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Macroeconomic dynamics and healthcare provision in the UK

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Abstract

This paper makes a substantial contribution to the debate on health policy and its impact on the macro-economy. For the first time a model has been developed that captures the unique characteristics of public spending on health and how this impacts on the effectiveness of public policy in a macroeconomic setting. In the model, government expenditure on health has a direct effect on improving the effectiveness of labour, and this feeds through into the dynamic behaviour of the model via its effect on physical capital accumulation. Within this setting the paper sheds light on the effect of external changes to the labour market (for example by immigration increasing the labour force), which has obvious importance given the ageing population and ever increasing demand for health expenditure.

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Introduction

This paper identifies and models the effects of investment in health on the macroeconomic dynamics of the UK economy. Furthermore, it analyses the effect of labour mobility (for example increased inward migration of workers from Eastern Europe) and an ageing population on the relationship between health and macroeconomic behaviour over time.

First, the paper builds a dynamic macroeconomic model that captures the effects of investment in health on the UK macro economy. From this theoretical model, an econometric model is derived and estimated, and the effects of government policy on resource allocation in health and the effects of labour migration and an ageing population are quantified.

The modelling framework derives from the work of Grossman (1972) on the demand for healthcare and on the dynamic macroeconomic model literature beginning with Obstfeld and Rogoff (1995) and Turnovsky (1995). Healthcare provision has many similarities with some of the investment components of national income. Health may be viewed as a capital stock which will deteriorate over time unless augmented by investment in health care. It therefore shares some properties of other forms of capital with have received prominence in the macroeconomics literature. This paper therefore makes a novel application of this macroeconomic modelling framework to the health care provision. Moreover, the framework of analysis reveals important insights into the link between health status and socioeconomic status, particularly labour market participation.

The macroeconomic model comprises three dynamic equations representing income, health capital and equities as a measure of wealth. The macroeconomic model is essentially a representative agent model in which agents maximise their wellbeing with respect to the private and public budget constraints and given the dynamics of the accumulation of capital, labour and health.

Health care is a major target for private and public investment. Health care expenditure is now running at over 8% of GDP and is increasing. The model is specifically designed to capture taxation and government borrowing as mechanisms for financing public health care provision. The model therefore includes a consolidated constraint for both the public and the private sector.

Furthermore, the model captures rationing devices, including waiting lists (both time and numbers of patients for the public sector) with healthcare insurance and direct purchase costs for the private sector. This emphasis arises from the growing demand and accompanying cost of health care provision. It also brings into focus the age profile of the population, the increasing problem of pension provision and the mounting burden of taxation on the working population. The growing concern over labour migration can also be addressed head on within this framework of analysis.

Side issues considered include the role of index linking in state and other pension plans where evidence suggests that the index for retired people should reflect the actual consumption pattern of this growing segment of the population and not that of the population at large.

From the general theoretical framework developed in the first part of the paper, an econometric model is specified and estimated. Monetary and fiscal policy instruments are specified together with many other time series variables which together may have a long run and/or a short run joint relationship. The stationarity of the individual variables is investigated, allowing for possible structural breaks, deterministic trends, seasonality (where applicable) and asymmetric adjustment.

The paper is organised as follows. The theoretical framework is given in section 2, empirical analysis is described in section 3, section 4 discusses the policy implications and conclusions are given in section 5.

2. Theoretical Framework

The model centres around three state equations concerning the dynamics of physical capital, health capital and net foreign assets, and follows in the path of Obstfeld and Rogoff (1995) and Turnovsky (1995).

The utility function for the representative agent is additively separate and given by

$$U = \sum_{t=0}^{\infty} \beta^t \left[u\left(c_t + c_t^h, m_t\right) + v\left(g_t\right) + w\left(g_t^h\right) \right] \tag{1}$$

The agents' subjective rate of time preference is represented by the parameter β. Consumers derive utility from private consumption of both non-health and health augmenting products, $c + c^h$, real money balances as a means of transaction, m, consumption of public services excluding health, g, and consumption of publicly provided health services, g^h. Output is produced using the neoclassical production function

$$y = F\left(k\right) \tag{2}$$

which has the expected properties and where output y and capital k are defined in *per effective labour unit* terms, and that further that effective labour grows at the rate $\left(n+i\right)$ where n is the (exogenous) rate of population growth and i is the (exogenous) rate of change of health status[1]. In other words, the health of the population is the specified determinant of the effectiveness of labour (in contrast to the growth literature where effectiveness of labour is captured by an exogenous technology parameter). In other words, health is labour-augmenting. The dynamics of capital accumulation per effective labour unit is given by

$$k_{t+1} - k_t = I_t \tag{3}$$

where I is the rate of investment, and depreciation is ignored.

