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The Dynamic Interaction between Equity Prices and Supply Shocks

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2003-12

ISSN 0908-7745

The activities of EPRU are financed by a grant from
The National Research Foundation

The Dynamic Interaction between Equity Prices and Supply Shocks[1]

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Abstract. This paper develops a theory of medium term share price movements under slow adjustment in the labour market relative to the share market and perfect foresight in the share market. The model seeks to explain the slow movements in real share prices that have been observed in the OECD countries over the past 130 years. Using 130 years of data for the OECD countries, the empirical evidence indicates that movements in factor shares are crucial determinants of medium-term movements in share prices.

JEL Classification: G12, E31, E43.

Key words: Share prices, supply shocks, rational expectations.

1 Introduction

Real share prices have been fluctuating significantly around an upward trend on medium term frequencies of approximately 25-years duration in most of the OECD countries over the past 130 years. Medium term increases have been experienced in the periods 1876-1910, and 1947-1973, and particularly from 1982 to 2000. The periods in-between stand out as periods of stagnant or declining real share prices.

Despite their significance, very little attention has been given to the explanation of medium-term fluctuations in real share prices. A few attempts have been made to explain the share market boom in the 1990s, but no general theory has been forwarded to explain factors that give rise to medium-term movements in share prices (see for instance IMF, 2000, for a discussion of the share market boom in the 1990s). Technology innovations are often stressed as important factors to the share market run-up in the 1990s. Although this explanation has some validity, it fails to explain previous share market runups in history as shown in the next sections.

This paper argues that factor shares are influential for medium term fluctuations in share markets and that factor shares are predominantly determined in the labour market. A simple macroeconomic framework for analysing the dynamic interaction between the share and the labour markets is established. The model extends Blanchard's (1981) model of the

[1] Excellent research assistance from John Gould is gratefully acknowledged. Helpful comments and suggestions from seminar participants at University of Copenhagen, Odense University, University of Western Australia, and University of Konstantz, and Nic Groenewold are gratefully acknowledged.

interaction between share prices and output by allowing for the influence of the supply side. The supply side plays the dual role of determining the distribution of income between wages and profits and at the same time ensures that profits are neutral to supply shocks in the long run.

The supply side is incorporated into the model using the augmented Phillips curve framework. The model shows that movements in earnings in the short run and in the medium term are dominated by supply shocks, and that demand shocks only play a role for fluctuations in share prices on business cycle frequencies. The perfect foresight model incorporates into share prices the empirical regularity that earnings per unit of capital are neutral to demand and supply shocks in the long run. An adverse supply shock that pushes wages in excess of the full employment equilibrium, simultaneously increases unemployment and squeezes earnings. The higher unemployment reduces the wage growth rate, which in turn increases earnings until the natural rate of unemployment is reached. Due to sluggish adjustment in the labour market, the perfect foresight model embodies into share prices that the reduction in earnings is temporary and therefore leads to a substantially smaller reduction in share prices than predicted by the myopic model. The predictions of the model are tested in Section 4 using panel data for the OECD countries.

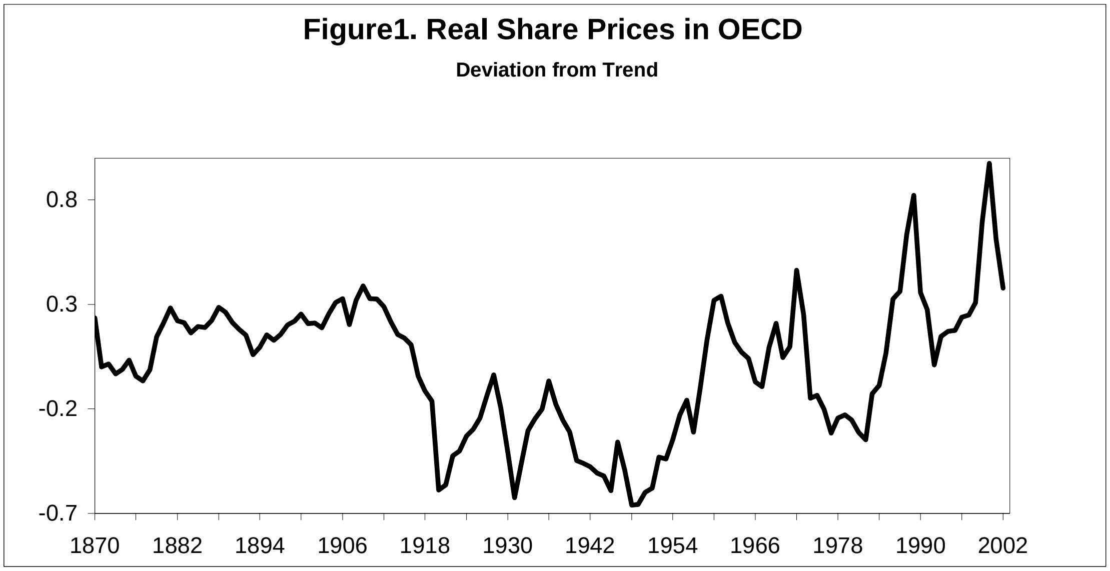
2 Medium-term movements in share prices in the OECD countries

Using data for the OECD countries over the past 130 years, this section gives an overview of the medium term movements in real share prices and their determinants. Real share prices, factor shares, and technology innovations are examined. The trends in the data are removed by least squares regressions on linear time trends and the dependent variable is measured in logs. To simplify the presentation, the whole OECD area is considered and a more disaggregated analysis is delegated to the empirical section.[2] The data sources are detailed in the Data Appendix.

Figure 1 shows the least squares deviation of the log of real share prices from a linear time trend in the OECD countries over the period from 1870 to 2002. The curve is constructed as an unweighted average. The curve shows large medium term swings in particular, and swings on business cycle frequencies. Five upturns of approximately 15 years duration can be traced in the approximate periods 1875-1890, 1995-1910, 1920-1930, 1950-1970, and 1980-2000. The medium-term upturns have all been interrupted by significant falls

[2] Data for the following 22 OECD countries are included in the graphs: Canada, the US, Japan, Australia, New Zealand, Austria, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK.

that are often associated with recessions and depressions such as the depressions in 1920-21, 1929-32, and the recessions in 1948-49, 1974-75 and 1990-92.



There are several factors that influence the medium-term movements in share prices, but probably the most important factor is capital's share in total income. The log of capital's income share's deviation from its trend since 1880 in manufacturing is shown in Figure 2. Manufacturing data are used because aggregate data are biased.[3] Data are only available for a few countries before 1900, but become available for almost all the 22 OECD countries after 1952, as detailed in the data appendix. The average for the OECD countries is unweighted.

