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Discussion Paper 99-12

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June 1999

Abstract: Recent models of endogenous growth have emphasized the role of capital in the process of economic development. However, it is very difficult to assess the contribution of capital due to definitional and measurement problems. Moreover, the value of the capital stock of the economy may change as a result of developments in economic fundamentals that affect the growth rate of the economy. This paper attempts to relate the valuation of capital by the market with aggregate economic growth. We present a model of endogenous growth with adjustment costs in private investment, which shows that the growth rate of market valuation of capital, as measured by stock prices in real terms, is associated to the growth rate of the economy. Evidence from industrialized countries with deep financial markets shows that the empirical patterns observed in the data are consistent with the theoretical findings of the model. Moreover, the model provides useful information for forecasting economic growth and real stock prices.
Keywords: Economic growth, capital valuation, real stock returns.

Acknowledgements: We have benefited from valuable comments by M. Haliassos, P. Kalaitzidakis, A. Michaelides, N. Pittis, T. Stengos and seminar participants at the Macroeconomics and Finance Series held at the University of Cyprus. The second author acknowledges financial support from TMR Project ERBFMRXCT98-0213. The usual proviso applies.
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1. Introduction

One of the aims of the resurrection of growth theory during the last decade is the explanation of long-run growth. Specifically, there is little doubt that investment rates are significantly related to economic growth and that the differences in growth across countries can be explained by differences in the capital accumulation process.[1] In turn, determination of the investment process requires a detailed analysis of decisions, taken primarily at firm level in the financial sector of the economy. These decisions are related to profits and business conditions both current and anticipated. Therefore, any attempt to explain growth should take into account, explicitly or implicitly, the main factors that influence, first, investment decisions in the financial sector and, second, production decisions in the real sector of the economy.

Brainard and Tobin (1968) were the first to underline the interactions between these sectors in the context of a macroeconomic model. According to the authors, capital formation is triggered when the market values new capital higher than its replacement cost (*q* theory of investment). Thus, there exists a close link between output and asset markets running in both directions, which explains movements in these markets.[2] For instance, a rise in output or capital efficiency, which may be considered exogenous to the financial sector, prompts a rise in the value of equities and private wealth.

In his study of the stock market and the economy, Bosworth (1975) observes a similar cyclical pattern in the stock market and real economic activity. In particular, changes in nominal stock returns are found to precede changes in production. The author identifies two major channels through which stock market affect output: consumption and investment. In the first case, consumption, and consequently wealth and output, may rise after a rise in stock prices generated either by optimistic expectations on future profits, or, alternatively, by a fall in interest rates.[3] In the case of a financial crisis accompanied by an interest rate rise the symptoms may be more intense, because the stock market crash and the fall of firms' net worth induces adverse selection and moral hazard problems, which

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[1] See, among others, Levine and Renelt (1992) and Mankiw et al. (1992).

[2] In fact, the authors point out that no other monetary variable, like the money supply or interest rates, should be targeted by authorities in order to affect the real economy, since in this framework the sole determinant of investment is the market valuation of capital. Therefore, according to the authors, authorities can only influence real activity through short-term rates on alternative assets that affect stock returns and output.

[3] In the latter case, however, apart from the positive substitution effects between present and future consumption, one should also take into account the rise in present discounted consumption and income streams.

ultimately lead to decreased lending and a fall of output.

In the case of investment, the cost of capital derived by a neoclassical production function is obviously the most important determinant of investment, but this approach requires a fully developed secondary market for capital, estimates of expected capital gains and tax effects, while it ignores transaction costs and default risk. A solution to this problem could be offered by the market mechanism, as the market value of the firm is assumed to incorporate all necessary information. This holds in the absence of speculative bubbles and if stockholders and managers share the same objectives, i.e. the principal-agent problem does not arise.

Nevertheless, one should not allege that other factors do not play a prominent role in determining responses of stock prices and output. Blanchard (1981) presents a model that studies the effects of monetary and fiscal shocks on output, the stock market and the term structure. His analysis is based on standard IS-LM principles with gradual adjustment of output supply to demand shifts. The author finds that after an expansionary policy shock, asset prices change as a result of anticipated changes in real interest rates and profitability. This, in turn, affects wealth and spending, and fuels a rise in supply and equilibrium output, which justifies the original rise in stock prices. In this framework, asset prices will tend to predict future output, but are not the cause of such changes, because both variables will tend to respond to changes in the economic environment.

The new endogenous growth literature has attempted to shed new light on the issue of economic development and capital valuation by the market. Financial organisation and the depth of the stock market are crucial for the explanation of long-run growth trends while higher growth fosters financial development. As noted by Pagano (1993), financial markets may have a permanent effect not only on the level of income, but also on the growth rate of the economy. This effect may stem either from technology improvement that affects the marginal and average product of capital in the context of a standard *AK* model, or from an increase in the proportion of savings funnelled to firms and the saving rate.[4]

Levine (1991) shows that the emergence of stock markets promotes growth by eliminating

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[4] However, as pointed out by the author the effects of financial development on the saving rate and growth are ambiguous. Apart from the effects due to decreased interest rates noted above, financial development may also lower the saving rate due to the elimination of liquidity constraints. These binding constraints can be shown to induce savings and, consequently, decrease current consumption (see Jappelli and Pagano, 1994).

premature withdrawal of capital from firms and by encouraging investment through the reduction of productivity risk and the improvement of firm efficiency. However, in his model there is no feedback between stock markets and growth. Greenwood and Jovanovich (1990) build a model where financial development and growth are interconnected. Financial organisations boost growth, firstly, because they facilitate the acquisition and dissemination of valuable information, thus allowing for higher expected returns, and, secondly, by risk pooling across investors. This process, in turn, accelerates growth and the economy results with a higher growth rate than the one prevailing in the early stages of development.[5]

In this paper an attempt is made to reconcile theoretical findings with the relationship postulated in empirical work between stock markets and growth. We build a simple endogenous growth model that merges financial decisions at the firm level and real activity at the economy level. Households make allocation decisions based on arbitrage between bond and equity returns and the consumption saving choice. Firms, in turn, produce in two stages: first, they attempt to minimise the real cost of capital through optimal investment financing and, second, they maximise net cash flows through optimal production decisions subject to adjustment costs in investment. The model produces an equilibrium relationship between the market value of capital measured by the stock price index and output growth. To assess the empirical interactions between real stock returns and economic growth we adopt the 'agnostic' Vector Autoregression (VAR) modelling strategy. We employ data from the major industrialised economies to investigate whether there exists a relationship between these two key variables, as implied by the theoretical results of our simple model.