Next we turn to the dynamics of net foreign asset accumulation. Agents accumulate net foreign bonds according to the equation

$$s_t f_{t+1} - (1 + r_t^*) s_t f_t = F(k_t) - (n+i) k_t - c_t - c_t^h - X_t - \psi(I_t) \tag{4}$$

Foreign bonds pay an exogenous interest rate r^*, f are the holdings of the bond, $c + c^h$ is the level of consumption, X is the level of real lump-sum taxes, $\psi(I)$ is the cost of capital investment, which is taken to be a convex function of the rate of investment, I (that is, $\psi'(I) > 0$). The term $(n+i)k_t$ reflects the fact that, in an economy where the population is growing and health is improving, part of output must be devoted to increasing the capital stock and the health status in order for capital per effective labour unit to be constant. Foreign variables are expressed in terms of units of domestic output by multiplying by the real exchange rate, s, defined as the domestic price of foreign currency. The government's flow budget constraint may be expressed in real terms as

[1] Additionally, labour could directly enter the utility function to capture disutility from work. However, the focus of this paper is not the labour market *per se* and in this paper changes in the quantity of labour and its effectiveness are captured through the dynamics of capital defined in terms of effective labour unit.

$$b_{t+1}-(1+r_t)b_t+m_t-m_{t-1}=g_t+g_t^h-X_t+p_t m_t \tag{5}$$

Government debt, on the right hand side, comprises of government spending (public consumption, g and g^h, plus debt interest repayments, rb) minus revenues the lump-sum tax, X, and inflation tax, pm (where m is the real money supply and p domestic inflation). The domestic real interest rate is r. The private and public budget constraints (4) and (5) can be combined[2], thereby eliminating X, to give the consolidated budget constraint

$$\begin{aligned} & d_{t+1}-(1+r_t)d_t+m_t-m_{t-1} \\ & =F(k_t)-(n+i)k_t-c_t-c_t^h-\psi(I_t)-g_t-g_t^h-p_t m_t \end{aligned} \tag{6}$$

The term $d \equiv sf-b$ represents the net credit of the domestic economy in terms of units of domestic output. Note that the only spending on health is *public* spending. The Lagrangian[3] for the discrete optimisation problem is therefore

$$\begin{aligned} L \equiv & \sum_{t=0}^{\infty}\beta^t\left[u(c_t,m_t)+v(g_t)+w(g_t^h)\right] \\ & +\lambda_t\left[\begin{array}{l} \sum_{t=0}^{\infty}(1+r)^{-t}\left[F(k_t)+(n+i)k_t\right]-\sum_{t=0}^{\infty}(1+r)^{-t}\left(c_t+c_t^h\right)-(1+r)^{-t}\psi(I_t) \\ -\sum_{t=0}^{\infty}(1+r)^{-t}g_t-\sum_{t=0}^{\infty}(1+r)^{-t}g_t^h+(1+r)d_t-d_{t-1}+m_{t-1}-m_t-p_t m_t \end{array}\right] \\ & +q_t\left[I_t-k_t+k_{t+1}\right] \end{aligned} \tag{7}$$

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[2] Through UIP, $\dot{s}^e=\dot{s}=r-r*$, where $\dot{s}^e$ is the expected rate of depreciation of the exchange rate (defined as the domestic price of foreign currency), which is equal to the actual rate of depreciation, $\dot{s}$, under perfect foresight. In equilibrium, $\dot{s}=0$, and hence $r=r*$.

The first order conditions for each of the control variables are given by

$$L_c = 0 \Rightarrow u'\left(c_t + c_t^h\right) = \beta\left(1+r\right)u'\left(c_{t+1} + c_{t+1}^h\right) \tag{8}$$

$$L_I = 0 \Rightarrow q = \lambda \psi'\left(I\right) \tag{9}$$

$$L_g = 0 \Rightarrow v'(g_t) = \beta(1+r)v'(g_{t+1}) \tag{10}$$

$$L_{g^h} = 0 \Rightarrow v'\left(g_t^h\right) = \beta\left(1+r\right)w'\left(g_{t+1}^h\right) \tag{11}$$

The additional first order conditions with respect to the co state-variables are

$$-L_d = \lambda_{t+1} - \lambda_t \Rightarrow \left(1+r\right) = -\left(\lambda_{t+1} - \lambda_t\right)/\lambda_t \tag{12}$$

$$-L_m = \lambda_{t+1} - \lambda_t \Rightarrow u'(m_t)\lambda_t^{-1} + (1-p) = -(\lambda_{t+1} - \lambda_t)/\lambda_t \tag{13}$$

$$\begin{aligned} -L_k &= q_{t+1}\left(1+r\right)^{-1} - q_t \Rightarrow \\ q_{t+1} &- q_t\left(1+r\right) = -\lambda_{t+1}\left(F'\left(k_{t+1}\right) - \left(n+i\right)\right) \end{aligned} \tag{14}$$

Finally

$$L_\lambda = d_{t+1} - d_t \tag{15}$$

$$L_q = k_{t+1} - k_t \tag{16}$$

Combining (12) with (13) yields

$$-L_m = \lambda_{t+1} - \lambda_t \Rightarrow u'\left(m_t\right)\lambda_t^{-1} + \left(1-p\right) = \left(1+r\right) \tag{17}$$

