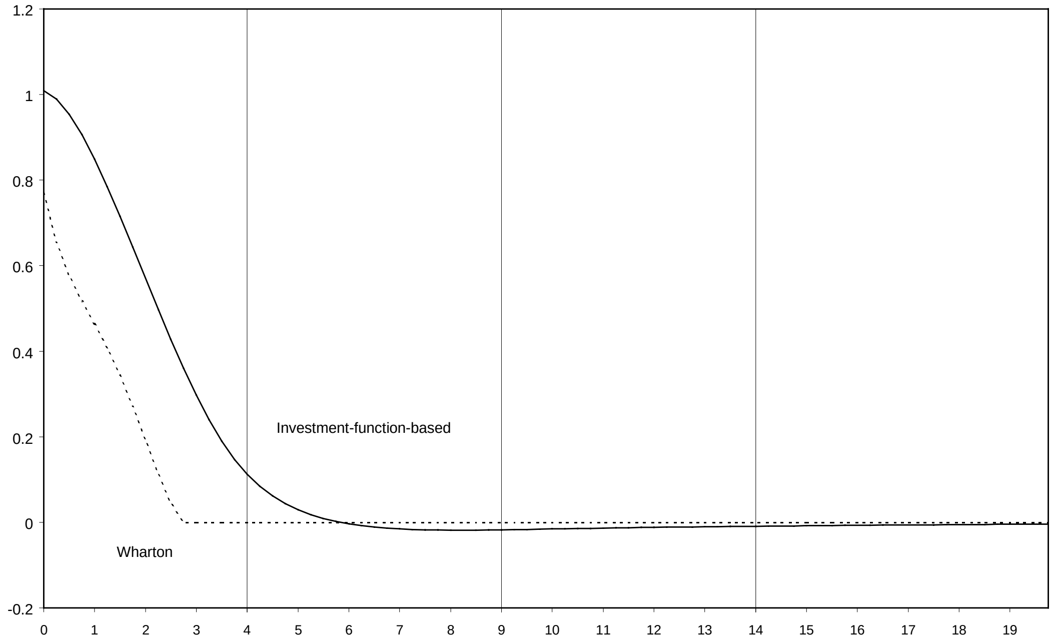


Figure 3.11

IMPACT OF A 1 PER CENT INCREASE IN PRIVATE SECTOR VALUE ADDED ON THE IFB AND WHARTON MEASURES OF UTILISED CAPACITY



Finally, we examined the effects produced by a permanent 1 per cent shock to actual private sector value added. Figure 3.10 shows the reaction of potential value added, both IFB and Wharton. The latter adjusts much more rapidly, the elasticity to the shock being approximately 0.5 at the end of the first year after the shock, and 1.0, by construction, after 12 quarters. The former adjusts at a considerably slower pace, the elasticity being only 0.1 after 4 quarters and 0.5 after 10. Starting in the 7th year after the shock, potential value added over-reacts slightly, its elasticity exceeding 1.0; the overshooting is re-absorbed very gradually.

Consistently with these results, the degree of utilised capacity rises by 0.8 points in the first quarter if the Wharton measure is used, and returns to the baseline after 12 quarters (Fig. 3.11). By contrast, the IFB measure of capacity utilisation initially jumps by as much as the amount of the shock, and then, after about 15 quarters, drops to below the baseline.

While this overshooting behaviour may be not fully plausible, the new measure appears to be more sensitive to the cycle and thus to pressures exerted by aggregate demand.

4. Other measures of capacity utilisation and the output gap for the Italian economy

In this section we compare our estimate of capacity utilisation with those computed for the Italian economy by the IMF, the OECD, the EC and the survey-based indicator published by the ISAE[14]. The definition of the level of activity underlying these measures differs from the one employed in building the IFB, Wharton and HP indicators presented above (it is worth recalling that these indicators refer to the value added in the private non-farm, non-energy sector). Specifically, the IMF, OECD and EC measures give an estimate of potential GDP, while the survey-based indicator by the ISAE refers to output in the manufacturing sector. A more detailed description of the features of these measures of potential output and the output gap is given in Appendix II. The comparison of the available indicators is carried out with annual data, as some are only available at an annual frequency.

[14] Till the end of 1998, qualitative surveys on business and consumers were run by ISCO, the Institute for the Analysis of Economic Conditions, which in 1999 was absorbed into the newly created ISAE, the Institute for Economic Analysis.