The model is based on work by Turnovsky (1995) and Alogoskoufis (1995). Turnovsky (1995) examines the link between financial decisions, investment and the shadow price of capital. The author introduces a two-stage character in financial decisions by firms. The model presented here is a simplified variant of this class of models that allows us to focus on the implications between the growth rate and market valuation of capital. From a different standpoint, Alogoskoufis (1995) builds an

[5] This study belongs to a part of the literature that investigates the theoretical links between financial functions and growth. See also, among others, Bencivenga and Smith (1991). In his extensive survey, Levine (1997) identifies two channels through which financial intermediation enhances growth and productivity, namely capital accumulation and technological innovation, by pooling risk and providing a solution to asymmetric information problems, such as adverse selection and moral hazard.

endogenous growth model with adjustment costs in investment. His approach relates the growth rate of the economy with the shadow price of capital, but does not include an optimising capital structure of firms and joint determination of financial decisions at firm level with the behaviour of households.

The outline of the paper is the following. Section 2 presents the theoretical model. Section 3 gives the data description and sources and Section 4 presents empirical results for the G7 countries. Finally, Section 5 concludes the paper.

2. A model of capital valuation and endogenous growth

In this section we shall develop a model that illustrates the relationship between output growth and capital valuation of firms by the market. We assume that the economy consists of two sectors: households and firms. Households provide labour to firms and receive wages while they also receive income in the form of dividends and interest earnings on bonds.[6] Their consumption-savings choice determines the demand for bonds issued by firms. The latter hire labour for production and decide every period on the distribution of profits, which are either retained to finance additional investment, or are distributed to households as dividends and interest payments. Investment, which is subject to adjustment costs is also financed by issuing new bonds and shares.

As the main focus is in the productive side of the economy, we make the following simplifying assumptions. First, we assume that there is no government in the economy. As a result, no taxes are imposed on labour income, on dividends paid to stockholders, or on income from interest payments on bonds, that would affect the allocation of resources available to households. Moreover, there is no public expenditure in the form of consumption or investment that would directly affect the utility of households or the production by firms in the form of public infrastructure. Second, the model does not include a monetary sector. Hence, households do not keep money holdings while prices do not play any role in the production decisions of firms. This amounts to assuming complete money neutrality: households base their decisions between consumption and savings on real earnings and the market real interest rate while production decisions are based on the real cost of capital and pricing is in terms of output. In the present context, where one homogeneous good is produced and the external balance of the country is not analysed, this approach is not very restricting. However, in an n-goods production

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[6] See Chami et al. (1999) for the effects of monetary policy via the stock market when households do not own physical capital directly, but hold instead nominally denominated stocks.

framework, relative prices would be of importance in the determination of production shares for each type of goods.

Let us assume an economy with a large number of households whose behaviour is given by a representative household. Each household is assumed to choose *c* and *l* in order to maximise the infinite intertemporal utility function:

$$\max \int_0^\infty e^{-rt} U(c,l)\, dt \qquad (1)$$

where *c* denotes consumption and *l* labour. The utility function satisfies $U_c>0$, $U_l<0$, $U_{cc}<0$, $U_{ll}<0$, $U_{cl}<0$, and the budget constraint faced by households has the form:

$$\dot{b} + c + s\dot{E} = wl + rb + D + \dot{(sE)} \qquad (2)$$

where *b* denotes corporate bonds with real interest rate *r*, *E* denotes the number of shares, *s* denotes the price of shares in terms of output, *w* denotes the real wage rate and *D* denotes real dividends. By the budget constraint we have that the income of households consists of labour income, interest earnings, dividends, and capital gains due to changes in the value of equity capital, which is in turn used for consumption, or saving in the form of purchase of corporate bonds and equities. By the definition of

$\dot{(sE)} = s\dot{E} + \dot{s}E$ the budget constraint is equivalent to:

$$\dot{b} + c = wl + rb + D + \dot{s}E \qquad (2)'$$

The initial conditions for this problem are $b(0)=b_0$ and $E(0)=E_0$. The first order conditions for this problem amount to:

$$U_c = -ë \qquad (3a)$$

$$U_l = ëw \qquad (3b)$$

$$r = i + \frac{\dot{s}}{s} \qquad (3c)$$

where *ë* is the marginal utility of wealth and $i=(D/sE)$ is the dividend to equity value ratio. Equations (3a) and (3b) determine jointly labor supply in terms of the real wage rate, while equation (3c) is the familiar arbitrage condition which states that the real interest rate on bonds equals the dividend to equity ratio and the capital gain, defined as the change in equity prices.

In the production side of the economy we assume a large number of competitive firms. The production function of firm *i* has the following form:

$$Y_i = Y\left(K_i, l_i\right) = AK_i^{á}\left(hl_i\right)^{1\text{-}á} \qquad (4)$$

where Y_i, K_i and l_i denote output, capital and labour, respectively, of firm *i*, *A* is a constant technology parameter with *A>0*, and *á* and *(1-á)* are the relative shares of private capital and labour respectively. Parameter *h* stands for total capital per worker and we assume that the latter is a function of the existing total capital stock per worker -denoted by *K* and *l* respectively- so that:

$$h = \left(\frac{K}{l}\right) \qquad (5)$$

According to equations (4) and (5) the firm's output is a function of its own capital stock and of the total capital stock which is available to the economy. The return on the firm's capital from (4) is clearly diminishing since *á<1* given the total capital stock. Equation (5) is in the spirit of Romer (1986) and Barro (1990a) where learning-by-doing and knowledge spillovers arise from total capital to all producers. Each firm separately neglects its own contribution thus taking the amount of total capital as given.