Using the first order condition that $\lambda_t = u'\left(c_t + c_t^h\right)$ this can be rewritten as

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[3] The interpretation of the Lagrangian coefficients λ, q are the marginal utility of wealth and the shadow price of capital, respectively.

$$-L_m = \lambda_{t+1} - \lambda_t \Rightarrow \left(u'(m_t) \big/ u'\left(c_t + c_t^h\right)\right) + (1-p) = (1+r) \tag{18}$$

Assuming that $u\left(c+c^h\right) = \ln\left(c+c^h\right)$ and hence $u'\left(c+c^h\right) = 1\big/\left(c+c^h\right)$, and that $u(m) = \ln m$ and hence $u'(m) = 1/m$, and ruling out seigniorage, then equation (18) may be written as

$$\left(c_t + c_t^h\right)\big/ m_t = (1+r) \tag{19}$$

Linearising, and assuming consumption is a function of income, yields

$$m_t = l_1 y_t - l_2 r \tag{20}$$

Equation (14) gives our first dynamic equation, redefining the shadow price of capital in terms of bonds (i.e $q \equiv q/\lambda$), as

$$q_{t+1} = -\left(F'\left(K_{t+1}\right) + (n+i)\right) + (1+r)q_t \tag{21}$$

This yields the familiar Blanchard (1981) arbitrage relationship equating the returns on capital and bonds

$$\frac{F'\left(K_{t+1}\right) - (n+i)}{q_t} + \frac{q_{t+1}}{q_t} = (1+r) \tag{22}$$

$$q_{t+1} - q_t = rq_t - F'\left(K_{t+1}\right) + (n+i) \tag{23}$$

Linearising about steady state values $\bar{q}, \bar{r}$ yields

$$\Delta q = \bar{r}q_t + \bar{q}r - F'\left(K_{t+1}\right) + (n+i) \tag{24}$$

Assuming that the rate of change of health status has a direct linear relationship with both private and government spending on health, such that

$$i_t = \eta c_{t-1}^h + \iota g_{t-1}^h \tag{25}$$

then

$$\Delta q = \bar{r} q_t + \bar{q} r - F'\left(K_{t+1}\right) + n + \eta c_{t-1}^h + \iota g_{t-1}^h \tag{26}$$

Taking the both the marginal product of capital and private consumption on health to be a function of output this may be rewritten to yield our first dynamic equation

$$\Delta q = \bar{r} q_t + \bar{q} r - \phi y_{t-1} + n + \chi y_{t-1}^h + \iota g_{t-1}^h \tag{27}$$

This may be further refined by using equation (20) to replace r thus obtaining

$$\Delta q = \bar{r} q_t + \bar{q}\left(\frac{l_1}{l_2} y_{t-1} - \frac{1}{l_2}\left(m_{t-1} - p_{t-1}\right)\right) - \left(\phi - \chi\right) y_{t-1} + n + \iota g_{t-1}^h \tag{28}$$

Taking the foreign price level as numeraire and assuming purchasing power parity[4], this gives

$$\Delta q = \bar{r} q_t + \bar{q}\left(\frac{l_1}{l_2} y_{t-1} - \frac{1}{l_2}\left(m_{t-1} - s_{t-1}\right)\right) - \left(\phi - \chi\right) y_{t-1} + n + \iota g_{t-1}^h \tag{29}$$

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[4] Purchasing power parity states that the real exchange rate takes a value of unity, i.e. $s\left(p^*/p\right) = 1$. Using the foreign price level as numeraire then gives $s = p$.

Equation (15) gives our second dynamic equation

$$d_{t+1}-(1+r_t)d_t+m_t-m_{t-1}=F(k_t)-(n+i)k_t-c_t-c_t^h-\psi(I_t)-g_t-g_t^h-p_t m_t \tag{30}$$

Given that the left hand side represents the change in the domestic country's net international credit, which is equal to the domestic country's trade surplus, T, given balance of payments equilibrium, this reduces to

$$F(k_t)-(n+i)k_t=c_t+c_t^h+\psi(I_t)+g_t+g_t^h+p_t m_t+T_t \tag{31}$$

Taking consumption to be a function of income (with a marginal propensity to consume of υ), investment in physical capital to be a function of the shadow price, the trade surplus to be a function of the exchange rate, s, and ruling out seigniorage, we may write

$$F(k_t)-(n+i)k_t=\upsilon y_t-\alpha q_t+g_t+g_t^h+\varepsilon s_t \tag{32}$$

Now, letting $F(k_t)=\gamma^{-1}y_{t+1}$ to reflect that output in the next period depends on production in the current period, then

$$y_t=\gamma\left(\upsilon y_{t-1}-\alpha q_{t-1}+g_{t-1}+g_{t-1}^h+\varepsilon s_{t-1}\right) \tag{33}$$

$$\Delta y=-\gamma\alpha q_{t-1}+\gamma(\upsilon-1)y_{t-1}+\gamma\left(g_{t-1}+g_{t-1}^h\right)+\gamma\varepsilon s_{t-1} \tag{34}$$