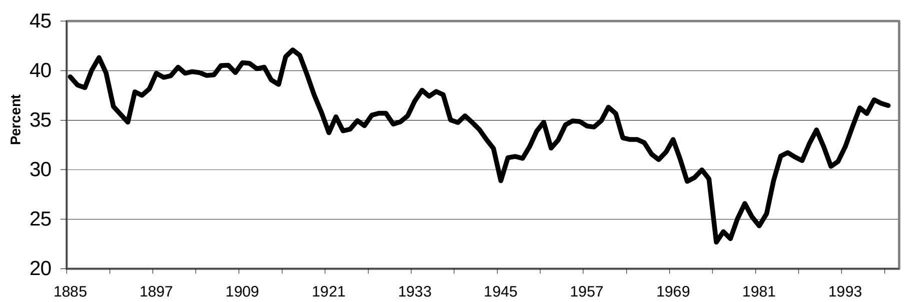
Medium-term cycles of approximately 25 years duration can be identified from the figure. Upturns in capital's income share are visible in the following periods: 1895-1915, 1920-1935, 1945-1960, and 1980-2000. These periods are almost identical to the medium-term cyclical upturns in share prices in Figure 1. The correlation coefficient between the series in Figures 1 and 2 is 0.92, which suggest a very strong relationship between share prices and factor shares.[4] Although the data are highly aggregated and factor shares are only

[3] First, income from self-employment is categorised as property income in national accounts. Since the proportion of self-employment varies substantially among sectors, it follows that changes in sectoral compositions alter the economy-wide factor shares even if sectoral factor shares remain constant. Furthermore, the fraction of self-employed declined substantially prior to the 1970s and hence artificially increased labour's income share (Chan-Lee and Sutch, 1985). The manufacturing sector, however, was not significantly affected by this compositional change since this sector contains a relatively low fraction of self-employed (Chan-Lee and Sutch, 1985). Second, the increasing share of governmental services, such as investment in infrastructure and provision of schooling, in the postwar period has artificially contributed to an increase in labour's income share because these governmental services do not earn an operating surplus. Third, there is also a strong argument in favour of excluding returns to real estate and financial services since they are imputed in national accounts, and profits of financial institutions include the seigniorage earned by the central bank.

[4] Regressing cyclical share prices, q^c, on cyclical capital shares, $s^{k,c}$, yields:

available for a few countries in the beginning of the sample period, this evidence nevertheless suggests that the factor share is a potential important determinant of share prices.

Figure 2. Capital's Income Share in OECD Manufacturing



The share market run-up in the 1980s and the 1990s is often attributed to the 'new economy'. To get a visual impression of the history of the innovative activity, the deviation of the total number of patents in the OECD countries from its trend is displayed in Figure 3. Number of patents is a recognised measure of innovative activity, as argued by Griliches (1990) among others. Furthermore, patents are available over a much long historical time-span than other measures of innovative activity such as *R&D* expenditures, which are first available from around 1960 for the US and from around 1970 in most other OECD countries.

Figure 3 identifies two waves of accelerating or strong growing innovative activity; namely over the period from 1880 to 1886 and from 1980 to 2000. The innovative activity was below the trend over the period from 1933 to 1986. A comparison between Figures 1 and 3 indicates some relationship between real share prices and patents before 1915 and after 1980, but very little in the intervening period.[5] These casual results suggest that technological innovations are of some importance for share prices but that factor shares are the overwhelming forces driving real share prices on medium term frequencies. The extent to

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$$q_t^c = \underset{(0.16)}{0.02} + \underset{(3.55)}{0.83} s_t^{k,c} \qquad R^2 = 0.84, \qquad DW = 1.74$$

where the numbers in parentheses are *t*-statistics and *DW* is the Durbin-Watson statistic. The estimates cover the period from 1871 to 1999. The estimated coefficients of patents is significant at the 5% level if the estimation period is changed to 1871-1915 and 1980-1999 regardless of whether factor shares are included in the estimates.

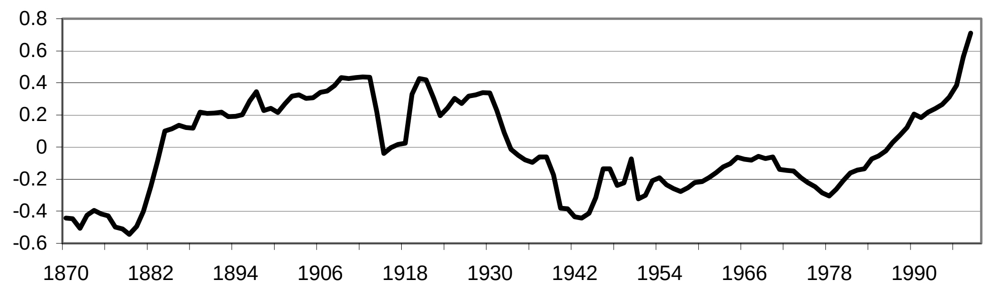
[5] Regressing cyclical share prices on cyclical capital shares and cyclical patents, pat^c, yields:

$$q_t^c = \underset{(0.13)}{0.01} + \underset{(3.54)}{0.82} s_t^{k,c} + \underset{(0.84)}{0.11} pat_t^c \qquad R^2 = 0.84, \qquad DW = 1.74.$$

The estimated coefficient of patents remains insignificant at any conventional significance level, even if factor shares are excluded from the estimates.

which and why factor shares are important for medium term movements in share prices and dividends are shown more formally in the next two sections.

Figure 3. Patents in OECD
Deviation from Trend



3 A model of the interaction between the share and the labour markets

In this section a model of the supply side is incorporated into a dynamic model of share prices in order to examine how supply shocks and unemployment interact with the share market. The idea underlying the model is that factor shares, which are in turn determined by conditions in the labour market, determine earnings per unit of capital. The first part of this section incorporates factor shares into the optimisation problem of the individual firm. The supply side, which determines factor shares, is subsequently incorporated into the model.

Consider the firm's objective function:

$$\max \Pi = (1-\tau)\int_{t=0}^{\infty} e^{-rt}[P_t F(K_t, L_t) - W_t L_t - P_t\, I_t - P_t\, C(I_t)]dt$$

st.

$$K_{t+1} = I_t + K_t$$

where Π is nominal profits, P is the value-added price-deflator, F is aggregate value-added output, K is capital services, I is net investment, W is the wage rate, L is labour services, r is a constant required return to equity, $C(I)$ is the adjustment cost of investment as a positive function of investment, τ is the corporate tax rate, and P is the price deflator, which for simplicity is the same for investment and output. The depreciation rate is set to zero for simplicity.