We define the gross profits of firms as

$$Ð = õ\left(K, l\right) - wl \qquad (6)$$

which are distributed to dividends paid to shareholders, earnings and interest payments to bondholders as debt:

$$Ð = D + R + rb \qquad (7)$$

where *R* denotes earnings. In the presence of adjustment costs in the formation of private capital, investment cost is assumed to be given by:

$$cost\ of\ investment = I[1+\frac{f}{2}(\frac{I}{K})] \qquad (8)$$

where *I* denotes private investment and *ö>0*. Investment costs are an increasing function of new capital relative to installed capital. Consequently, the *net* cash flow, or net output of firms, i.e. output minus the cost of labour and investment, is given by

$$P' = U\left(K, l\right) - wl - I[1+\frac{f}{2}(\frac{I}{K})] \qquad (6)´$$

The financing constraint of the firm is that the sum of earnings, revenues from the issue of new stocks and lending in the bond market equals the cost of investment:

$$R + s\,\dot{E} + \dot{b} = I[1 + \frac{ö}{2}(\frac{I}{K})] \qquad (9)$$

Using equations (7) and (9), adding $\dot{s}E$ on both sides and defining the market value of outstanding securities to be V=sE+b with $\dot{V} = \dot{s}E + s\dot{E} + \dot{b}$ we get that

$$\dot{V} = \left[r\frac{b}{V} + (i + \frac{\dot{s}}{s})\frac{sE}{V} \right] V - \mathbf{P}' \qquad (10)$$

The first term in parenthesis in the right hand side is the real cost of capital and the second term is the real cost of equity capital. Their sum in square brackets is the real cost of capital $è^*$:

$$q^* = r\frac{b}{V} + (i + \frac{\dot{s}}{s})\frac{sE}{V} \qquad (11)$$

As shown in Turnovsky (1995), by the definition of the real cost of capital we observe that it is independent of the production decisions of firms concerning investment and labour. Therefore, the firms' problem can be expressed in two stages. The firm makes its *financial* decision so as to minimise the real cost of capital, and, then, it makes the optimal *production* decision. However, financial decisions are constrained by the behaviour of households through the arbitrage condition (3c) that, in turn, determines the savings decisions. As a result, by equations (3c) and (11) and the definition of the market value of firms, we obtain under this setting that the real cost of capital which optimises financial decisions of firms equals the real interest rate $q^* = r$. Note here that this result would not hold in the presence of differential taxes on dividends, interest payments or capital gain taxation. Also, by assumption, total capital impacts only on the production of firms and leaves household utility unaffected.

The infinite horizon problem of the representative firm i is to maximise the present discounted value of net cash flows taking h as given:

$$max \int_0^{\infty} e^{-\int_0^t q^*(t)dt} \left\{ F(K_i, l_i) - w_i l_i - \left[1 + \frac{f}{2}\left(\frac{I_i}{K_i}\right)\right] I_i \right\} dt \qquad (12)$$

w.r.t. l and I s.t. to (4), the capital accumulation formula $\dot{K} = I_i - dK_i$ and taking (5) as *given*. The first-order conditions are given, after replacing for h and aggregating across firms, by:

$$w = A(1 - a)\left[\frac{K}{l}\right] \qquad (13a)$$

$$\left(\frac{I}{K}\right)=\frac{q-1}{f} \tag{13b}$$

$$q^{*}=\frac{\dot{q}}{q}+\frac{\mathrm{A}a}{q}+\frac{(q-1)^{2}}{2qf}-d \tag{13c}$$

$$\lim_{t\to\infty}\left(qe^{-\int_{0}^{t}q^{*}(t)dt}K\right)=0 \tag{13d}$$

where q is the shadow price of capital. Equation (13a) is the usual condition that the real wage rate equals the marginal product of labour, while equation (13b) states that private investment is an increasing function of the shadow price of private capital in terms of contemporaneous output and a negative function of the adjustment cost parameter *ö*. The shadow price of price of capital is larger than unity for positive investment, due to the presence of adjustment costs. Equation (13c) gives the real cost of capital as the sum of the rate of change of the shadow price of capital, the return on capital per unit of capital and the marginal reduction of adjustment costs as private capital increases valued at its shadow price, minus the depreciation rate. It is obvious that under no adjustment costs the shadow price of capital equals one and the real cost of capital of return would be given by the difference between the physical rate of return on capital and the depreciation rate.[7] Finally, equation (13d) gives the usual transversality condition.

The optimal values for the real cost of capital, investment, capital and the real wage rate determined by the optimality conditions of firms can be replaced in (10), which gives the market value of the firm at the optimum. At the optimum:

$$q=\frac{V^{*}}{K} \tag{14}$$

Equation (14) gives the shadow price of capital, as the ratio of the market value of outstanding securities to the existing capital stock (see also Turnovsky, 1995). Brainard and Tobin (1968) first suggested that the average value of q, the firm's market value relative to the capital stock, could be used as a proxy for marginal q. As shown by Hayashi (1982), the average and marginal values of q are

[7] For a detailed discussion of these conditions and the relationship with Tobin's q, see Hayashi (1982) and Barro and Sala-I-Martin (1995). Note here that the competitive equilibrium allocation does not attain the social optimum as the marginal product of private capital in (14c) falls short of the social rate of return. In such a case, the term *á* in equation (14c) should be replaced by *á+(1-á)=1* in the artificial case of a benevolent social planner who takes into account the beneficial effects of total capital.

identical, as long as the production function exhibits constant returns to scale. Thus, in the rest of the paper we will use the average q instead of the marginal q.