Taken together, the two dynamic equations (29) and (34) yield the following system to be estimated[5]

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[5] Annual nominal data was obtained from Thomson DataStream for the FT All Share Index (q), GDP (y), M4 (m), USD/GBP exchange rate (s), UK government spending (g, g^h) and population (n) and converted into real terms using the UK CPI.

$$\begin{bmatrix}\Delta q\\ \Delta y\end{bmatrix}=\begin{bmatrix}\bar{r} & -\phi+\chi+\bar{q}\,l_1/l_2\\ -\gamma\alpha & \gamma(\upsilon-1)\end{bmatrix}\begin{bmatrix}q_{t-1}\\ y_{t-1}\end{bmatrix}+\begin{bmatrix}-\bar{q}/l_2 & \bar{q}/l_2 & 0 & \iota & 1\\ 0 & \gamma\varepsilon & \gamma & \gamma & 0\end{bmatrix}\begin{bmatrix}m_{t-1}\\ s_{t-1}\\ g_{t-1}\\ g^h_{t-1}\\ n_{t-1}\end{bmatrix} \tag{35}$$

Let us rewrite into a more streamlined notation to simplify the exposition:

$$\begin{bmatrix}\Delta q\\ \Delta y\end{bmatrix}=\begin{bmatrix}\overset{+}{q}_q & \overset{-*}{q}_y\\ \overset{-}{y}_q & \overset{-}{y}_y\end{bmatrix}\begin{bmatrix}q_{t-1}\\ y_{t-1}\end{bmatrix}+\begin{bmatrix}\overset{-}{q}_m & \overset{+}{q}_s & 0 & \overset{+}{q}_{gh} & 1\\ 0 & \overset{+}{y}_s & \overset{+}{y}_g & \overset{+}{y}_{gh} & 0\end{bmatrix}\begin{bmatrix}m_{t-1}\\ s_{t-1}\\ g_{t-1}\\ g^h_{t-1}\\ n_{t-1}\end{bmatrix} \tag{36}$$

The variables are all able to be signed unambiguously except those denoted by *, i.e. $q_y < 0$ which is signed under the assumption that $\phi > \chi + \bar{q}\,l_1/l_2$. We may note that

$$\begin{aligned} Det\mathbf{A} &= \left(\overset{+}{q}_q\,\overset{-}{y}_y - \overset{-*}{q}_y\,\overset{-}{y}_q\right) < 0*\\ Tr\mathbf{A} &= \overset{+}{q}_q + \overset{-}{y}_y < 0^{\dagger} \end{aligned} \tag{37}$$

The determinant is signed using the assumption * already described[6]. Given this, the system is confirmed to be stable, and adjustment back to equilibrium following a shock to the system is of saddle path form. It is easily confirmed that the stable eigen vector, θ, is

[6] The trace is signed under the assumption † that $\bar{r} < \gamma(\upsilon-1)$, i.e. the interest rate is relative small in comparison with product of the marginal propensity to save and the speed of output adjustment. The sign of the trace is irrelevant to stability providing assumption * holds.

$$\theta = \left(-\overset{-*}{q_y}\right) \Big/ \left(\overset{+}{q_q} - \overset{-}{\rho}\right) > 0* \tag{38}$$

where ρ is the negative characteristic root. The slopes of the stable loci are

$$q_y\big|_{\Delta q=0} = -\overset{-*}{q_y} \Big/ \overset{+}{q_q} > 0* \qquad \text{(slope } \Delta q = 0\text{)} \tag{39}$$

$$q_y\big|_{\Delta y=0} = -\overset{-}{y_y} \Big/ \overset{-}{y_q} < 0 \qquad \text{(slope } \Delta y = 0\text{)} \tag{40}$$

By comparing equations (38) and (39) it can be seen that the $\Delta q = 0$ locus has a slope greater than that of the saddle path. The phase diagram is shown in Figure 1 below.

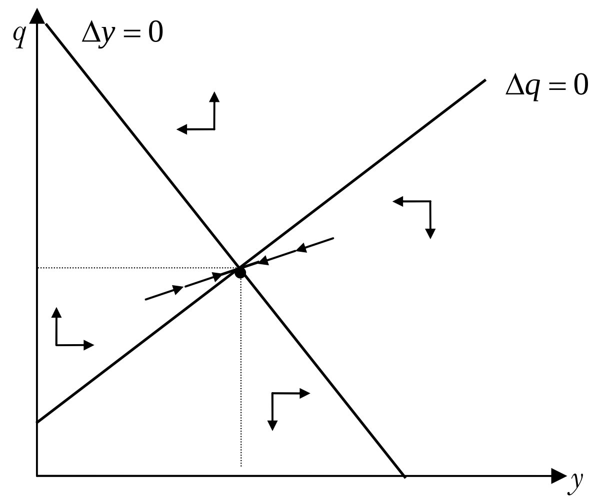

Figure 1

Phase diagram

3. Empirical Analysis

The model in equation (35) is estimated from annual data for the United Kingdom 1964-2005. Before any tests were executed, the data was converted to real variables and was standardised to zero means scaled by the individual standard deviations so the coefficients in any regression analysis are beta coefficients. This seemed to be a more satisfactory scaling of the data since the individual series were widely different in absolute size with implications for the comparability of the estimated coefficients.