The current-value Hamiltonian of this optimisation problem is given by:

$$H = (1-\tau)[P_t F(K_t, L_t) - W_t L_t - P_t\, I_t - P_t\, C(I_t)] + Q_t[I_t - \Delta K_t]. \qquad (1)$$

A condition for optimum under the assumption of imperfect competition in the goods market is:

$$(1-\tau)MP_K(1+1/\eta) = rQ_t - \dot{Q}_t\,, \tag{2}$$

where η is the price elasticity of demand facing the firm, and MP_K is the marginal productivity of capital. This equation says that earnings per share are equal to the sum of dividends and capital gains.

From the condition of profit maximisation, $\eta = P/(P - MC)$, where MC is marginal cost, Equation (2) can be written as:

$$\dot{Q}_t = rQ_t - (1-\tau)MP_K(2 - MC/P)\,. \tag{3}$$

To find an exact expression for the marginal productivity of capital and marginal costs, the following Cobb-Douglas production function is assumed:

$$Y_t = AL_t^{\alpha}K_t^{\beta}$$

where Y is value added output, A is a constant, L is labour inputs, K is capital stock and α and β are output elasticities of labour and capital. The marginal productivity of capital equals $\beta(Y/K)$. Furthermore, the marginal costs can be further decomposed into

$$MC_t = W_t MP_{t,L}^{-1} = W_t\alpha^{-1}(L/Y)_t\,,$$

where W is the wage rate and MP_L is the marginal productivity of labour. Substituting into Equation (3) yields:

$$\dot{Q}_t = rQ_t - (1-\tau)\beta\left(\frac{Y}{K}\right)\left(2 - \alpha^{-1}S_L\right). \tag{4}$$

where S^L is the before-tax share of income of the company that is going to labour. This equation applies for the representative individual firm and therefore also holds on an aggregated level. Given that no distinction is made between expected and unexpected values, demand shocks do not play any role in Equation (4). This restriction is relaxed below.

Equation (4) says that the value of shares depends on permanent earnings in equilibrium. Earnings, in turn, depend on the corporate tax rate, the marginal productivity of capital and factor shares. Factor shares are the most influential determinants of movements in earnings since Y/K is relatively constant over time, as shown below. Corporate taxes have been increasing steadily over the past century and have, in that sense, affected the trend in earnings.

To identify which factors determine the share of income going to labour consider the following standard augmented Phillips curve:

$$\Delta \ln W_t = \beta_1 \pi_t^{va} + \beta_2 \Delta \ln MP_{L,t} - \beta_3 (U_t - \phi_t) + \Delta \ln Z_t \nu', \tag{5}$$

where π^{va} is the expected inflation rate measured by the value added price-deflator, MP_L is the expected marginal productivity of labour, U is the rate of unemployment, ϕ is the natural rate of unemployment, Z is a vector of wage push variables, β_1-β_3 are constants, and ν is a vector of constants.[6] The natural rate of unemployment is the benchmark rate of unemployment below which inflation starts increasing. The Z-variables consist of direct and indirect taxes, relative commodity prices, relative food prices, union wage pushiness, unemployment benefits, and other wage push factors (see Madsen, 1998). Under the Cobb-Douglas technology assumption the marginal productivity of labour is given by $\alpha(Y/L)$. Imposing long-run price and productivity neutrality, $\beta_1 = \beta_2 = 1$ Equation (5) reduces to:[7]

$$\Delta \ln S_t^L = -\beta_3 (U_t - \phi_t) + \Delta \ln Z_t \nu'. \tag{6}$$

This equation shows that labour's income share is intimately related to the deviation of unemployment from the natural rate and supply shocks. Unemployment above the natural rate reduces the growth in excess wages until unemployment is brought back to its natural rate. An unemployment rate above the natural rate has been observed in most OECD countries in the 1980s and 1990s, and has therefore contributed to the decrease in labour's income share in the same period (Madsen, 1998). By contrast, a rate of unemployment below the natural rate in the second half of the 1960s and the first half of the 1970s contributed to the increase in labour's income share over the same period. Supply shocks will change the wedge between labour costs and the value-added price-deflator and consequently influence firms' earnings as discussed above.

To find the dynamic path of mark-ups following a supply shock, unemployment is assumed to be a positive function of excess wages and a negative function of demand shocks,

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[6] Blanchflower and Oswald (1994) argue that the labour market obeys the wage equation and not the Phillips curve. Blanchard and Katz (1999), among others, argue that the Phillips curve applies for some labour markets and the wage curve for others. The wage curve-Phillips curve controversy is not yet resolved. Incorporating the wage curve into the framework here yields the same principal results as the ones based on the Phillips curve that the income share of labour is a mean-reverting process if Z is a mean-reverting process. Since there is strong evidence that labour's income share is mean-reverting, as discussed below, the results below are insensitive to the choice of labour market behaviour.

which is a standard assumption in modern theories of unemployment (Madsen, 1998). Excess wages are measured by the real wage gap, W^x, following Bruno and Sachs (1985). Denoting the full employment share of labour in total income, $\bar{S}^L$, which is assumed to be constant, and the wage gap is defined as $W^x = (S^L / \bar{S}^L - 1)$, which is the wage in excess of the full employment equilibrium wage (see Bruno and Sachs, 1985). In other words the real wage gap measures real wages in excess of the marginal productivity of labour at full employment. Inserting this equation into Equation (6) yields the following first-order differential equation:

$$\Delta \ln(W_t^x + 1) = -U(W_t^x, M_t, Q_t, \phi_t) + \Delta \ln Z_{t-1} \nu', \quad (7)$$

where demand shocks are decomposed into real share prices, Q, and other demand shocks, M. Real share prices affect demand due to wealth effects in consumption, and through investment by influencing the marginal value of fixed capital stock relative to its replacement cost and hence investment (Tobin's q). Following the natural rate hypothesis demand shocks affects unemployment due to expectational errors. A demand shock drives a wedge between expected and actual wage and price inflation and hence affects employment. Supply shocks are assumed to influence wages with a one-period lag due to nominal rigidity in the labour market.

Equation (7) shows that a one-off adverse supply shock increases the real wage gap with a one period lag and hence increases labour's factor share by reducing the monopoly profits. However, the effect on factor shares is only temporary. Assuming that the labour market is initially in its long-run equilibrium, a supply shock brings unemployment above its natural rate and leads to subsequent reductions in the real wage gap until labour market equilibrium is restored. The question is what the optimal share market reaction to changes in labour shares is. We now turn to this issue.

