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A Revised Tobin Effect from Inflation: Relative Input Price and Capital Ratio Realignments, USA and UK, 1959–1999

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The paper studies the realignments induced by inflation within an endogenous growth monetary economy. Accelerating inflation raises the ratio of the real wage to the real interest rate, and so raises the use of physical capital relative to human capital across all sectors. We find cointegration evidence for the US and UK economies consistent with a general equilibrium, Tobin-type, effect of inflation on input prices and capital intensity, even while the growth rate of output is reduced by inflation.

INTRODUCTION

Non-neutralities of long-term inflation have been identified as a key topic in macroeconomic research such as Lucas (1996). The Tobin (1965) effect is a long studied type of inflation non-neutrality. As Walsh (1998) details, Tobin looks at what happens, in an exogenous growth Solow economy with a fixed savings rate, to the use of physical capital when inflation increases. Money serves no useful role other than as a financial capital asset like physical capital. Assuming *ad hoc* that the money–capital ratio depends negatively on the inflation rate, an increase in the inflation rate causes a greater holding of capital relative to money. Output and consumption therefore rise in the steady state. This very simple model gives this result easily because there is no cost arising from using less money. It is an improvement on earlier models in that it gives us the basic asset stock and asset flow constraints for a model that includes money and capital as assets.

Using the similar stock and flow constraints as in Tobin's asset approach, Sidrauski (1967) lets the agent optimize with money entering the utility function. Deriving the marginal product of capital, he finds that it does not in fact depend on the inflation rate. This is a result that continues to hold in all subsequent models with such stock and flow constraints.[1] With goods and money in the utility function (MIUF), inflation decreases utility by taxing money and inducing the agent to substitute goods consumption for money; money and goods are necessarily substitutes, with only two goods in the utility function. But steady-state output and consumption remain unaffected. The only result is that the demand for money goes down. Walsh (1998) analyses the transition dynamics of such a MIUF model, and shows that inflation can induce more consumption, and so requires more capital accumulation to produce that consumption along the path. Thus, the Tobin effect is only transitional here.

The more recent cash-in-advance approach to the Tobin-type effect dates back to Stockman (1981). He requires capital as well as consumption goods to be bought with cash, so that inflation has a negative effect on physical capital and the level of output, the opposite of the Tobin result. Ireland (1994) employs a linear, capital-only model, the so-called 'AK' model, with a cash-in-advance constraint on consumption. However, the agent can avoid inflation by using credit for exchange, on condition that capital is employed in providing the credit services. This causes a speed-up of capital accumulation along the transition path. The growth rate of output in the AK setting is unaffected. This represents a transitional Tobin-type effect similar to that of Walsh (1998). Dotsey and Sarte (2000), in a similar AK model, find no growth effect of inflation in the deterministic case. Ahmed and Rogers (2000) review other variations of Tobin-type effects within exogenous-growth, representative-agent monetary models.

In this paper we present an endogenous-growth, cash-in-advance model with striking Tobin-type effects in general equilibrium. The model redefines the Tobin effect in a way very sympathetic to the original work. Here it is the realignment of factor inputs whereby an increase in the inflation rate increases the physical capital–effective labour ratios across sectors. The savings rate rises as well. These are permanent effects on the new balanced-growth path.

The rationale for this new-style Tobin effect is based on the effect that inflation has on the return to capital, as well as on the real wage—i.e. the factor prices. An inflation rate increase induces substitution from (exchange) goods to (non-exchange) leisure. This leisure increase drives the results. First, the 'leakage' of time through more leisure reduces the return on *human* capital.[2] Since all capital earns the same return in equilibrium, the real interest, i.e. the return on physical capital, must also fall. Meanwhile, labour is diverted in the model towards credit services, similar to how Ireland (1994) diverts capital for this purpose, and so the real wage rises.[3] The growth rate falls because the return on all capital falls. The capital–effective labour ratios are increased, because of the rise in the real wage relative to the real interest rate, thereby allowing the decrease both in the return to capital and in the growth rate to be slightly mitigated. So, while the 'Tobin effect' of the capital–effective labour reallocation does not increase output or the growth rate of output, the better allocation of inputs in the face of the inflation tax does lessen the fall in the growth rate.