The model to be estimated is composed of two interactive equations. Since the variance covariant is matrix of the system is not diagonal this interaction is stochastic and this aspect of the model must be allowed for to obtain efficient parameter estimates.

Breusch and Pagan (1980) suggest an LM test of the significance of this contemporaneous cross equation interaction. The statistic $n\sum_{i}^{m} r_i^2$ for $m = 2,$ and r_i the cross equation correlation of the errors, is distributed as $\chi^2_{(j)}$ where j s the number of correlations. This statistics was computed to be 11.814 where n is the sample size, and this value may be compared with the tabulated value of $\chi^2_{(1),0.05} = 3.814$ rejecting diagonality of the system variance covariance matrix.

Not only are the errors significantly contemporaneously correlated but the problem of heteroskedasticity arises. Homoskedasticity for each equation separately is not rejected but when the two equations are combined partitioned heteroskedasticity may arise if $\sigma_q^2 \neq \sigma_y^2$ (where q refers to the stock price equation and y refers to the real income equation). In this case the variances are each homoskedastic but are unequal suggesting a heteroskedastic correction in the variance covariance matrix Σ for efficient SURE estimation.

The estimator then takes the form.

$$\hat{\beta}_{SURE/GLS} = (X'(\hat{\Sigma} \otimes I)^{-1} X)^{-1} X'(\hat{\Sigma} \otimes I)^{-1} y$$

where $X = \begin{bmatrix} X_q 0 & \\ 0 & X_y \end{bmatrix}$ and $y = [\Delta q \ \ \Delta y \ ]$

The matrix $\hat{\Sigma}$ is also positive definite.

If the errors in each equation are normal then iteration of the estimator will provide Maximum Likelihood Estimates, Kmenta and Gilbert (1968). By the Jarque- Bera test, normality of the errors was not rejected as given in Table 1. This implies that the GLS/SURE estimator will converge to Maximum Likelihood Estimates with iteration.

Δq	0.3784
	(0.8276)
Δy	0.3024
	(0.8597)

Table 1 Jarque-Bera Test statistics for the null of normality of the errors with probability values in parenthesis.

Finally all the explanatory variables should be at least weakly exogenous and should differ across equations. Since the explanatory variables are all lagged values except for the FT index in the Δq equation, the explanatory variables meet this requirement provided FT index is instrumented. The endogeneity of the FT index most likely arises from the temporal aggregation of the data in an annual model.

Following Kinal (1980) at least two instruments are necessary to provide a parameter estimate for which the first which the first two moments. (mean and variance) exist. Lagged FT index and interest rates were chosen as valid instruments in this case. The coefficient values obtained are reported in Table 2 and Table 3.

In each equation the dependant variable (Δq and Δy) is stationary since the null of a unit root is rejected. Also the residual series in each case is also stationary by the same criterion.[7] From the estimates of Table 2 and Table 3, the estimates of the coefficients on Δq_{t-1} and Δq_{t-2} are -0.4123 and -0.3196 respectively. Combined with the dependent variable Δq_t these imply a second order system in Δq which in homogeneous form is:

$$\Delta q_t + \phi_1 \Delta q_{t-1} + \phi_2 \Delta q_{t-2} = 0$$

where $\phi_1 = 0.4123$ and $\phi_2 = 0.3186$

The conditions necessary for stability are

$$\phi_1 + \phi_2 < 1, \qquad -\phi_1 + \phi_2 < 1, \qquad \phi_2 > -1$$

Since there conditions are met the AR(2) process in equation Δq is stationary. However the series q is not stationary in levels by the Augmented Dickey Fuller statistical value. These results imply that Δq follows a stationary (convergent) path around a stochastically trending q. This is not surprising given the time path of the stock market over the data span (1965-2005).

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[7] Since all of the variables in the model are non-stationary in the levels by the ADF test the possibility of cointegration was considered. Support for this possibility comes from the stationarity of the dependent variables Δq and Δy and the stationarity of the residual series for each equation. This would be a possible outcome if the non-stationary variables were co-integrated. Such a conclusion may however be tendentious as the span of annual observations (1965-2005) is unlikely to be sufficient to support clear results on stationarity and more especially on the existence or otherwise of cointegrating vectors. The investigation by the authors led to this conclusion.