To find the dynamic path of the wage gap and share prices, Equations (4) and (7) define two first order differential equations as follows, where Equation (4) is written in compact form for simplicity:

$$\dot{W}_t^x = -U(W_t^x, Q_t, M_t, \phi_t) + \dot{Z}_{t-1} \nu' \quad (8)$$

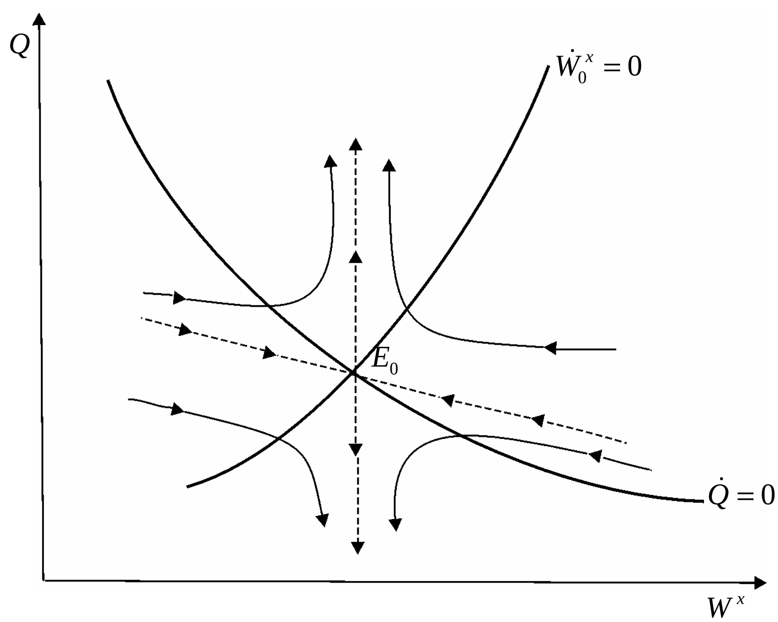
$$\dot{Q}_t = Q_t r - \Psi(W_t^x, \tau_t, Y_t / K_t, M_t), \quad (9)$$

[7] These assumptions are standard in the natural rate framework. If they are not satisfied, then a unique natural rate of unemployment does not exist.

where a dot over a variable signifies a proportional change and ψ is earnings. The equation system has four unknowns, where Q is the jump variable and W^x is the variable that gradually adjusts towards equilibrium.

Demand shocks affect share prices positively due to price expectational errors following standard macroeconomic models. An unanticipated demand shock increases the price mark-up over marginal cost because prices are unexpectedly higher, whereas marginal costs remain constant. Furthermore, due to adjustment costs, firms cannot adjust the capital stock instantaneously and therefore tend to always have excess capacity except at cyclical peaks.[8]

Figure 4. Dynamics of Q and W^x



The phase diagram in Figure 4 illustrates the dynamics of Equations (8) and (9). In steady state equilibrium, $\dot{Q}_t = \dot{W}_t^x = 0$. In the labour market the steady state equilibrium, $\dot{W}_t^x = 0$, is depicted by a positive relationship between real share prices and the wage gap. An increase in real share prices, for example, brings the rate of unemployment below the natural rate, and the wage gap has to increase to maintain equilibrium in the labour market. The optimal dynamic path for the system lies on the saddle point stable manifold shown by the dashed line, where W^x and Q converge to a stable equilibrium (point E_0 in figure 4).[9]

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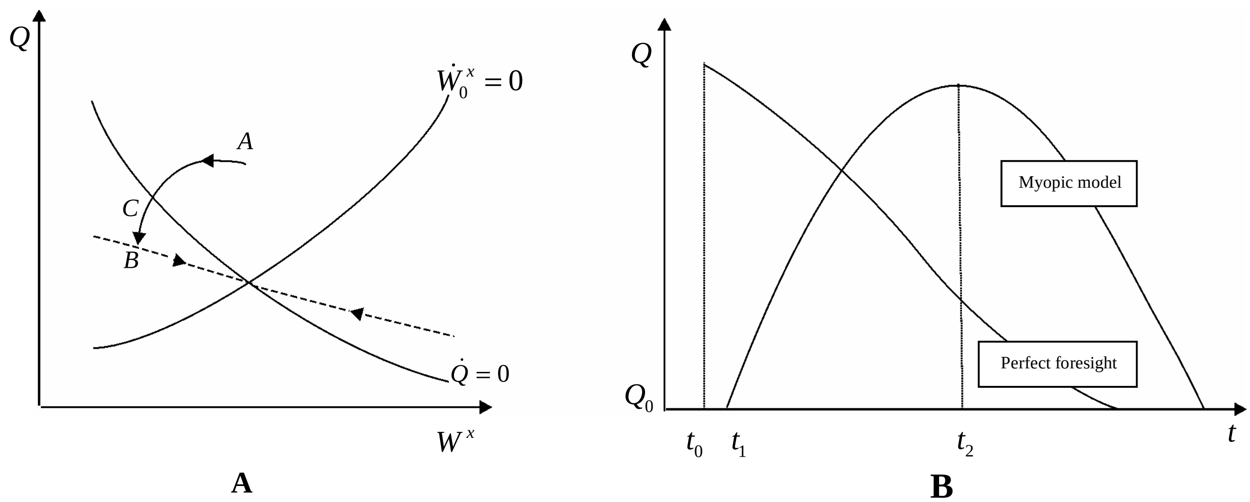
[8] A more formal incorporation of demand shocks is not included since demand shocks are not the focus of the paper.

3.1 Supply shocks and the dynamics of share prices and the wage gap

Suppose that the economy is hit by an unanticipated positive supply shock such as a decrease in the income tax rate, lower real oil prices or a reduction in union activity, which is perceived to be permanent by the share market. A perfect foresight share market will not only take into account that profits will increase shortly after the tax cut has been announced, but also that W^x will revert back to its equilibrium, E_0, in the long run (section A in Figure 5). When the economy is hit by the positive supply shock, Q jumps from E_0 to A to capitalise on expected temporarily higher profits. The economy then moves gradually towards the point B as the supply shock materialises in lower labour costs. The effects on the wage gap of the positive supply shock are borne out at point B. At the point B there is excess demand for labour because the lower wage gap has pulled unemployment below its natural rate; thus leading to a growing wage gap. This process continues until the economy is at the point E_0 where unemployment equals it natural rate.

Figure 5. A positive supply shock



The rational share market incurs a capital loss in the adjustment path A-B-E_0. However, the capital loss is counterbalanced by earnings, which are higher than in their long-run equilibrium, so that a constant required rate of return to shares is maintained. The speed of adjustment towards equilibrium depends predominantly on the speed of adjustment of wages to unemployment and innovations in wage push factors.