In our model, optimality conditions for households give a set of demand functions for consumption, through equation (3a), corporate bonds, through the arbitrage condition (3c), and a supply function for labour, through equations (3a) and (3b). In the production side, optimality conditions for firms provide a supply function for bonds, through equation (11), and demand functions for labour and capital, through equations (13a) and (13b) with (13c), respectively. Equilibrium occurs when supply equals demand in the labour, capital and bond markets.[8]

The optimal capital stock of the economy, given the financial decisions of firms, is determined in the production sector through optimal capital accumulation. From (4) and (5) the aggregate production function is given by the familiar AK form $Y = AK$ and –given the capital accumulation equation- the growth rate of output is given by:

$$g_Y = \frac{\dot{Y}}{Y} = \frac{I}{K} - d \qquad (15)$$

Replacing (13b) in (13c), using (15) and solving for the rate of change of the shadow price of capital we obtain the following system of equations:

$$\frac{\dot{q}}{q} = -\frac{Aa}{q} - \frac{f(g_Y + d)^2}{2q} + (q^* + d) \qquad (16a)$$

$$g_Y = \frac{(q-1)}{f} - d \qquad (16b)$$

The last two equations yield the joint determination of the growth rate of output, g_Y, and the rate of change of real stock prices, $\dot{q}/q$. (We can obtain explicitly the growth rate of output, as a function of the rate of change of real stock prices by solving (16a) for q and replacing in (16b)). Now, equations (16a) and (16b) form a system, which can be solved for q and g_Y. The relationship between the steady state values of output and the shadow price of capital $\bar{g}_Y$ and $\bar{q}$ are obtained by setting $\dot{q} = 0$ in (16a):

[8] In particular, equilibrium in the labour market is given by (3a), (3b) –which determine the supply of labour by households as a positive function of the real wage rate- and (14a), which determines the demand for labour by firms. Equilibrium employment is thus given by $A(1\text{-}á)\ [-U_c/U_l]K$.

$$\bar{q}_{|\dot{q}=0} = \frac{\mathrm{A}a}{(q^{*}+d)} + \frac{(\bar{g}_{Y}+d)^{2}}{2(q^{*}+d)} \tag{17}$$

Equations (16b) and (17) jointly give the equilibrium values for the growth rate of the economy and the shadow price of capital. Alogoskoufis (1995) shows that the dynamics of the model are described by two equilibria: the first one is globally unstable and the other one is globally stable. Since both variables are non-predetermined the solution we are interested in is the positive root of q (which is a forward-looking variable). This determines the unique convergent path that fulfils expectations and ensures convergence of the series.

We define balanced growth as the state where output and capital grow at the same rate and in this model growth is endogenous, as the economy grows with a steady-state constant growth rate. By (16b) and (17), the steady-state growth rate depends positively on technology parameter A. Suppose that there is an exogenous improvement in technology: as a result the marginal -and average- product of capital A will rise. Investment will rise with q, and so will the growth rate of output, implying a higher steady state growth rate of output and a higher shadow price of capital. The new steady-state is achieved as the jump in the shadow price of capital induces a rise of output through the production function.[9]

Finally, it is interesting to note that by (16a) the growth rate of the shadow price of capital given depends negatively on the growth rate of the economy. As output growth boosts (say, from the positive technology shock), the rise in q and investment increase adjustment costs and the growth rate of the shadow price of capital $\dot{q}/q$ falls to drive the economy to equilibrium. Next, we move on to estimate empirically these relationships between the growth rate and the shadow price of capital.

3. Data description and sources

To capture the empirical relationship between economic growth and market valuation of capital

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[9] Recalling that the elasticity of intertemporal substitution is given as *ó=[-U_c /$U_{cc}c$]*, we have that steady-state consumption is given by differentiating (3a) with respect to time and equals *ó(r-ñ)*. This relationship states the well-known Keynes-Ramsey rule for consumption which states that steady-state consumption grows at a constant rate equal to the difference between the real interest rate on a domestic riskless bond and the rate of time preference. The growth rate of consumption is positive, as long as the real interest rate exceeds the rate of time preference, and does not depend on the capital stock. Note that we also need to impose that *ñ>ó(r-ñ)*, so that attainable utility is bounded and the transversality conditions holds (see Barro and Xala-I-Martin, 1995, chapter 4.1.3).

we used existing measures of output and we calculated the real stock prices for the G7 countries. Growth rates of output and real stock prices were calculated using the following variables from the International Financial Statistics, October 1998 CD-ROM edition:

Industrial production: For all countries we used the Industrial production index, seasonally adjusted. *Stock prices*: For Canada we used the C.L. Toronto stock prices. For the rest of the countries we used the quoted share prices. *Prices*: For Canada we used the aggregate industrial selling price index. For France and Italy the consumer price Index. For Germany (for unified Germany from 1991) and Japan the industrial wholesale price index. For the United Kingdom we used the price of industrial output. For the United States we used the price of industrial goods.

As expected, all series are found to be non-stationary in levels and stationary in first differences (analytical results on descriptive statistics and unit root tests are available from the authors upon request). Growth rates of real stock prices (denoted by ROGS) and output (denoted by ROGY) are depicted in Figures 1 and 2 for annual and quarterly data, respectively. The overall picture indicates that the series are closely related and it is likely that both series contain useful information in predicting each other. The next section surveys previous empirical studies on the relation between stock prices and output and give the empirical results of the VAR modeling approach.

4. Empirical results

4.1. A survey of previous empirical studies

In an empirical context, Goldsmith (1969) was the first one who assessed the positive relationship between stock returns and economic growth. The author used the GDP percent of financial intermediary assets and established a positive correlation with growth for 35 countries. Lately, the relationship between stock markets returns and growth has been empirically investigated mainly in cross-section studies. King and Levine (1993a, b) use a sample of 80 countries and a variety of financial and growth indicators and document that the level of financial intermediation is strongly related to higher growth and capital accumulation rates, and productivity. Moreover, initial financial level is economically important and financial expansion is found to precede these growth indicators by 1 to 3 decades.

Evidence on the direct impact of stock market returns on income and growth, by use of cross section data, is presented by Atje and Jovanovich (1993). For a sample of 40 countries, they find that both are significantly dependent upon the value of total stock market trades as GDP percent. However, their results are recently questioned by Harris (1997) who claims that the inclusion of lagged investment in the explanatory equation for growth is inappropriate since it is not highly correlated with current investment. Replicating the results of Atje and Jovanovich (1993) with a richer data set and controlling for endogeneity by use of instrumental variables to eliminate the upward bias in estimated coefficients, Harris (1997) asserts that the effect of the stock market is much weaker and statistically insignificant.