4 Policy Analysis

In this section we reveal how the theoretical and empirical analysis conducted in the previous two sections throws into sharp focus the role of public spending on health in the affecting the transmission mechanism behind fiscal and monetary policy, and exposes the precise way in which an economy with substantial public spending on health responds to external labour market shocks.

The underlying theory implicitly embodies a Classical dichotomy in which money appears in the specification of the equity equation alone, while fiscal policy is specified in the income equation only. However, once we decompose government spending into general public spending and public spending on health, the Classical dichotomy is broken, since public spending on health has an effect on the rate of change of health status, which has a direct effect on the effectiveness of labour, and hence on capital per effective labour, and hence on equity prices. It is of note that fiscal policy is measured by government net borrowing; this implies that it also represents the supply of government bonds which many agents might consider as a form of lower risk wealth. Thus, fiscal policy is subject to a Ricardian equivalence effect, by which public borrowing that takes the form of current consumption is viewed as a future tax liability, and therefore has a negative effect on real income.

Looking first at fiscal policy, it is clear from the theoretical model that a rise in *non-health* government borrowing (g) has a negative effect on both real GDP and equity prices[8]. The phase diagram is shown in Figure 2. Consistent with the notion of the Classical dichotomy described above, only the stationary locus for GDP is affected by the rise in general public spending. The crowding out effect of the public spending reinforces the Ricardian equivalence effect in raising interest rates, depressing capital investment, and reducing both GDP and equity prices.

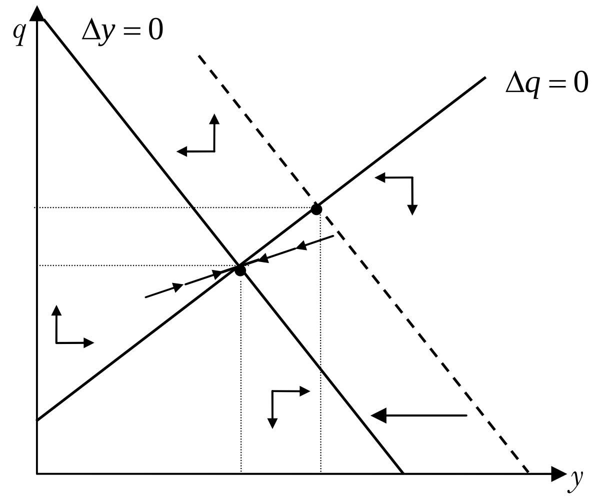

Figure 2

Effect of rise in government spending *excluding* health (g) (the loci corresponding to the initial equilibria are represented by dashed lines)

In contrast, a rise in public spending on health opens the opportunity of a rise in equity prices, if the effect of the consequential improvement in health status has a sufficiently large impact on improving the effectiveness of capital. The phase diagram shown in Figure 3 is drawn showing a neutral effect on equity prices for illustration.

A comparison of the relative magnitudes suggests that the deleterious Ricardian effect on GDP is dominant, possibly capturing the fact that a large proportion of public spending on health is indeed contributing to current consumption (in the form of increases in administration and rises in salaries) rather than true long term investment in productive capacity through more effective workers.

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[8] The detailed proofs are available from the authors upon request.

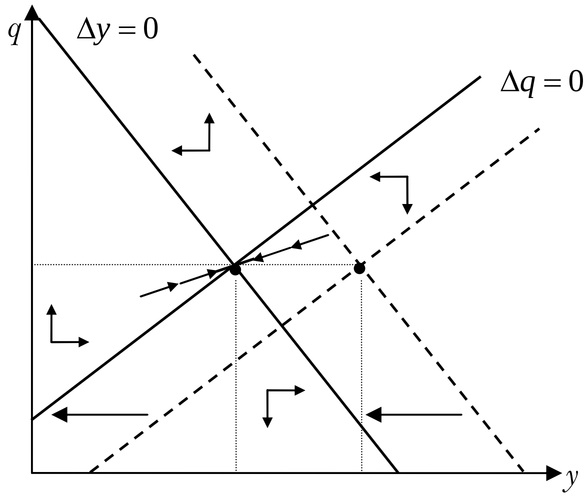

Figure 3

Effect of rise in government spending on health (g_h) (the loci corresponding to the initial equilibria are represented by dashed lines)

It is also interesting to compare the short run dynamic behaviour that results from these two aspects of fiscal policy. In the first case (a rise in general public spending) it is clear that there is undershooting behaviour, but in the second case (a rise in health related public spending) there is potentially overshooting behaviour. That is, equity prices initially rise to a level higher than, and then adjust down to, the new long run equilibrium. In other words, there is a honeymoon period for the policy maker in which the economy appears to be doing well, since the stock market improves instantaneously while the negative effect on GDP takes some time to be realised. This may capture quite well recent policy in the UK during which Chancellor Gordon Brown substantially increased health related public spending against the backdrop of a buoyant economy and a recovering stock market, but with the widely held prospect of slowdowns in performance just around the corner.