The Kormendi–Meguire (1985) negative effect of inflation on growth has recently been found to be robust empirically by Ghosh and Phillips (1998), Khan and Senhadji (2000) and Gillman *et al.* (2001) using advanced panel data estimation methods. These papers clarify how, for developing countries, the inflation–growth effect can be positive at low ranges of the inflation rate. But for high ranges of the inflation rate for developing countries, and for all (positive) inflation rates for developed countries, the effect is negative. Further, a nonlinearity in the inflation–growth effect is identified theoretically in Chari *et al.* (1996), explained theoretically in Gillman and Kejak (2000a), and found econometrically in the above-mentioned three empirical papers. For example, Gillman *et al.* identify the nonlinearity by segmenting a postwar OECD panel into three average inflation rate ranges of 0–10%, 10%–20% and above 20%. They find the highest magnitude of the negative inflation–growth effect in the low inflation rate range of 0–10%, and the smallest magnitude in the high range of above 20%. Thus, the nonlinearity is that the negative inflation–growth effect gets weaker as the level of the inflation rate rises.

In this paper we continue to extend this literature on the effects of inflation by giving a theoretical statement of the Tobin-style effect as derived from the Gillman–Kejak (2000b) model.[4] We then test it with time-series evidence for two of the most developed, lowest-inflation countries, the United States and the United Kingdom. For these countries both the inflation–growth effect and the Tobin-type effect of factor allocation should be strongest, in that evidence suggests that the strongest, negative, inflation–growth effect is in industrial countries. The strength of the growth effect translates through to the strength of the Tobin-type effect, according to calibrations by Gillman and Kejak (2000b). They show that the strength of the inflation–growth effect and the input reallocation effects are part of the same set of adjustments, and so are related in the magnitude of their effects. The Tobin-type input reallocation is just another side of the inflation–growth effect. On this basis, the United States and the United Kingdom should be fertile ground for finding evidence of Tobin-style input reallocations.

We present the monetary model in Section I and discuss the equilibrium link of the Tobin effect and the growth effect. We discuss the quarterly data and present unit root, causality and cointegration results in Section II. We conclude, in Section III, that this adds significant new evidence in support of this new style of Tobin effect.

I. Endogenous Growth, Cash-in-Advance Model

The model is that of Gillman and Kejak (2000b), and our restatement of it will focus on details relating to the factor reallocation effects of inflation. It is an endogenous-growth, cash-in-advance model with human and physical capital, and with a finance sector producing credit services that are used to avoid the inflation tax. Utility at time t depends on goods, c_t, and leisure, x_t, in the CES form:

$$(1) \qquad U = \int_0^{\infty} \mathrm{e}^{-\rho t}[c_t^{1-\theta} x^{\alpha(1-\theta)}/(1-\theta)]\mathrm{d}t.$$

Goods and human capital are produced with physical capital and effective labour, each through a Cobb–Douglas production function. With h_t and k_t denoting the stock of human and physical capital, and l_{Gt} and s_{Gt} the share of raw labour and physical capital used in goods production, with $\beta \in (0, 1)$, and with A_{Gt} a productivity shift parameter, the output y_t of goods is given by

$$(2) \qquad y_t = A_G(s_{Gt}k_t)^{1-\beta}(l_{Gt}h_t)^{\beta}.$$

With similar notation, using H for the human capital sector, with $\eta \in (0, 1)$, and with the depreciation rate given by $\delta_h \in \mathbb{R}_+$, the change in the human capital stock is given by

$$(3) \qquad \dot{h}_t = A_H(s_{Ht}k_t)^{1-\eta}(l_{Ht}h_t)^{\eta} - \delta_h h_t.$$