However, in their cross-country study, Levine and Zervos (1996) find that a robust positive relationship between stock market development and growth. The authors build an index of stock market development and find that the positive relationship holds, after controlling for endogeneity by use of instrumental variables that might affect variables, such as the initial income and education level, the inflation rate and other potential factors,. These results are recently extended and, in general, confirmed in Levine and Zervos (1998).

Another strand of the literature focuses on time series methods to gauge the relationship between stock returns and real activity. Work by Fama (1981, 1990) and Schwert (1990) shows that real stock returns are highly correlated with future real activity. These results hold for all data frequencies covering very long periods and are robust to alternative definitions of the data series. Such evidence may be the result of stock returns being a good proxy –in the form of a leading indicator- for future production and/or from shocks that affect stock returns and investment decisions immediately, but become visible in production after several periods. In his analysis, Barro (1990b) claims that real stock prices have significant explanatory power for future investment and output in the U.S. and outperform a standard definition of the *q*-type variable, as provided by Blanchard et al. (1993).

Thus it appears that, so far, empirical studies on the impact of stock market prices or returns on economic activity are either based on cross section data averaged over long periods of time, or on estimation by single-equation methods for large data spans. Proponents of cross-country studies, such as Levine and Zervos (1996), recognize that the results from cross-country studies are subject to criticism due to the wide discrepancies between included countries. Cross-country regressions suffer from heterogeneity inherent in the selection of the sample, due to the existence of large variations in country specific characteristics and because of the widening of these discrepancies as the sample size increases. This poses severe problems in the econometric estimation of the coefficients of the related equations and their economic interpretation. A great deal of caution is also required in the formation of the conditioning set because estimated parameters are not always robust to the omission of other, potentially relevant, regressors (Levine and Renelt, 1992). Additionally, averaging over long periods of time imposes the similar treatment of exogenous shocks that occur simultaneously during the period under investigation.

Another caveat that is often neglected in studies with capital stock data series is the poor quality of the data set. As pointed out by Levine and Zervos (1996) researchers in country studies often face large discrepancies between official data and their personal estimates. These disparities can be attributed to alternative definitions, weaknesses during the data collection process and measurement errors. Since for the case of capital stock series, the usual computation methods are based either on steady state estimates, which assume a constant capital to output ratio, or on perpetual inventory methods, which require an initial capital stock. Moreover, all methods require an estimate of the depreciation rate, which is usually assumed to be exogenously given and constant.[10]

As far as time-series analysis is concerned, the univariate framework adopted in almost all relevant studies neglects the interaction between stock market returns and real activity by considering *ad hoc* current production as being determined by past returns. Alternatively, future production is the principal element mirrored in current stock returns, while the issue of causality cannot be taken into account. This setting obviously excludes the possibility that financial development and, consequently, future returns may well be the outcome of current changes in production brought about e.g. by economic and political factors or external policy shocks, as outlined above in Blanchard (1981).[11]

4.2. VAR estimation

Next, we go on to estimate baseline bivariate VARs in first differences of output and real share

[10] See King and Levine (1994) for alternative methods for the calculation of capital stock series.

[11] In the context of time-series analysis, exceptions to the univariate framework are the papers by Demetriades and Hussein (1996) and Arestis and Demetriades (1997). These authors utilise cointegration techniques in bivariate systems to investigate the links between financial development (in the form of market depth and volatility) and growth, and the presence of causality. Although there is substantial evidence of bidirectional effects between financial organisation on growth in both developed and developing countries, the authors emphasise the large variation across countries which questions result from cross-countries studies with similar data. It should be noted that stock returns are not included in the explanatory variables in these studies and, so, there is no estimate of potential effects of stock prices on growth.

prices for the G7 countries.[12] Letting Z_t=[$ROGS_t$, $ROGY_t$]´, where *ROGS* and *ROGY* denote the growth rates of real stock prices and industrial production, respectively, the VARs have the following form:

$$Z_t = A_0 + \sum_{i=1}^{k} A_i Z_{t-i} + u_t$$

where A_0 is a *2X1* vector of constants, A_i are *2X2* matrices of coefficients and u_t is a *2X1* vector of residuals with $E(u_t) = 0, E(u_t u_s') = 0 \forall t \neq s, E(u_t u_s') = \Omega \forall t = s$ and Ù defined as a symmetric positive semidefinite matrix. Results are depicted in Tables 1 to 7 with a number of misspecification tests for serial correlation, normality, heteroscedasticity, ARCH effects and functional form. The choice of the lag length was based on the Akaike information criterion and lagged values from 1 to 3 for annual frequency and 1 to 8 for quarterly frequency were tried. All systems appear to be well specified and coefficients enter with correct and significant signs in most cases.

In particular, all annual VARs are estimated with one lag, with the exception of Italy where two lags were included. Real stock returns enter the output growth equation with a significantly positive sign for the five biggest economies, namely Canada, Germany, Japan, UK and the US. The positive coefficients for the US support previous evidence by Lee (1992) who uses a four-variable VAR system and reports that a rise in real stock returns signals an upward movement in growth in industrial production. The coefficient for France is positive, but statistically insignificant while the two coefficients for Italy are of opposite sign and statistically insignificant. Interestingly, all coefficients of output in the equations for real stock returns enter with a negative sign, as predicted by the theoretical model outlined above, albeit they are statistically significant only for the UK and the US. Given that the UK and the US are the economies with the deepest financial markets, one would exactly expect output variations to be mirrored primarily in equity markets of these countries.

The general impression is confirmed when we move on to the quarterly VARs. Lag specifications are of order two for Canada, Germany and Italy, of order three for France, Japan and the UK, and of order four for the US. A number of dummies were also included to account for the impact

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[12] We also tested for cointegration, but no such evidence was found in annual or quarterly data. Cheung and Ng (1998) report evidence of cointegration between national stock market indexes and measures of aggregate real economic activity, like real GNP, real oil prices, real money and real consumption.

of events, such as the stock market crash in October 1987, the two oil price shocks, or political upheavals in these countries (like those of spring 1968 in France). Again, coefficients on real stock returns enter with positive -and significant in most cases- signs in the equations of output growth for all countries. Similar results with those derived from annual data emerge from estimated coefficients on output in equations for real stock returns, and almost all coefficients are negative, with a few statistically insignificant exceptions.