The theoretical predictions of the model with respect to monetary policy yield some intriguing results. An expansionary monetary policy can be seen from the phase diagram in Figure 4 to have a positive effect on GDP but a negative effect on share prices. It is easy to hypothesise on the mechanism behind the former effect, but the latter effect demands further explanation. A fall in the interest rate will have the expected positive effect on capital investment and hence on real GDP. However it will also render capital projects that were previously unattractive to be more viable and the substitution effect into equities will have the effect of reducing share prices. The theoretical model suggests that this substitution effect dominates any income effect, and this is borne out by the empirical results. An alternative hypothesis may be provided by the portfolio balance effect of a rise in the money supply in increasing equity holdings and hence reducing equity prices.

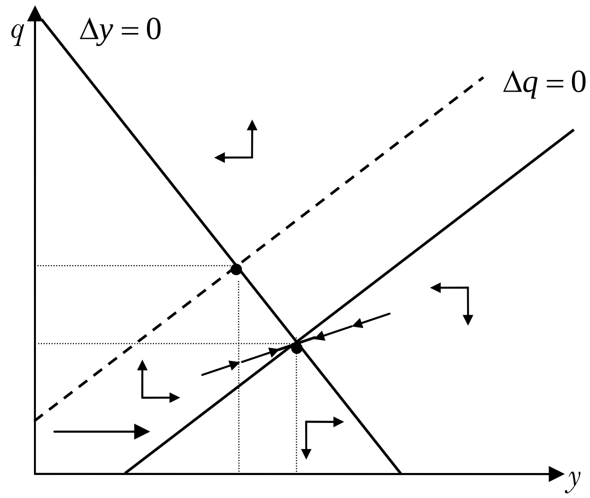

Figure 4

Effect of rise in money supply (m) (the loci corresponding to the initial equilibria are represented by dashed lines)

Finally, we should also draw attention to the overshooting property, through which we can establish that there is initially a negative overreaction of the equity market to the monetary expansion, reflecting the substitution effect described above, followed by a gradual, but insufficient, improvement, perhaps reflecting the emergence of a positive income effect as GDP improves.

5 Conclusions

This paper makes a substantial contribution to the debate on health policy and its impact on the macro-economy. For the first time a model has been developed that captures the unique characteristics of public spending on health and how this impacts on the effectiveness of public policy in a macroeconomic setting. In the model, government expenditure on health has a direct effect on improving the effectiveness of labour, and this feeds through into the dynamic behaviour of the model via its effect on physical capital accumulation. Within this setting the paper sheds light on the effect of public policy. Health related government spending is shown to have a positive effect on GDP and equity prices, since health related spending has an investment effect in increasing the effectiveness of capital. However, non-health government spending has the opposite effect, capturing a crowding out or Ricardian effect of government consumption. The paper therefore highlights the positive role of health investment that governments can achieve, providing that care is taken not to offset these gains by other less positive forms of government intervention. Thus, there emerges a policy recommendation in favour of public investment in health in place of, for example, pure transfer payments. Additionally, there is shown to be a short run period of overshooting as the stock market anticipates the rise in the efficiency of capital. In other words, the policy maker investing in health is rewarded by very rapid and positive responses to the policy. Finally expansionary monetary policy in this setting is shown to have the normal positive effect on GDP, but a negative effect on equity prices due to a dominant substitution effect.

Nomenclature

d	domestic bonds
c	consumption
d	net domestic credit
f	foreign bonds
g	net government spending (subscript h on health)
i	rate of improvement in health status
I	physical capital investment
k	physical capital (per effective labour)
L	Lagrangian function
l	labour
m	money supply
n	exogenous rate of population growth
p	inflation
q	share price
r	interest rate
s	exchange rate
U	utility
u	utility function
v	utility function
X	lump sum taxes
y	output
γ	output adjustment parameter
l_1	income sensitivity of money demand
l_2	interest sensitivity of money demand
α	stock market sensitivity of investment (alpha)
β	subjective rate of time preference (beta)
χ	marginal propensity to consume (health) (chi)
λ	marginal utility of wealth (lambda)
ι	elasticity of health status wrt public spending on health (iota)
υ	marginal propensity to consume (non-health) (upsilon)
ψ	cost of capital investment (phi)
ε	exchange rate sensitivity of net exports (epsilon)
ϕ	sensitivity of profits from physical capital to income (psi)
η	elasticity of health status wrt private spending on health (eta)

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Table 2 - Regression results – share price equation

	Δq_{-1}	Δq_{-2}	q_{-1}	y_{-1}	m	s	g_{h-1}	n	Constant
Δq	***-0.4123***	-0.3196	0.6117	-0.0139	-0.0092	0.0040	0.0173	*0.0098*	0.6421
	(-3.2574)***	(-2.9317)***	(6.9801)***	(-3.7050)***	(-1.8476)**	(5.2131)***	(4.9717)***	(2.373)***	(6.9937)***