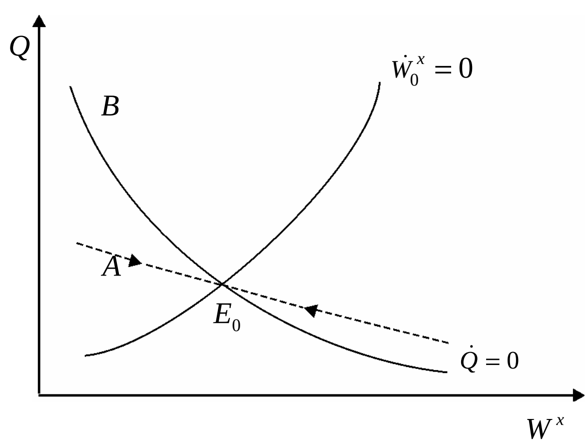
The dynamic path of the myopic share market, where share prices reflect current earnings, is quite different from the perfect foresight market in that share prices first increase as the supply shock materialises in a lower wage gap and therefore higher earnings. The

[9] This path is stable, which is demonstrated in mathematical appendix available from the author.

myopic market will always be on the $\dot{Q}_t = 0$ line. Share prices therefore increase slowly to the point *C*. At the point *C* unemployment is below the natural rate and the wage gap increases until labour market equilibrium is established at E_0.

The time-profiles of share prices, which are displayed in section *B* in Figure 5, show quite different paths for the myopic and the perfect foresight markets. Share prices jump in the perfect foresight market when the income tax cut is announced at time t_0, and decline slowly thereafter, thus suggesting overshooting in the share market. Due to wage stickiness, wages will start declining with a delay from t_1 and share prices will first start increasing in the myopic market from t_1 to t_2 following increasing profits. From t_2 onwards, earnings decrease because the effects on wages of an excess demand for labour outweighs the tax reduction effects. It is noteworthy that *Q* moves in opposite directions in the myopic and the rational share markets over the time period from t_1 to t_2. At the time when earnings start increasing, share prices in the perfect foresight market start decreasing because the market has already incorporated the positive earning prospects into share prices.

Figure 6. A series of adverse supply shocks.



An empirically much more relevant case is the share market response to a series of supply shocks as shown in Figure 6. Historically supply shocks have tended to cluster in certain periods, such as the adverse supply shocks following the two world wars and the period from the late 1960s to the mid 1970s, during which the wage gap was driven up for several years as show by Bruno and Sachs (1985) and as can be seen from Figure 2. Conversely, the positive supply shocks in the 1980s and 1990s and a rate of unemployment, which was well above the natural rate, have driven the share of income going to profits well above its long run equilibrium. The effects of the series of positive supply shocks are depicted in Figure 6. Assuming that the recent decline in W^x has reached its minimum at the point *A* in Figure 6, the perfect foresight share prices are almost at the same level as in the long-run equilibrium in E_0 because the slope of the stable manifold is almost horizontal. By contrast the myopic market is always on the $\dot{Q}_t = 0$ line and has reached the point *B* at the time when the wage gap reached its minimum. Clearly, a myopic share market reacts substantially more positively to a decrease in the wage gap than a perfect foresight market.

In summary, this section has shown that share prices are intimately related to factors shares, which in turn are driven by supply shocks and the deviation of unemployment from its natural rate. Furthermore, it was shown that factor shares are slow to revert to their long run equilibrium due to sluggish adjustment of the labour market towards its long-run equilibrium. This explains why the adverse supply shocks in the post war periods and from the mid 1960s to the mid 1970s simultaneously increased unemployment and depressed share markets for prolonged periods. An important result from the analysis is that share holders need not be myopic to react positively to a positive supply shock, even if they know that profits are temporarily higher, because the present value of expected earnings has increased.

4 Empirical estimates

The model in Section 3 predicts 1) that share prices are driven by factor shares on medium term frequencies; 2) that factor shares are determined in the labour market and therefore that supply shocks and changes in unemployment are the primary sources of changes in factor shares; and 3) that adverse supply shocks affect share prices negatively on impact but subsequently lead to increasing share prices because factor shares converge to a constant mean in the long run. These implications are tested in this section using data for 19 OECD countries over the period from 1953 to 1999, where the countries are listed in the notes to Table 1 below.

First, the importance of factor shares for share prices and the dynamic adjustment of share prices to disequilibrium in the labour market are examined. In order to do that, the model presented in the previous section needs to be transformed to an estimation equation. Integrating Equation (4) yields the value of a share as follows:

$$Q_t = (1-\tau)\int_{\nu=t}^{T} e^{-r(\nu-t)}\beta\left(\frac{Y}{K}\right)\left(2-\frac{1}{\alpha}S_L\right)d\nu + e^{-r(T-t)}Q_t \ .$$

From the transversality condition it follows that the second right-hand-side term in this equation disappears. Assuming that earnings remain constant this equation reduces to:[10]

[10] The expected earnings are only constant in the myopic model. A more complete model would allow for more complex dynamics using the dividend-price model of Campbell and Shiller (1988), for instance.

$$Q = (1-\tau)\beta\left(\frac{Y}{K}\right)\left(2-\frac{1}{\alpha}S_L\right)r^{-1} = (1-\tau)\beta\left(\frac{Y}{K}\right)\psi r^{-1}, \qquad (10)$$

where $\psi = (2-\alpha^{-1}S_L)$, and is referred to below as factor shares. Taking log-first differences yields the following empirical counterpart:

$$\begin{aligned}\Delta \ln Q_{it} &= a_0 + a_1\Delta\ln(Y/K)_{it} + a_2\Delta\ln(Y/K)^e_{i,t+1} + a_3\Delta\ln\psi_{it} + a_4\Delta\ln\psi^e_{i,t+1} \\ &\quad + a_5\Delta\ln(1-\tau_{it}) + a_6\ln Pat_{it} + a_7\Delta\ln r^B_{it} + a_8\Delta\ln r^{B,e}_{i,t+1} + a_9\ln(S^L_{i,t-1}/\bar{S}^L_{i,t-1}) + \varepsilon_{1,it}, \qquad (11)\end{aligned}$$

which is augmented with patents and the deviation of labour's income shares from their long run equilibrium, to allow for the effects of technology innovations and disequilibria in the labour markets as discussed in detail below. Here, the subscripts *i* and *t* refer to country *i* and time *t*, the superscript *e* stands for expected value conditional on information available to the share markets at period *t*, a_1-a_9 are fixed coefficients, *Pat* is the number of patent applications by domestic residents, r^B is the nominal interest rate on long-term government bonds minus the rate of consumer price inflation, and ε is a stochastic error term. Share prices, *Q*, are deflated by consumer prices and α is set to 0.65 in the factor share terms. The *Y/K* ratio is measured as economy-wide real GNP divided by the non-residential capital stock, and $\bar{S}^L_{it}$ is measured as the least squares deviation of the log of labour's income share from a deterministic time-trend for each individual country. The capital stock is based on the perpetual inventory method using data over a century.[11]