Finally, to test the bidirectional link between the two series at hand, we performed standard Granger-causality tests. Results are tabulated in Table 8 and indicate the presence of causality running from real stock prices to output for Canada, Japan, UK and the USA for both data sets and for Germany using quarterly data. On the other hand, evidence for causality from output to real stock prices is weaker and appears only in the UK and USA, and for Germany using quarterly data.[13]

4.3. Estimates with alternative measures of q

Given that the VAR model appear to be well specified, an important issue that arises in their estimation is how close is the average value of q to the observable average value of q measured by real stock prices. The latter may be a poor proxy of future flows determining financial decisions of firms under the presence of imperfect capital markets, speculative bubbles, or nonlinear production and cost of adjustment functions.[14]

As an alternative strategy to assess the robustness of our results to the definition of the shadow price of capital we also estimated the bivariate VARs using two available measures of q for the US provided by Blanchard et al. (1993) and Brainard et al. (1991). More specifically, Blanchard et al. (1993) construct q, the market valuation of capital, for the period 1900-1990 as the market value of bonds and equities relative to the replacement cost of capital. According to these authors, results on the effects of percentage changes in q on the percentage change of investment to capital ratio are not altered significantly when nominal stock price changes are used instead of their estimate of q; in fact, the effect

[13] In a similar vein, Tease (1993) has reported results from Granger causality tests derived from bivariate VARs with growth rates of GDP and nominal stock prices estimated for the period 1969-1993. The tests indicate the presence of causality from stock prices to output in the G7 countries and confirm the absence of causality for continental European economies, namely France and Italy. The author finds evidence of causality from output to stock prices only in the case of Germany. Unfortunately, the VAR estimates are not reported, so no direct comparison can be made.

is somewhat stronger. As shown in Figure 3A, where real stock prices and the Blanchard et al. (1993) estimate of *q* are depicted for the common sample period 1951-1990, the levels and the growth rates of the series tend to move together. In fact, the correlation coefficient in the -stationary- growth rates exceeds 0.95. The second measure of *q* is the ratio of market value to replacement costs given in Table 10.2 in Brainard et al. (1991) for the period 1963-1985. Again, as shown in Figure 3B, real stock prices and the Brainard et al. (1991) measure of *q* for the US, as well as their growth rates, move together. Here, the correlation coefficient between the two variables is 0.76.

Regression results are displayed in Parts I and II of Table 9. As can be readily seen, the coefficient estimates do not differ significantly from the results reported earlier for the US. The negative coefficient of output growth rate in the equation for real stock returns remains negative and statistically significant while real stock returns enter with a significantly positive sign in the output equation. Thus, it appears that, at least for the US where data is available, the estimates are not affected by including direct estimates of *q*.

Moreover, to investigate the stability of the estimates over a longer time span, we constructed the growth rate of industrial production for the US for the period 1900-1990. In particular, for the period 1900-1919 we used the index of manufacturing production for 1863-1930 from the NBER Macrohistory Database. For the period 1920-1990 we constructed growth rates of industrial production (defined as capacity, utilization and electric power use) from seasonally adjusted monthly series, available from the Federal Reserve, Board of Governors.[15] Results are displayed in Part III of Table 9 for a VAR estimated with the growth rate of constructed industrial production and the *q* variable of Blanchard et al. (1993) growth rates and confirm the general findings reported earlier. Hence, we conclude that as regards the market valuation of capital there is reason to believe that stock prices are a good proxy of *q*.

4.4. Impulse responses

We now move on to investigate of the impact of changes in market valuation of capital and economic growth. Given the contemporaneous correlation of the innovations there is a common

[14] For theoretical and empirical considerations on the relationship between *q* and investment using dynamic panel data sets, see e.g. Hayashi and Inoue (1991) and Blundell et al. (1992).
[15] The two series are closely linked for the common period 1920-1930. In fact, the correlation coefficient between their growth rates amounts to 0.985.

component which cannot be associated with a specific variable. Therefore, the errors were orthogonalized by the Cholesky decomposition so that the covariance matrix of the resulting innovations is lower-triangular with the ordering *[ROGS, ROGY]*. This implies that innovations in the growth rate of industrial production do not affect contemporaneously innovations in the growth rate of real stock prices, or, equivalently, shocks in the real sector of the economy are not immediately observable by financial markets, albeit shocks in real stock prices are observable by both the real and the financial sectors of the economy. Figures 3 to 10 display the responses of the two variables *ROGS* and *ROGY* to unanticipated shocks given by a one standard deviation shock in the residuals of the two equations. Impulse responses are reported for a 10-period horizon for each country with two standard deviation bands calculated with Monte Carlo integration methods from 100 replications.

More specifically, in all cases there is a positive effect on output growth and real stock returns after a positive shock in real stock prices. The impact of the shock in stock returns dies out after approximately 1 year, or 2 to 4 quarters. The response of output is somewhat sluggish, and peaks after 1 year or 3 to 4 quarters, with the exception of Italy. However, the reaction is rather prolonged in some cases, and particularly in Japan. On the other hand, the reaction of output after a shock in production lasts about 1 to 2 years, or 2 to 3 quarters in quarterly data, again with the exception of Japan where the return to benchmark is more protracted and lasts 6 quarters. The growth rate of real stock prices responds negatively to a shock in output, and returns to baseline after 2 to 5 years for annual data or 8 to 12 quarters for the quarterly data sets. Finally, in accordance to estimated coefficients, impulse responses for real stock prices are significant only for the UK and the US, both in annual and quarterly data.