From a descriptive viewpoint, the variability of the IFB measure is broadly similar to that of the ISAE and IMF ones, while the indicators developed by the OECD and the EC seem to be less volatile (Table 4.1).[15] The consistently lower level of the ISAE series is due to the vague definition of capacity in the survey. In particular, it is likely that firms form their estimate of utilised capacity on the basis of what they perceive as the maximum output that could be obtained under normal work schedules, so that the (theoretical) possibility of reaching a peak of 100 per cent is virtually ruled out. Remarkably, the ISAE series shows the lowest correlation with all other measures, possibly reflecting the fact that this measure is limited to the manufacturing sector only. It is worth remarking that all measures are characterised by broadly similar cyclical behaviour (Fig. 4.1). However, compared with most other measures, the IFB indicator appears to anticipate the cyclical peaks at the beginning of the 1980s and 1990s, as well as the trough of the mid-1980s; interestingly, the same holds true for the ISAE survey-based measure.

As regards the correlation with inflation, the latter is highest for the IMF series (table 4.1), followed by the IFB figures. Relatively low correlation is observed in the case of the EC indicator, while the ISAE indicator has a negative correlation with inflation. This is presumably due to the fact, mentioned above, that this measure only covers the manufacturing sector. All indicators of utilised capacity are highly correlated with the change in inflation (last two columns of Table 4.2): the correlations range from a minimum of just under 0.4 (for the IMF measure) to about 0.7 (for the EC series).

Summing up, the comparison with other estimates of the potential output and the output gap do not signal any drawbacks in the measure proposed in this paper, a remarkable result given the tight constraints imposed by our procedure.

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[15] The relatively low volatility of the ISAE indicator is a frequent result of survey-based methods; see Christiano (1981).

Figure 4.1

IFB, ISAE, EC, IMF AND OECD MEASURES OF UTILISED CAPACITY, 1970-1997

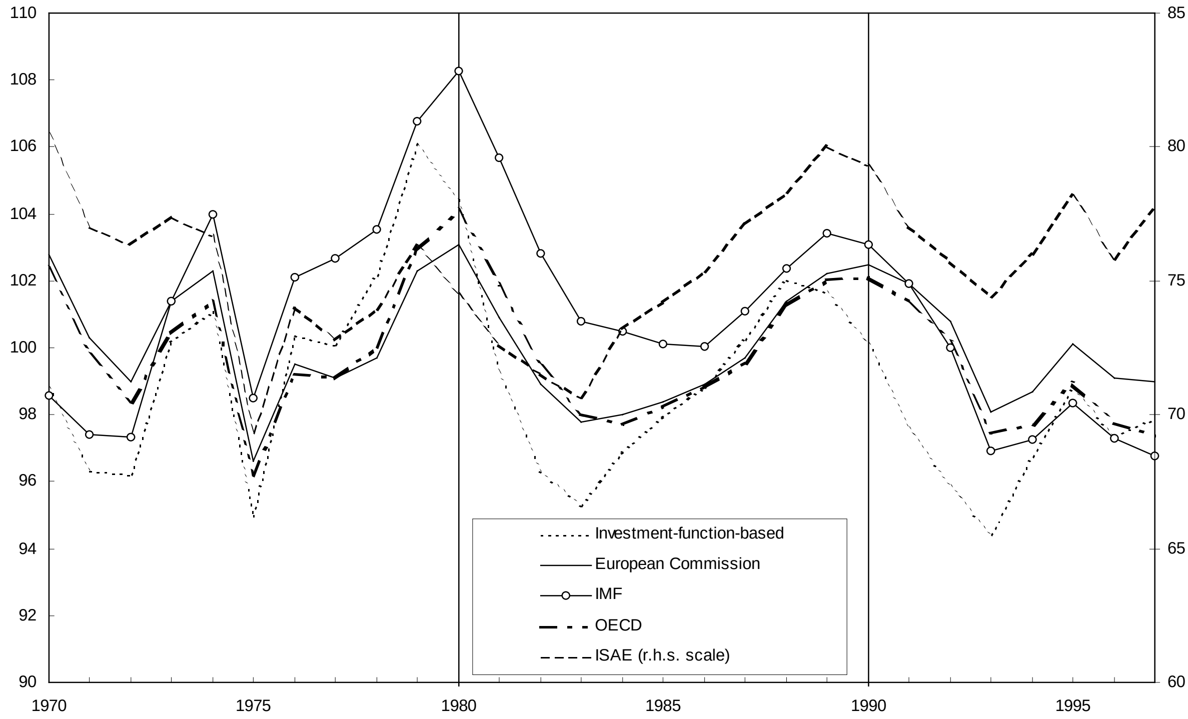

Table 4.1

DESCRIPTIVE STATISTICS OF DIFFERENT UTILISED CAPACITY MEASURES
(annual data; 1970-1997)