The share of goods bought with currency is an endogenous fraction $a_t \in (0, 1]$ and the share of goods bought with credit residually is $(1 - a_t)$. The share of credit is produced using only the effective labour per unit of goods consumption, with diminishing returns. Let l_{Ft} denote the fraction of raw labour devoted to credit service production and assume that $\gamma \in (0, 1)$. The production function is

$$(4) \qquad (1 - a_t) = A_F(l_{Ft}h_t/c_t)^{\gamma}.$$

Money purchases are constrained by the nominal money balances in a Clower-type constraint,

$$(5) \qquad M_t = a_t P_t c_t,$$

which can be restated with substitution from (4) as

$$(6) \qquad M_t = [1 - A_F(l_{Ft}h_t/c_t)^{\gamma}]P_t c_t.$$

Money is supplied by the government at a constant rate $\sigma \in \mathbb{R}$ each period through a lump-sum cash transfer of V_t, so that $\dot{M}_t = V_t \equiv \sigma M_t$.

The total financial wealth, denoted by Q_t, is the sum of the money stock M_t and the nominal value of the physical capital stock:

$$(7) \qquad Q_t = M_t + P_t k_t.$$

The output of goods is divided between consumption and investment net of capital depreciation:

$$(8) \qquad c_t + \dot{k}_t - \delta_k k_t = A_G(s_{Gt}k_t)^{1-\beta}(l_{Gt}h_t)^{\beta}.$$

The nominal capital and labour income from goods production is the nominal value of the marginal products factored by the capital and effective labour used in production. Let r_t be the marginal product of capital $(s_{Gt}k_t)$, and w_t be the marginal product of effective labour $(l_{Gt}h_t)$. The change over time in the agent's financial capital $\dot{Q}_t$ equals the income net of expenditure and depreciation, plus the term $\dot{P}_t k_t$ to account for the change in nominal value of physical capital:

$$(9) \qquad \dot{Q}_t = \dot{M}_t + P_t\dot{k}_t + \dot{P}_t k_t = r_t P_t s_{Gt} k_t + w_t P_t l_{Gt} h_t + V_t - P_t c_t - \delta_k P_t k_t + \dot{P}_t k_t.$$

Equilibrium

The agent maximizes utility in (1) subject to the stock constraints (6) and (7) and the flow constraints (3) and (9) with respect to c_t, x_t, s_{Gt}, $l_{G\tau}$, l_{Ft}, M_t, Q_t, k_t and h_t. Using a Becker (1965)-type allocation of time constraint, $1 = x_t + l_{Gt} + l_{Ht} + l_{Ft}$, and the constraint $1 = s_{Gt} + s_{Ht}$, the problem can be stated as follows:

$$\begin{aligned}(10) \qquad \text{Max} \sim \boldsymbol{H} = {} & \mathrm{e}^{-\rho t} c_t^{1-\theta} x_{\mathrm{t}}^{\alpha(1-\theta)}/(1-\theta) \\ & + \eta_t(M_t - [1 - A_F(l_{Ft}h_t/c_t)^{\gamma}]P_t c_t) \\ & + \varphi_t(Q_t - M_t - P_t k_t) \\ & + \lambda_t(r_t P_t s_{Gt} k_t + w_t P_t l_{Gt} h_t - P_t c_t + V_t - \delta_k k_t + \dot{P}_t k_t) \\ & + \mu_t(A_H[(1 - s_{Ft} - s_{Gt})k_t]^{1-\eta}[(1 - x_t - l_{Ft} - l_{Gt})h_t]^{\eta} - \delta_h h_t).\end{aligned}$$

The first-order equilibrium conditions are:

(11) $u_c/u_x = x/(\alpha c) = [1 + aR + (1 - a)\gamma R]/wh;$

(12) $-\dot{\lambda}/\lambda \equiv R = r + \dot{P}/P;$

(13) $R = (w/[A_F \gamma (s_F k/l_F h)^{1-\gamma}]);$

(14) $w/r = (s_G k/l_G h)(\beta/[1-\beta]) = (s_H k/l_H h)(\eta/[1-\eta]), ;$

(15) $g \equiv \dot{c}/c = \dot{k}/k = \dot{h}/h = [r - \rho]/\theta$

$= [(1 - x)A_H \beta (s_H k/l_H h)^{1-\eta} - \rho]/\theta.$

By (11), the marginal rate of substitution between leisure and goods per unit of human capital equals the ratio of the shadow price of leisure to goods. As the inflation rate increases, the nominal interest rate R rises and induces substitution on the utility side from c/h to x. Gillman and Kejak (2000a) show that the nominal interest rate, which by (13) equals the marginal factor cost divided by the marginal factor input, represents the marginal cost of credit services, a generalization of the Baumol (1952) model.

Further, calibrations in Gillman and Kejak (2000b) show that the inflation-induced reallocation of time into credit services and leisure, away from goods production and human capital accumulation, raises the real wage w. On the other hand, by taxing goods consumption, inflation reduces the return on both physical and human capital in goods production, which is reflected in a lower real interest rate r and confirmed by calibration in Gillman and Kejak. The combined effect is that the input price ratio of the net real wage to the net real interest rate rises and the capital–labour ratio rises as well (equation 14), also confirmed by calibration.

Finally, by (15), the steady-state growth rate equals the return on physical capital, or the return on human capital net of leisure leakage, minus the subjective rate of time preference, all normalized by θ. The reduction in the return on capital, as a result of an increased inflation tax, causes a lower growth rate. The advantage of this model is that some of the burden of inflation avoidance that otherwise falls on substitution from goods to leisure is now taken over by reallocation of time into credit services. This produces a realistically large fall in growth, and one that becomes smaller as the inflation rate increases, which matches the nonlinearity of the negative inflation–growth evidence. In addition, (14) and (15) imply that the fall in the growth rate is also mitigated by the reallocations of inputs, in Tobin fashion, in that a rise in the capital–effective labour ratios across sectors will make the growth rate decline less than otherwise.

A test of first-order conditions

Gillman *et al.* (2001) use equation (15) as the basis for a test of the determinants of economic growth. They use postwar panel data, adjusted for fixed country and time effects, for OECD and APEC countries and find a strong negative, nonlinear, growth effect of inflation on growth for the OECD countries, whereby the marginal effect of inflation rate increases is highest at the lowest levels of the inflation rate. The primary relation tested below is instead the little studied factor input reallocation that is induced by the inflation distortion, as given in (14). In particular, the ratio of the real wage to the real interest rate determines the capital intensity across sectors. Since calibrations in Gillman and Kejak (2000b) show a robust positive effect of the inflation rate on the real wage–real interest rate ratio, there is *a direct relation between the three sets of variables*, i.e. the inflation rate, the real wage–real interest rate ratio and the capital–effective labour ratio, in the goods and human capital sectors.

To see the effect of inflation on the total capital–effective labour ratio, and not just on each of the goods and human capital sectors, we need to sum up across the three sectors including credit services. As this sector uses only effective labour in the model, the effect of inflation on the total capital to total effective labour is a priori ambiguous, since the inflation rate has a positive effect on the labour used in credit services. Because of the small size of the credit services sector, calibrations in Gillman and Kejak (2000b) find that the total capital–total effective labour ratio across all sectors similarly rises with the inflation rate, as does each of the goods and human capital sectors. Thus, we are able to proceed to test, based on the model, the effect of inflation on the input–price ratio and the capital–effective labour ratio.

II. Empirical Methodology and Results

The empirical analysis uses seasonally adjusted quarterly data for the United States and the United Kingdom from 1950(I) to 1999(IV). These economies traditionally have had the highest-quality data and also are candidates for operating close to the steady state. For both countries, data on inflation, the interest rate, wages and GDP are obtained from *International Financial Statistics* (February 2000), published by the IMF. For the United States the series for the unemployment rate, productivity and hours worked are from the Bureau of Labor Statistics online database. For the United Kingdom the series for the unemployment rate and productivity are obtained from the National Statistics online databank. The capital stock series for both countries are those constructed by Easterly and Levine (1999). We use variables definitions and notation as set out in Table A1 in the Appendix.