4.5. Forecasting performance

Given the empirical support for the VARs of output and real stock prices we move to compare their forecasting performance against plausible benchmark alternatives, which are given by AR(1) processes for annual data and AR(4) processes for quarterly data.[16] These give adequate representations of the series at hand with no signs of misspecification in the residuals. We re-estimate the VARs excluding the last five observations in annual models and the last eight observations for quarterly models, and one-period-ahead forecasts are generated by continuously updating the sample and re-estimating the model as new observations are incorporated in each period. Results are displayed in Table 10 and it is clear that VARs outperform simple AR representations, which adopted as alternative benchmark models, in most countries both in annual and quarterly frequencies.[17]

5. Conclusions

In this paper we sought to offer some insights in the links between the real and the financial sectors of the economy by investigating the links between output and market valuation of capital. First, we presented a simple growth model in which financial decisions of firms affect their market value and we showed how this model results in the joint determination of growth rates of output and the market value of capital, as measured by real stock prices. Empirical estimates from the main industrialized economies are consistent with the theoretical findings of the model and it was shown that unanticipated movements in output and real stock prices play a role in future economic growth and market valuation of capital. All impulse responses move in the same directions across countries and data frequencies; the robustness of the results is rather surprising, given that the G7 economies have experienced a variety of policies, that have affected the real and the financial sectors of the economies.

An important question that arises, though, concerns the interpretation of the results in the VAR framework. As emphasized by Cochrane (1998), the problem of 'observational equivalence' is present in all simulations conducted with VARs, and results may bear different interpretations in the context of alternative identifying assumptions about the anticipated and unanticipated character of shocks, and the persistence of perturbations. Moreover, one should not ignore that other forces in the economic environment may drive movements in economic growth or capital valuation, like money and inflation.

We find that the results of the paper are promising for the literature of economic growth and finance. A possible route for further research could be the development of a model that also looks at the monetary sector of the economy and re-examines the question of the effects of monetary policy on output by analyzing additionally its effects through the financial sector of the economy. In such a case,

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[16] The only exception is the case of the quarterly output for the USA where a standard AR(2) was used.

[17] Exceptions occur particularly in cases of recent rapid stock price increases. For instance, a notable exception is real stock returns growth in the US. Given that the Dow Jones index increased by more than 2.5 times between January 1995 and January 1999, it is hard to believe that such trends signal solely anticipations of future economic growth and further research in a richer context is needed explain the magnitude of these dynamics.

augmented VARs with a monetary variable included could give a more clear view of the effects of the real, the financial and the monetary sector of the economy. Finally, a fruitful extension of the paper could be towards investigating these effects in other developed economies or, alternatively, in transition economies and in countries with emerging markets. Our modeling approach might provide an explanation for the large variations in growth and real stock returns in these countries.

APPENDIX

Proof that at the optimum $q = \frac{V^*}{K}$.

By (10) and (11) we have that $\dot{V} = q^* V - \Pi'$. Given (13c) and (6)´ where in the latter equation we replace from the first order conditions (13a) and (13b), and after some manipulation it follows that:

$$\dot{V} = \left[\frac{\dot{q}}{q} + \frac{\mathrm{A}\boldsymbol{a}}{q} + \frac{(q-1)^2}{2qf} - \boldsymbol{d} \right] V - \left[\mathrm{A}\boldsymbol{a} - \frac{(q^2-1)}{2f} \right] K$$

Now, following Turnovsky (1995) we postulate a solution of the form $v = \frac{V}{qK}$ which implies that $\frac{\dot{v}}{v} = \frac{\dot{V}}{V} - \frac{\dot{q}}{q} - \frac{\dot{K}}{K}$. Replacing for the growth rate of capital given by the capital accumulation equation, and using the expression for $\dot{V}$ and (13b) we obtain that:

$$\frac{\dot{v}}{v} + \frac{q-1}{f} = \left[\frac{\mathrm{A}\boldsymbol{a}}{q} + \frac{(q-1)^2}{2qf} \right] - \left[\mathrm{A}\boldsymbol{a} + \frac{(q^2-1)}{2f} \right] (vq)^{-1}$$

Solving for $\dot{v}$ we end up with the following expression:

$$\dot{v} = \left[\frac{\mathrm{A}\boldsymbol{a}}{q} - \frac{(q^2-1)}{2qf} \right] (v-1)$$

The only stable solution for this differential equation is when $v=1$, which gives us that $q = \frac{V^*}{K}$ at the optimum.

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TABLE 1. CANADA

A. Annual data (sample period: 1957-1997)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.072 (0.162)	-0.650 (0.508)
Real stock returns (-1)	0.111 (0.054)	-0.073 (0.171)
Constant	3.204 (0.898)	5.594 (2.814)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	1.525 (0.232)	0.404 (0.671)
Normality Chi-square	5.823 (0.054)	0.780 (0.677)
Heteroscedasticiy	0.726 (0.580)	1.000 (0.422)
ARCH test	0.397 (0.533)	1.783 ((0.190)
Functional form	0.795 (0.562)	0.813 (0.550)

B. Quarterly data (sample period: 1957.2-1998.1)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.216 (0.073)	0.002 (0.317)
Industrial production growth rate (-2)	0.171 (0.070)	-0.351 (0.303)
Real stock returns (-1)	0.060 (0.017)	0.292 (0.076)
Real stock returns (-2)	0.050 (0.018)	-0.004 (0.079)
Constant	0.428 (0.134)	1.058 (0.584)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	0.840 (0.523)	0.542 (0.744)
Normality Chi-square	5.034 (0.081)	2.288 (0.312)
Heteroscedasticiy	1.519 (0.155)	2.696 (0.082)
ARCH test	1.025 (0.397)	0.842 (0.508)
Functional form	2.004 (0.021)	1.718 (0.058)

Notes: Results are from a Vector Autoregression estimated by OLS. Standard errors are in parentheses next to the estimated coefficients. A dummy for 87.4 is included in the quarterly data specification.