Patents are included in the estimates to allow for the effects on share prices of technology innovations as discussed in Section 2, and the term $\ln(S^L_{i,t-1}/\bar{S}^L_{i,t-1})$ allows for adjustment of share prices to the disequilibrium in the factor market, where $\ln(S^L_{i,t-1}/\bar{S}^L_{i,t-1})$ is computed as the residual from regressing the log of S^L on a time-trend for each individual country. A generalised instrumental variable estimator that allows for the correlation of error terms across countries and over time is used to gain efficiency.[12]

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[11] Several national and international data sources are used. Data sources are available from the author.

[12] More specifically the following variance-covariance structure is assumed:

$$\mathrm{E}\{\varepsilon^2_{it}\} = \sigma^2_i, \quad i = 1, 2, \ldots N,$$
$$\mathrm{E}\{\varepsilon_{it},\varepsilon_{jt}\} = \sigma_{ij}, \quad i \neq j,$$

where σ^2_i = the variance of the disturbance terms for country *i* = 1, 2,... *N*; σ_{ij} = the covariance of the disturbance terms across countries *i* and *j*; and ε is the disturbance term. The variance σ^2_i is assumed to be constant over time but to vary across countries and the error terms are assumed to be mutually correlated across

Table 1. Parameter estimates of Equations (11) and (12).

	Equation (11) Unrestricted	**Equation (11)** Restricted		**Equation (12)** Unrestricted	**Equation (12)** Restricted
$\Delta \ln(Y/K)_t$	-1.52(7.07)		$\Delta \ln(Y/K)_t$	0.45(1.34)	
$\Delta \ln(Y/K)^e_{t+1}$	0.56(1.01)		$\Delta \ln(Y/K)^e_{t+1}$	-3.67(5.39)	
$\Delta \ln \psi_t$	0.55(7.44)	0.72(9.46)	$\Delta \ln Pat_t$	0.18(4.37)	0.18(5.27)
$\Delta \ln \psi^e_{t+1}$	3.50(10.1)	3.09(9.55)	$\Delta \ln Pat^e_{t+1}$	0.21(2.75)	0.21(3.22)
$\Delta \ln Pat_t$	0.13(3.35)	0.08(4.24)	$\Delta \ln Tot_t$	-0.81(5.62)	-0.53(6.79)
$\Delta \ln Pat^e_{t+1}$	0.11(1.48)		Δt^d_t	-1.02(3.43)	-1.32(4.58)
$\Delta \ln(1-\tau)_t$	0.35(2.54)		$(U_t - \phi_t)$	1.32(5.19)	1.91(7.81)
Δr^B_t	2.04(2.10)		$\Delta \ln Str_t$	0.00(0.01)	
$\Delta r^{B,e}_{t+1}$	-8.01(4.77)	-5.70(6.31)	Δr^B_t	-0.12(0.13)	
$\ln(S^L_{t-1}/\bar{S}^L_{i,t-1})$	0.13(3.13)	0.13(3.19)	$\Delta r^{B,e}_{t+1}$	-1.41(0.82)	
Constant	0.03(2.91)	0.03(2.62)	$\ln(S^L_{t-1}/\bar{S}^L_{i,t-1})$	0.02(0.44)	
			Constant	-0.07(4.56)	-0.01(0.50)
R^2(mom)	0.27	0.20	R^2(mom)	0.20	0.16
DW	1.96	1.84	*DW*	1.93	1.87

Notes: Absolute t-statistics are given in parentheses. R^2(mom) = Buse's raw moment R-squared. *DW* = Durbin-Watson test for first order serial correlation in fixed effect panel data models. The following variables in first differences are used as instruments for time t+1 variables: Lagged dependent variable, one period lag of the real interest rate, unlagged values and one period lag of the log of real GNP, a one period lag of the log of real share prices, and the log of consumer prices. The following countries are included in the data sample: Canada, the US, Japan, Australia, New Zealand, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Norway, Spain, Sweden, Switzerland, and the UK. Estimation period: 1955 to 1998.

The results of estimating the unrestricted and the restricted models of Equation (11) are shown in the left-hand-side of Table 1. The general-to-specific model reduction procedure is applied in the restricted model at the one-percentage significance level. Instruments are used for expectational variables and the instruments are listed in the notes to Table 1. The estimates suggest that factor shares, patents, the expected real interest rate, and labour market disequilibrium, as represented by the deviation of factor shares from their long-run equilibrium, are statistically significant determinants of share prices. The estimated coefficient of the period $(Y/K)_t$ ratio is negative, and therefore restricted to zero in the restricted model. Its negativity could be due to reverse causation running from real share prices to the Y/K ratio. The increasing share prices in the 1980s and 1990s, for instance, reduced the cost of capital and hence induced an expansion in the

countries, σ_{ij}, as random shocks are likely to impact on all countries at the same time. σ_i^2 and σ_{ij}, are estimated fixed capital investment to such an extent that the *Y/K* ratio was reduced at the same time as real share prices increased.

In both the restricted and unrestricted models, the sum of the estimated coefficients of factor shares is approximately 4, which suggests that factor shares are highly influential for share prices given that factor shares, ψ, typically move 20% within a 20-30 year cycle. Using the point estimates of 4, the 25% increase in factor shares in the OECD countries on average over the period from the mid 1970s to the late 1990s contributed to a 100% increase in share prices over the same period; thus being a major force behind the share market run-up in the last two decades on the last century. The contribution of patents to the share market run-up in the 1980s and the 1990s has been less important. The number of patent applications increased by 150% in the OECD countries over the period from 1980 to 1999. Using the point estimate of 0.08 from the restricted model, this has contributed to a 13% increase in the share prices over the same period.

The estimated coefficient of the deviation of labour's income share from its long-run equilibrium is significantly positive, which is consistent with the predictions of the model in the previous section. The share market will therefore adjust share prices downwards if factor shares are in favour of capital and vice versa. The share market therefore incorporates into share prices that factor shares will converge towards a constant mean in the long run.