Testing for the existence of statistical relationships among the variables is conducted in three steps. The first step is to verify the order of integration of the variables, to determine which of them may enter into stable equilibrium relationships. The second step establishes such relationships through cointegration testing, using both the Engle–Granger (1987) two-step procedure and the Johansen maximum likelihood approach (Johansen 1995; Johansen and Juselius 1990). And in the third step we test for causality in the Granger (1969) sense, applying the procedure of Mosconi and Giannini (1992) for causality testing in cointegrated systems.

Unit root tests

We apply three tests for unit root: the augmented Dickey–Fuller (ADF) (1979), the Phillips–Perron (1987) and the KPSS (Kwiatkowski *et al.* 1992). The first two tests have as null hypothesis that of non-stationarity, and we use the t-statistic with critical values calculated by MacKinnon (1991). In the ADF test the order of autoregression in the test equation is determined in two ways: (i) by adding lagged difference terms until error autocorrelation (measured by the Breusch–Godfrey LM test) is removed (see Godfrey 1988); and (ii) by starting with a sufficiently large number of lags and reducing them until all lagged differences become significant at 5%. Since these two methods sometimes produce a different number of lags for inclusion into the test equation, we also apply the Phillips–Perron test with a standard lag truncation of 4.

Furthermore, we test the converse null hypothesis, that of stationarity, by applying the KPSS test. That test requires a consistent estimate of the error variance, and we use the Newey–West HAC estimator (Newey and West 1987) with a Bartlett kernel of width from 1 to 4.

The results from testing the null of unit root (see Table 1) are very similar for the United States and the United Kingdom and show that all series are non-stationary at the standard 5% significance level except perhaps the inflation rate, which is a controversial case. The augmented Dickey–Fuller test for inflation is sensitive to the order of autoregression: with one lagged difference the null hypothesis of unit root is rejected at 5%, while with more lags it cannot be rejected even at 10%. While the LM test indicates that more lags are necessary in order to remove residual autocorrelation, suggesting that inflation is non-stationary, the Phillips–Perron test rejects non-stationarity. On the other hand, testing for stationarity with the KPSS yields a rejection of the null hypothesis for all variables except possibly the US effective capital–labour ratio. We accept the combined results as sufficient evidence for the presence of unit root in all series and proceed with that hypothesis.

Cointegration

In this section we perform tests for pairwise cointegration of inflation with the real wage–real interest rate ratio, the capital–effective labour ratio, and between the real wage–real interest rate ratio and the capital–effective labour

TABLE 1
UNIT ROOT TESTS

Series	ADF	Phillips–Perron	1%*	5%*	10%*	KPSS 1 lag	KPSS 4 lags	5%**	Order of integration
UK									
INFL	−2.56	−6.98	−3.47	−2.88	−2.58	1.10	0.54	0.46	I(1)
KLH	−2.25	−2.21	−3.47	−2.88	−2.58	5.10	2.10	0.46	I(1)
WR	−2.68	−2.78	−3.48	−2.88	−2.58	1.46	0.65	0.46	I(1)
M0	2.94	4.86	−3.48	−2.89	−2.58	6.06	2.50	0.46	I(1)
USA									
INFL	−2.07	−3.65	−3.47	−2.88	−2.58	1.16	0.52	0.46	I(1)
KLH	−2.92	−2.81	−3.48	−2.88	−2.58	0.43	0.20	0.46	I(1)
WR	−1.85	−1.90	−3.47	−2.88	−2.58	1.74	0.72	0.46	I(1)
M1	2.24	3.71	−3.47	−2.88	−2.58	7.77	3.17	0.46	I(1)

* MacKinnon (1991) critical values for rejection of the hypothesis of unit root.
** Sephton (1995) critical value for rejection of the hypothesis of stationarity.

ratio. Theoretically, if cointegration exists in two of the pairs, it should be present also in the third pair.