R squared 0.606186; Adjusted r-squared 0.497548; SE 0.002210; DW 1.477310; Mean 0.000395; SD 0.003117; SSR 0.000142
t-statistics in parentheses
*** denotes significant at 5% level
** denotes significant at 10% level
* denotes significant at 15% level
bold error correcting

Table 3 – Regression results – GDP equation

	q_{-1}	y_{-2}	Δy_{-1}	s_{-2}	g_{-1}	g_{h-1}	Constant
Δy	-1.1999	**-0.1411**	0.3202	0.0358	-0.2819	*0.1656*	-1.1916
	(-0.6879)	(-2.6262)***	(2.1414)***	(1.4847)*	(-2.6262)***	(2.5806)***	(-0.1916)***

R squared 0.422469; Adjusted r-squared 0.314182; SE 0.051478; DW 1.782639; Mean 0.081081; SD 0.062161; SSR 0.084800
t-statistics in parentheses
*** denotes significant at 5% level
** denotes significant at 10% level
* denotes significant at 15% level
bold error correcting

Appendix

The comparative statics are:

$$y_m\big|_{\Delta q=0} = \overset{-}{q}_m \Big/ \overset{-*}{q}_y > 0* \qquad (\text{m-shift } \Delta q = 0) \tag{41}$$

$$y_g\big|_{\Delta q=0} = \overset{0}{q}_g \Big/ \overset{-*}{q}_y = 0* \qquad (\text{g-shift } \Delta q = 0) \tag{42}$$

$$y_{gh}\big|_{\Delta q=0} = \overset{+}{q}_{gh} \Big/ \overset{-*}{q}_y < 0* \qquad (\text{gh-shift } \Delta q = 0) \tag{43}$$

$$y_n\big|_{\Delta q=0} = \overset{1}{q}_n \Big/ \overset{-*}{q}_y < 0* \qquad (\text{n-shift } \Delta q = 0) \tag{44}$$

$$y_m\big|_{\Delta y=0} = \overset{0}{y}_m \Big/ \overset{-}{y}_y = 0 \qquad (\text{m-shift } \Delta y = 0) \tag{45}$$

$$y_g\big|_{\Delta y=0} = \overset{+}{y}_g \Big/ \overset{-}{y}_y < 0 \qquad (\text{g-shift } \Delta y = 0) \tag{46}$$

$$y_{gh}\big|_{\Delta y=0} = \overset{+}{y}_{gh} \Big/ \overset{-}{y}_y < 0 \qquad (\text{gh-shift } \Delta y = 0) \tag{47}$$

$$y_n\big|_{\Delta y=0} = \overset{0}{y}_n \Big/ \overset{-}{y}_y = 0 \qquad (\text{n-shift } \Delta y = 0) \tag{48}$$

$$\tilde{q}_m = \det_{qm}/\det = \left(\overset{-}{q}_m \overset{-}{y}_y - \overset{-*}{q}_y \overset{0}{y}_m\right) \Big/ \left(\overset{+}{q}_q \overset{-}{y}_y - \overset{-*}{q}_y \overset{-}{y}_q\right) < 0* \tag{49}$$

$$\tilde{y}_m = \det_{ym}/\det = \left(\overset{+}{q}_q \overset{0}{y}_m - \overset{-}{q}_m \overset{-}{y}_q\right) \Big/ \left(\overset{+}{q}_q \overset{-}{y}_y - \overset{-*}{q}_y \overset{-}{y}_q\right) > 0* \tag{50}$$

$$\tilde{q}_g = \det_{qg}/\det = \left(\overset{0}{q}_g \overset{-}{y}_y - \overset{-}{y}_q \overset{+}{y}_g\right) \Big/ \left(\overset{+}{q}_q \overset{-}{y}_y - \overset{-*}{q}_y \overset{-}{y}_q\right) < 0 \tag{51}$$

$$\tilde{y}_g = \det_{yg}/\det = \left(\overset{+}{q}_q \overset{+}{y}_g - \overset{0}{q}_g \overset{-}{y}_q\right) \Big/ \left(\overset{+}{q}_q \overset{-}{y}_y - \overset{-*}{q}_y \overset{-}{y}_q\right) < 0 \tag{52}$$

$$\tilde{q}_{gh} = \det_{qgh}/\det = \left(\overset{+}{q}_{gh} \overset{-}{y}_y - \overset{-}{y}_q \overset{+}{y}_{gh}\right) \Big/ \left(\overset{+}{q}_q \overset{-}{y}_y - \overset{-*}{q}_y \overset{-}{y}_q\right) \tag{53}$$

$$\tilde{y}_{gh} = \det_{ygh}/\det = \left(\overset{+}{q}_q \overset{+}{y}_{gh} - \overset{+}{q}_{gh} \overset{-}{y}_q\right) \Big/ \left(\overset{+}{q}_q \overset{-}{y}_y - \overset{-*}{q}_y \overset{-}{y}_q\right) < 0 \tag{54}$$