To investigate the supply factors that determine share prices via factor shares, Equation (6) is substituted into Equation (11), which yields the following stochastic approximation:

$$\Delta \ln Q_{it} = b_0 + b_1 \ln(Y/K)_{it} + b_2 \ln(Y/K)^e_{i,t+1} + b_3 \Delta \ln Str_{it} + b_4 \Delta \ln t^d_{it} + b_5 \Delta \ln Tot_{it}$$
$$+ b_6 (U_{it} - \phi_{it}) + b_7 \Delta \ln Pat_{it} + b_8 \Delta \ln Pat^e_{i,t+1} + b_9 \Delta r^B_{it} + b_{10} \Delta r^{B,e}_{i,t+1} + b_{11} \ln(S^L_{i,t-1} / \bar{S}^L_{i,t-1}) + \varepsilon_{2,it}\,, \quad (12)$$

where the wage push factors are strikes, *Str*, the direct tax rate, t^d, and terms-of-trade, *Tot*, which are commonly used as wage push factors in the macro unemployment literature (see for instance Madsen, 1998). Strikes are measured as number of days lost in strikes and lockouts per worker, the direct tax rate is measured as total direct taxes divided by nominal GNP, and *Tot* is measured as consumer prices divided by the value-added price-deflator, and therefore encompasses indirect taxes and terms-of-trade shocks that create a wedge between the prices facing consumers and producers. Increasing oil prices, for instance, increase consumer prices more than the value-added price-deflator, and hence push wages in excess of their equilibrium, and therefore squeeze profits. Similarly, if unemployment is pushed below its natural rate, then wages will also be pushed in excess of their equilibrium. The deviation of

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using the feasible generalized least squares method described in Greene (2000, Ch. 15).

unemployment from its natural rate is estimated as the residual from regressing unemployment on a linear time trend for each individual country.[13]

The results of estimating the restricted and unrestricted versions of Equation (12) are shown in the right-hand side of Table 1. The sum of the estimated coefficients of the real interest rates and the output-capital ratio are opposite to what one should expect and these variables are consequently deleted in the restricted estimates. The estimated coefficient of strikes is statistically insignificant, which is not unusual in empirical applications, and the insignificance probably reflects that the strike activity is highly volatile and is often an outcome of several years' tension between employees and employers. In contrast to the estimates of Equation (11) the estimated coefficient of the deviation of labour's income share from its long-run equilibrium is insignificant at the 1-percentage level, which suggests that it is not entirely clear how the labour market interprets the effects of the deviation of factor shares from their long-run equilibrium on future earnings.

Apart from strikes, the wage push factors are highly significant and have their expected signs. This implies that oil price shocks and innovations to direct and indirect taxes are important for share prices by affecting labour's share in total income. Similarly, the deviation of the level of unemployment from its natural rate is influential for the growth in real share prices. Since unemployment is often out of its natural rate equilibrium for prolonged periods, share markets are similarly affected by the labour market disequilibrium for prolonged periods.

The estimated coefficients of patents are highly significant and exceed the point estimates of Equation (11) by a factor of five. This suggests that technology innovations are not only influential for earnings because they affect expected earnings, but also because they influence labour's income share. A technology innovation reduces labour's income share because firms are able to exploit the temporary monopoly rights that the patenting system gives them.

5 Conclusion

Real share prices have shown large medium term fluctuations around an upward trend in the OECD countries over the past 130 years. This paper has argued that labour's income share, which is determined in the labour market, is the most important factor explaining the medium-term movements in share prices around this upward trend. A simple macroeconomic model was established to show how these medium-term fluctuations were generated as

[13] It is of course questionable whether the natural rate follows a linear trend. The estimates, however, are robust to different specifications of the natural rate such as a constant and a second order polynomial.

responses to supply shocks and technological innovations. In the long run, however, factor shares will revert back to their initial equilibrium. This implies that real share prices return to their long-run equilibrium trend.

The model has important implications for the predictability of real share prices and share market rationality. The model implies that the deviations of real share prices from their long run trend and dividend yield are predictors of share prices in a rational share market. The empirical literature has often found that the dividend-price ratio predicts growth in share prices (see for instance Fama and French, 1989). The model in this paper suggests that this is a rational response among shareholders. A positive supply shock, for instance, increases share prices on impact and reduces the dividend-price ratio as share prices jump but dividends remain approximately unaltered because managers know that the higher earnings are temporary. Since share prices will decline after the initial impact, it follows that the dividend-price ratio will be a predictor of the growth in share prices.

Using panel data for the OECD countries over the period from 1953 to 1999, the empirical estimates showed that factor shares and supply shocks are important, if not the most important, macroeconomic variables driving real share prices. Hence, the increase in capital's income share in the 1980s and the 1990s were an influential factor behind the share market run-up in the 1980s and 1990s.

DATA APPENDIX.

Investment in equipment and non-residential structures in fixed and current prices. Several different data sources are used for historical data on investment and a list of sources is available from the author. The postwar data are from OECD, *National Accounts*, *Vol. II*, Paris,*(NA)*. **Real and nominal GDP.** *NA*. **Consumer Prices**. IMF, *International Financial Statistics (IFS)*. **Interest rates**. *IFS.* **Share prices**. Canada. 1900-1924: Dimson, Elroy, Paul Marsh and Mike Staunton, 2000, *The Millennium Book, A Century of Investment Returns*, London Business School, ABN, AMRO, 1924-98: Panjer, Harry H and Keith P Sharpe, 1999, "Report on Economic Statistics 1924-1998," Canadian Institute of Actuaries. Australia. All Ordinary Index, Sydney Stock Exchange, collected for the Reserve Bank of Australia. Denmark. 1900-1924: Hansen, K, 1976, "Om Afkastet af Danske Aktier i Tiden 1900-1974," Optrykt i Nordisk Fjerfabriks Jubilæumsskrift, Nordisk Fjerfabrik, Aktieselskab, 1924-99: Claus Parum, "Aktieindeks, aktieafkast og risikopræmier, Manuscript, 98-7, Institute of Finance, Copenhagen Business School, Claus Parum, "Estimation af Realkreditobligationsafkast i Danmark i Perioden 1925-1998," *Finans/Invest* 1999/7, Claus Parum, "Historisk Afkast af Aktier og Obligationer i Danmark," *Finans/Invest* 1999/3. France. 1874-1900: *NBER Macroeconomic Data Base*. Greece. Maurice Garnout, 1994, *World Directory of Stock Exchange*, WISER Research, Montreal, and OECD, *Main Economic Indicators*, Paris. Italy. Panetta, Fabio and Robert Violi, 1999, "Is there an Equity Premium Puzzle in Italy? A look at Asset Returns, Consumption and Financial Structure Data over the Last Century," Termi di Discussione 353, Bank of Italy (data received by personal correspondence with Fabio Panetta). Luxembourg. Maurice Garnout, 1994, *World Directory of Stock Exchange*, WISER Research, Montreal, and OECD, *Main Economic Indicators*. Netherlands. Eichholtz, Piet, Kees Koedijk and Roger Otten, 2000, "De Eeuw van Het Aandeel," *Economisch Statistische Berichten*, January (data received by personal correspondence with Piet Eichholtz and Roger Otten). Norway. 1960-1970: Roger G Ibbotsen, Richard C Carr and Anthony W Robinsen, 1982, "International Equity and Bond Returns," *Financial Analysts Journal*, 5-27. Sweden. Per Frennberg and Bjørn Hansson, 1992, "Computation of a Monthly Index for Swedish Stock Returns: 1919-1989," *Scandinavian Economic History Review*, XL, No 1, 3-27 (data received by personal correspondence with Bjørn Hansson). Switzerland. H Ritzmann-Blickenstorfer, 1996, *Historical Statistics of Switzerland*, Chronos: Zurich. United Kingdom. 1870-1913: Richard S Grossman, 2002, "New Indices of British Equity Prices, 1870-1913," *Journal of Economic*