The pairwise cointegration tests are performed applying both the Engle–Granger (EG)(1987) method and the Johansen (1991) maximum likelihood procedure. In the EG approach we check the residual for stationarity, applying the ADF test with critical values calculated according to MacKinnon (1991). We look also at the cointegrating regression Durbin–Watson statistic (CRDW).

We run the following diagnostic tests: (i) the Breusch–Godfrey LM test, which is the appropriate serial correlation test when a lagged dependent variable is a regressor; (ii) Ramsey's (1969) RESET test for specification errors such as omitted variables, incorrect functional form or correlation of the regressors with the disturbance term; and (iii) the CUSUM of squares test, which indicates parameter or variance instability when the plot of the test statistic moves outside the critical lines.

We find very strong evidence of cointegration between inflation and the real wage–real interest rate ratio, in both US and UK data, and applying both the Engle–Granger method and Johansen's procedure. In the US data, in which the null hypothesis of 'no cointegration' is rejected at 1% with both methods, inflation appears to explain a larger part of the variation in the real wage–real interest rate ratio compared with the UK data.

Evidence of cointegration between inflation and the capital–effective labour ratio is also good, though less compelling: in the UK data cointegration is found at 5% with Johansen's procedure and at 1% with the EG method, while in the US data it is found at 5% with Johansen's procedure but only at 10% with the EG method. In the UK data inflation is found to explain a larger part of the variation in the capital–effective labour ratio compared to the US data.

Next, we find evidence of cointegration directly between the capital–effective labour ratio and the real wage–real interest rate ratio: in the US data cointegration is found at 5% with both methods, while in the UK the hypothesis of 'no cointegration' can be rejected at 5% with Johansen's procedure but cannot be rejected with the EG method at reasonable levels of significance. Interestingly, applying the EG test for the UK in the opposite direction—putting the capital–effective labour ratio as explanatory variable and the real wage–real interest rate ratio as dependent variable—results in rejection of the null of 'no cointegration' at 10%. Finally, in both US and UK data, money supply and the respective consumer price indexes are found to be cointegrated at the 1% significance level applying Johansen's test.

Granger causality

The Granger (1969) causality test is performed on the basis of Mosconi and Giannini (1992), which is appropriate for cointegrated systems. Let z_t = (INFL, KLH, WR) be a three-dimensional vector partitioned into y_t = INFL and x_t = (KLH, WR). The hypothesis to be tested is that y_t does not Granger-cause x_t. Formally, given the ECM representation of the system,

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + ... + \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-k} + e_t,$$

TABLE 2
GRANGER CAUSALITY TEST

	r_1	r_2	No. of iterations	Converge	Log-L.	Test	DGF	Signif.	Akaike
UK	0	2	2000	Yes	735.4	66.896	6	0.0000	−13.080
	1	1	2000	Yes	746.0	45.771	6	0.0000	−13.272
USA	0	2	2000	Yes	2634.1	47.835	6	0.0000	−39.076
	1	1	2000	Yes	2643.5	29.000	6	0.0001	−39.216

the hypothesis under test is

$$H_0(r_1, r_2): \alpha = [U_\perp a_1 \mid a_2], \qquad \beta = [b_1 \mid Ub_2], \qquad U'\Gamma_i V = 0,$$
$$i = 1, ..., k-1,$$

where

$$U_\perp = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, \qquad U = \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \end{bmatrix}, \qquad V = I_{k-1} \otimes U_\perp,$$
$$\Gamma = [\Gamma_1, ..., \Gamma_{k-1}], \qquad \Pi = \alpha\beta',$$

a_1 is a $1 \times r_1$ vector of unknown constants, a_2 is a $3 \times r_2$ matrix of unknown constants, b_1 is a $3 \times r_1$ matrix of unknown constants, and b_2 is a $2 \times r_2$ matrix of unknown constants. The interpretation of r_1 and r_2 is discussed in Mosconi and Giannini (1992). Under the null hypothesis, the matrices Π and Γ_i, ($i = 1, ..., k-1$) should be upper-block triangular so that the variables in the first subset (y_t) do not Granger-cause the variables in the second (x_t). In order to reject non-causality, we need to reject the null hypothesis for all pairs (r_1, r_2) satisfying