	Average (1)	Standard deviation (2)	(2)/(1)	Max-min
IFB measure of capacity utilisation, non-farm, non-energy sector	98.84	2.83	2.86%	11.67
ISAE survey-based measure (manufacturing sector)	75.56	2.73	3.62%	11.20
European Commission measure (GDP)	100.09	1.75	1.75%	6.5
IMF measure (GDP)	101.03	3.07	3.04%	11.50
OECD measure (GDP)	99.78	1.98	1.98%	7.92

Table 4.2

CORRELATION BETWEEN DIFFERENT MEASURES OF UTILISED CAPACITY AND THE INFLATION RATE
(annual data; 1972-1997)

	IFB	ISAE	EC.	IMF	OECD	Δ% Cons. defl.	Δ% GDP defl.	Δ(Δ% Cons. defl.)	Δ(Δ% GDP defl.)
IFB	1.00	0.40	0.74	0.77	0.78	0.35	0.39	0.49	0.50
ISAE	-	1.00	0.64	-0.01	0.41	-0.57	-0.56	0.46	0.42
EC	-	-	1.00	0.70	0.94	0.32	0.35	0.70	0.65
IMF	-	-	-	1.00	0.87	0.69	0.72	0.38	0.37
OECD	-	-	-	-	1.00	0.14	0.16	0.56	0.53

5. Concluding remarks

This paper has shown how the empirical estimate of the investment function in the BIQM was used to construct a measure of potential value added that is consistent with the capital accumulation process and more generally with the rest of the supply-side block of the model.

The results are qualitatively not very different from those of the Wharton measure previously in use in the BIQM, as the peaks and troughs of the two series largely coincide and roughly the same cyclical picture emerges (similarly if the IFB measure is compared with the Hodrick-Prescott filter indicator). The new measure appears to be a promising indicator of the pressure exerted on prices by demand accelerations, in that its correlation with the rate of change and with the acceleration of prices is not dissimilar (and in general higher) from that of the other two indicators.

Further work will be needed to identify all the properties of the new measure of utilised capacity (in particular, the features of the estimated investment function that are responsible for the overshooting behaviour of potential value added when actual value added is permanently raised will need to be identified) and to investigate the scope for further uses, both within the BIQM and for other purposes (e.g., for the assessment of structural budget balances). Also, the approach described in this paper can be extended to recover a measure of potential labour demand, and thus to investigate the properties of the latter as compared with those of actual labour demand in the model.

Appendix I

The data

All empirical results presented in this work regard the private sector, net of the farm and energy sectors (hereafter, PNFNE sector). Thus, the empirical investigation considers the manufacturing, construction and service sectors. A number of experiments conducted in the course of building the BIQM showed that no advantage could be gained, from an empirical viewpoint, by modelling these sectors separately.

In the following we give definitions of the main variables used in the empirical investigation presented in the text:

Investment: Equipment investment (inclusive of machinery and transport equipment) in the PNFNE sector, 1990 prices (N.A. data).

Output: Value added at factor cost in the PNFNE sector, 1990 prices (N.A. data).

Capital / output ratio: Given the assumption that the production function is of the Cobb-Douglas type, the optimal capital / output ratio is an increasing function of the (trend) cost of labour per unit of output / cost of capital ratio. The (trend) cost of labour per unit of output is in turn given by the ratio between compensation per employee and a measure of trend productivity (the rate of growth of trend productivity was derived from the estimate of the labour demand equation). The cost of capital was estimated following the well-known Jorgenson's approach; see Parigi (1998) for more details.

Business confidence index: Based on qualitative survey conducted by the Italian Institute for Economic Analysis (ISAE) on a large sample of Italian manufacturing firms. The numerical value of this variable is derived by averaging the answers to three questions concerning the level of production, the expected trend in production and the expected trend in orders. Answers are of a qualitative nature. They are transformed into quantitative measures on the basis of the balance between the percentage of positive and negative answers.

Credit control: Administrative controls on total credit were operative over the period July 1973 - March 1975; October 1976 - June 1983; January 1986 - June 1986. The variable *CREDRAT*, aiming at capturing the effects of administrative controls, was constructed as follows:

$$CREDRAT = (\Delta r^B - \varepsilon \Delta r^D) \cdot dumratio$$

where r^B and r^D are the interest rate on bank loans and the official discount rate, respectively, ε is a coefficient capturing the effects of changes in the official rates on the loan rates over periods with credit controls, and *dumratio* is a dummy variable assuming unit values in periods in which credit controls were in effect. For further details on the construction of this variable and more specifically the estimation of the coefficient ε, see Banca d'Italia (1986).