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MATHEMATICAL APPENDIX

1A. Stability

Equations (13) and (14) are linearized as follows:

$$\dot{Q} = \lambda_0 + rQ + \lambda_1 W^x - \lambda_2 M$$
$$\dot{W}^x = \alpha_0 - \alpha_1 W^x + \alpha_2 Q + \alpha_3 \dot{Z} + \alpha_4 M$$

where λ_i are constants for all $i = 0, 1, 2$ and α_i are constants for all $i = 0,.., 4$. The system can be compactly written as

$$\begin{pmatrix} \dot{Q} \\ \dot{W}^x \end{pmatrix} = \begin{pmatrix} \lambda_0 \\ \alpha_0 \end{pmatrix} + \begin{pmatrix} r & \lambda_1 \\ \alpha_2 & -\alpha_1 \end{pmatrix} \begin{pmatrix} Q \\ W^x \end{pmatrix} + \begin{pmatrix} 0 \\ \alpha_3 \end{pmatrix} \dot{Z} + \begin{pmatrix} -\lambda_2 \\ \alpha_4 \end{pmatrix} M . \qquad \text{(A1)}$$

A long-run solution to this system, where $\dot{Q} = \dot{W} = \dot{Z} = M = 0$ is given by

$$\begin{pmatrix} r & \lambda_1 \\ \alpha_2 & -\alpha_1 \end{pmatrix} \begin{pmatrix} Q \\ W^x \end{pmatrix} = \begin{pmatrix} -\lambda_0 \\ -\alpha_0 \end{pmatrix}$$

and solving for Q and W yields

$$\begin{pmatrix} \overline{Q} \\ \overline{W} \end{pmatrix} = \frac{1}{r\alpha_1 + \lambda_1 \alpha_2} \begin{pmatrix} -\lambda_0 \alpha_1 - \lambda_1 \alpha_0 \\ -\lambda_0 \alpha_2 + r\alpha_0 \end{pmatrix} .$$

1B. Solution Path

Let $X = \begin{pmatrix} Q - \overline{Q} \\ W^x - \overline{W}^x \end{pmatrix} \dot{X} = \begin{pmatrix} \dot{Q} \\ \dot{W}^x \end{pmatrix}$ and $A = \begin{pmatrix} r & \lambda_1 \\ \alpha_2 & -\alpha_1 \end{pmatrix}$.

Then the complementary solution to this system of ordinary differential equations is the solution to the system as follows:

$$\dot{X} = AX .$$

Its complementary solution has the form

$$X = c_1 \xi_1 e^{\mu_1 t} + c_2 \xi_2 e^{\mu_2 t}$$

where c_1, c_2 are constants subject to some initial conditions, μ_1, μ_2 are the eigenvalues of A, and ξ_1, ξ_2 are the eigenvectors associated with the eigenvalues. By definition,

$$A\xi = \mu\xi ,$$

hence

$$|A-\mu I|=0 \text{, which implies that } \begin{vmatrix} r-\mu & \lambda_1 \\ \alpha_2 & -\alpha_1-\mu \end{vmatrix} = 0,$$

or

$$-\mu^2+(r-\alpha_1)\mu+(\lambda_1\alpha_2+r\alpha_1)=0$$

which yield the two roots as follows

$$\mu_1=\frac{(r-\alpha_1)+\sqrt{(r-\alpha_1)^2+4(\lambda_1\alpha_2+r\alpha_1)}}{2}$$
$$\mu_2=\frac{(r-\alpha_1)-\sqrt{(r-\alpha_1)^2+4(\lambda_1\alpha_2+r\alpha_1)}}{2}$$

or

$$\mu_1=\frac{(r-\alpha_1)+\sqrt{(r+\alpha_1)^2+4\lambda_1\alpha_2}}{2} \text{ and } \mu_2=\frac{(r-\alpha_1)-\sqrt{(r+\alpha_1)^2+4\lambda_1\alpha_2}}{2}.$$

Assuming that the $(r-\alpha_1)>0$ then we have $\mu_1>0>\mu_2$ and therefore the steady-state is in fact a saddle point. Hence, only (W^x, Q) that lies on ξ_2 will be attracted towards the steady state and any other point on the (W^x, Q)-plane, diverges.

The eigenvectors associated with μ_1 and μ_2 are given by:

$$\xi_1=\left(\frac{(r+\alpha_1)-\sqrt{\alpha_1^2+4\alpha_2\lambda+2\alpha_1 r+r^2}}{2\alpha_2},1\right)$$

$$\xi_2=\left(\frac{(r+\alpha_1)+\sqrt{\alpha_1^2+4\alpha_2\lambda+2\alpha_1 r+r^2}}{2\alpha_2},1\right).$$

The initial value must satisfy $c_1=0$ in order to reach the steady state. Any initial value that fails to satisfy this condition will drift away from the steady state as time heads towards infinity. Therefore, the steady path is

$$c_1\begin{pmatrix} \dfrac{(r+\alpha_1)+\sqrt{\alpha_1^2+4\alpha_2\lambda+2\alpha_1 r+r^2}}{2\alpha_2} \\ \\ 1 \end{pmatrix}$$

where $c_1\in\Re$. It can also be expressed as a linear equation on the (W^x,Q)-plane as

$$Q-\overline{Q}=\frac{(r+\alpha_1)+\sqrt{\alpha_1^2+4\alpha_2\lambda+2\alpha_1 r+r^2}}{2\alpha_2}(W^x-\overline{W}^x).$$

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