$$r_1 + r_2 = r, \qquad 0 \leqslant r_1 \leqslant 1, \qquad 0 \leqslant r_2 \leqslant 2,$$

where r is the cointegration rank of the system (in our case, 2). The likelihood ratio test is distributed χ^2 with $3r - r_1 - 2r_2 - r_1 r_2 + 2(k-1)$ degrees of freedom.

The test was computed for different lag specifications from 1 to 8. In all cases the result was a strong rejection (at 1%) of the null hypothesis that inflation does not Granger-cause the input price ratio and the capital ratio. The output from the test for $k = 3$ is presented in Table 2. Notice that non-causality is rejected when the significance level is less than 0.05 for all possible combinations of r_1 and r_2.

III. CONCLUSIONS AND QUALIFICATIONS

Our results provide support for the model that there is an active Tobin-type realignment of inputs as part of the equilibrium response to changes in the expected inflation rate. This research aims to help fill out the broader effects of inflation in the postwar industrial economies and so enables us to understand better the rise and fall of stagflation. An increasing real wage–real interest rate ratio, and an aggregate physical capital–effective labour ratio, are candidate components of the effects of accelerating inflation. While motivated analytically by Tobin, the general equilibrium presentation of this input response is one involving both capital and labour and not just capital, as in Tobin. Further, it is a reallocation that coincides with a decrease in the growth rate within the model, as some evidence suggests, rather than an increase in the growth rate or no growth effect, as suggested by Ahmed and Rogers (2000) and Dotsey and Sarte (2000). This contribution represents a preliminary beginning of what could be a more extensive investigation into such input realignments internationally.

APPENDIX: DESCRIPTION OF THE DATA SET

The paper uses seasonally adjusted quarterly data for the United States and the United Kingdom from 1950(I) to 1999(IV). For both countries, data on inflation, the interest rate, wages and GDP are obtained from *International Financial Statistics*, published by IMF. For the United States the series for the unemployment rate, productivity and hours worked are from the Bureau of Labor Statistics online database. For the United Kingdom the series for the unemployment rate and productivity are obtained from the National Statistics online database. The capital stock series are obtained from Easterly and Levine (1999), calculated on the basis of disaggregated investment. We use variables definition and notation as presented in Table A1.

TABLE A1

VARIABLES DEFINITION AND NOTATION

Variables	Definition	Notation
Inflation	Quarterly % change in the Consumer Price Index	INFL
Money stock	M1 for the USA, M0 for the UK	M1, M0
Capital–effective labour ratio	Capital stock per skilled labour is the ratio of capital stock to the number of workers, adjusted by a productivity index as a proxy for human capital	KLH
Real wage–real interest rate ratio	Real wage is the nominal wage in production divided by CPI. The real 'raw' wage is the real wage divided by an index of productivity as a proxy for human capital. Real interest rate is the yield on government bonds less inflation. For the UK, w/r is the ratio between the real raw wage and the real interest rate. For the USA, where productivity gains are not reflected in a rising real wage, w/r is just the ratio of the real wage to the real interest rate.	WR

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NOTES

1. However, with capital taxes inflation can induce a higher effective tax rate on corporate profits, e.g. through an increase in tax liabilities due to inventory accounting methods, and the erosion

of depreciation allowances (Feldstein 1982). Jones *et al.* (1993) also show that, with nominally fixed depreciation allowances, inflation increases the effective tax on investment.
2. Boskin *et al.* (1980) and Leijonhufvud (1977) show how inflation can reduce work effort.
3. Baumol (1952) argues that the using up of resources in non-productive inflation tax-avoidance represents a loss.
4. See Einarsson and Marquis (1999) for a related model.

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