DUTREM: A dummy variable assuming unit values between 1994.Q3 and 1995.Q4 was introduced to take account of the so-called “Tremonti law”, which introduced temporary tax incentives for investment.

Appendix II

The OECD, IMF, EC and ISAE approaches

The OECD estimate

In estimating potential output, the OECD follows a methodology based on a production function framework, drawing on information concerning the capital stock, working population, trend participation rates, structural unemployment and factor productivity developments. In its simplest form, the procedure starts from the estimation of a two-factor Cobb-Douglas production function for the business sector, given constant, sample-average labour shares. The estimated residuals are then smoothed to give a measure of trend total-factor productivity. Potential output for the business sector is computed by combining this measure of trend total-factor productivity with the actual capital stock and estimates of potential employment, using the same estimated production function. Potential employment is defined as the amount of labour resources that do not imply additional inflation. This consists in adjusting the actual labour input of the production function for the gap between actual unemployment and the non-accelerating-wage rate of unemployment (NAWRU; see Giorno *et al*. (1995) for a description of the estimation procedure for the NAWRU). Potential output for the whole economy is finally obtained by summing actual value added in the government sector to business-sector potential output.

The IMF estimate

The approach followed by the IMF does not differ significantly from the one adopted by the OECD, as it relies on imposing a functional form on the production process and implies that, in the short-run, potential labour and capital inputs can be determined by the behaviour of unemployment relative to its natural rate and the deviation of output from its normal level. Judgmental elements play a role in setting the rates of growth of capital, labour and total factor productivity embodied in projections of potential output on the basis of recently observed trends (see De Masi (1997) for a more detailed description).

Starting with Artus (1977), where estimates for potential output were obtained from a Cobb-Douglas production function with constant shares, the IMF methodology has evolved with a significant improvement in the estimation techniques of the natural rate of unemployment. In particular, Adams *et al*. (1987) estimated a reduced form equation for the natural rate of unemployment using variables accounting for cyclical and structural factors, as well as other variables contributing to rigid wages, such as changes in relative import prices, contributions and underlying trend productivity. More recently, Adams and Coe (1990) enhanced the production function approach by accounting explicitly for the relationship between wage and price inflation, potential output and the natural rate of unemployment within a consistent analytical framework. This estimation technique ensures that the estimates of potential output and the natural rate of unemployment be consistent with one another.

The EC estimates

The EC method is based on the application of filtering techniques. This choice is in part influenced by the need to rely on a standardised method that can be easily applied to all European countries. The problems with this approach are well known and described at length in Christiano (1981). In brief, the application of filters, such as the Hodrick-Prescott one, suffers from problems in determining the trend component at the start and end points of the sample, exactly where the interest of the policy maker is mostly focused. For a technical discussion of the issues arising when filtering techniques are adopted, see Baxter and King (1995) and Harvey and Jaeger (1993).

Recently, the EC has computed potential output and the output gap according to a production function approach derived from the EC Quest macroeconometric model. Basically, a Cobb-Douglas two-factor inputs (capital and labour) production function is first estimated. An HP filter is then applied to the unemployment rate in order to obtain an estimate of the NAIRU, and total factor productivity is regressed on a measure of technical progress, based on a vintage representation of the capital stock. Potential employment and trend total factor productivity computed as described above are then fed into the estimated production function to compute potential output (see, Röger and Ongena (1999) for a more detailed description).

The ISAE indicator

The ISAE measure is completely different from those described above, as it is directly derived from a survey with manufacturing firms. The measure is an estimate made directly by companies and does not entail any intervention by the researcher, and thus presents "the obvious advantage [...] that direct questions relating to capacity are responded to by persons likely to know the answer" (Phillips (1963), p. 284). In the case of the ISAE survey, the question firms have to answer is: "At what percentage of total capacity did your company operate in the current quarter?". However, the survey method is not free of problems (see Christiano (1981) for a detailed analysis of the pros and cons of measures of this nature). In particular, this kind of survey does not entail a precise definition of capacity, so that the latter "may be interpreted in the narrow capital utilisation sense, or in a wider sense, that is the extent to which resources (capital labour, land, raw materials) are utilised. Moreover, [...] the time horizon that businesses have in mind in evaluating their capacity also introduces uncertainty for interpretation" (Christiano (1981), p.170).

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