<u>TABLE 2.</u> FRANCE

A. Annual data (sample period: 1950-1996)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.185 (0.147)	-0.406 (0.644)
Real stock returns (-1)	0.048 (0.034)	0.165 (0.151)
Constant	2.683 (0.838)	5.345 (3.676)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	0.618 (0.544)	0.207 (0.814)
Normality Chi-square	2.466 (0.291)	1.059 (0.589)
Heteroscedasticiy	1.068 (0.385)	0.177 (0.949)
ARCH test	1.846 (0.182)	0.001 (0.976)
Functional form	1.598 (0.185)	0.288 (0.916)

B. Quarterly data (sample period: 1957.2-1997.4)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.097 (0.054)	-0.238 (0.279)
Industrial production growth rate (-2)	0.052 (0.048)	-0.038 (0.247)
Industrial production growth rate (-3)	0.125 (0.046)	-0.348 (0.240)
Real stock returns (-1)	0.022 (0.014)	0.326 (0.074)
Real stock returns (-2)	0.010 (0.015)	-0.120 (0.077)
Real stock returns (-3)	0.017 (0.014)	0.170 (0.074)
Constant	0.472 (0.141)	0.909 (0.726)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	1.539 (0.181)	2.066 (0.073)
Normality Chi-square	4.820 (0.090)	3.745 (0.154)
Heteroscedasticiy	0.988 (0.464)	0.715 (0.735)
ARCH test	1.510 (0.202)	0.286 (0.887)
Functional form	1.093 (0.360)	0.696 (0.861)

Notes: See Table 1. Dummies for 63.2, 68.2, 68.3, 74.4, 75.1 and 87.4 are included in the quarterly data specification.

TABLE 3. GERMANY

A. Annual data (sample period: 1971-1996)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.049 (0.192)	-1.135 (0.949)
Real stock returns (-1)	0.097 (0.042)	0.190 (0.205)
Constant	0.099 (0.740)	5.085 (3.652)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	0.868 (0.435)	1.416 (0.266)
Normality Chi-square	0.527 (0.768)	3.624 (0.163)
Heteroscedasticiy	1.641 (0.210)	0.632 (0.647)
ARCH test	0.007 (0.936)	3.230 (0.087)
Functional form	1.237 (0.337)	0.476 (0.789)

B. Quarterly data (sample period: 1970.2-1996.4)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.231 (0.091)	-0.087 (0.394)
Industrial production growth rate (-2)	0.068 (0.088)	-0.896 (0.380)
Real stock returns (-1)	-0.006 (0.020)	0.245 (0.089)
Real stock returns (-2)	0.051 (0.020)	-0.043 (0.087)
Constant	0.187 (0.158)	1.408 (0.682)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	1.488 (0.201)	1.564 (0.178)
Normality Chi-square	2.716 (0.257)	2.586 (0.274)
Heteroscedasticiy	1.155 (0.335)	0.434 (0.897)
ARCH test	0.806 (0.524)	0.243 (0.913)
Functional form	0.678 (0.789)	0.341 (0.986)

Notes: See Table 1. A dummy for 87.4 is included in the quarterly data specification.

TABLE 4. ITALY

A. Annual data (sample period: 1949-1997)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.249 (0.151)	-0.381 (0.808)
Industrial production growth rate (-2)	0.122 (0.152)	0.233 (0.815)
Real stock returns (-1)	0.021 (0.029)	0.383 (0.156)
Real stock returns (-2)	-0.020 (0.029)	-0.244 (0.156)
Constant	2.787 (1.131)	4.351 (6.071)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	2.133 (0.132)	0.072 (0.931)
Normality Chi-square	2.388 (0.303)	4.584 (0.101)
Heteroscedasticiy	0.787 (0.617)	1.501 (0.195)
ARCH test	3.383 (0.073)	3.781 (0.059)
Functional form	0.847 (0.618)	1.161 (0.356)

B. Quarterly data (sample period: 1957.2-1998.1)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.189 (0.072)	-0.463 (0.323)
Industrial production growth rate (-2)	0.075 (0.067)	-0.261 (0.303)
Real stock returns (-1)	0.021 (0.018)	0.336 (0.082)
Real stock returns (-2)	-0.001 (0.018)	0.159 (0.083)
Constant	0.662 (0.203)	1.022 (0.917)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	0.348 (0.883)	1.674 (0.144)
Normality Chi-square	1.476 (0.478)	5.284 (0.071)
Heteroscedasticiy	1.578 (0.136)	2.762 (0.007)
ARCH test	0.353 (0.841)	2.048 (0.091)
Functional form	1.632 (0.078)	1.802 (0.044)

Notes: See Table 1. Dummies for 69.4, 70.1, 73.1 and 73.2 are included in the quarterly data specification.

<u>TABLE 5.</u> JAPAN

Annual data (sample period: 1957-1997)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.311 (0.135)	-0.590 (0.394)
Real stock returns (-1)	0.162 (0.055)	0.367 (0.160)
Constant	2.951 (1.408)	9.499 (4.099)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	2.484 (0.098)	1.773 (0.185)
Normality Chi-square	0.976 (0.614)	0.016 (0.992)
Heteroscedasticiy	0.951 (0.448)	1.160 (0.347)
ARCH test	4.577 (0.039)	0.503 (0.483)
Functional form	0.760 (0.586)	0.899 (0.494)

B. Quarterly data (sample period: 1958.2-1998.1)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.597 (0.077)	-0.105 (0.401)
Industrial production growth rate (-2)	0.166 (0.085)	0.094 (0.444)
Industrial production growth rate (-3)	-0.030 (0.073)	-0.443 (0.379)
Real stock returns (-1)	0.046 (0.016)	0.355 (0.081)
Real stock returns (-2)	0.026 (0.017)	-0.085 (0.089)
Real stock returns (-3)	0.030 (0.016)	0.155 (0.085)
Constant	0.157 (0.158)	1.777 (0.821)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	1.535 (0.182)	0.391 (0.855)
Normality Chi-square	3.130 (0.209)	3.280 (0.194)
Heteroscedasticiy	1.180 (0.303)	1.196 (0.292)
ARCH test	0.459 (0.766)	2.093 (0.085)
Functional form	1.328 (0.151)	1.023 (0.444)

Notes: See Table 1. A dummy for 75.2 is included in the quarterly data specification.

<u>TABLE 6.</u> UNITED KINGDOM

Annual dsata (sample period: 1960-1997)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	-0.032 (0.145)	-1.747 (0.717)
Real stock returns (-1)	0.124 (0.033)	0.260 (0.162)
Constant	1.548 (0.552)	6.084 (2.738)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	0.286 (0.753)	0.146 (0.865)
Normality Chi-square	3.626 (0.163)	2.286 (0.319)
Heteroscedasticiy	0.195 (0.939)	0.766 (0.556)
ARCH test	0.038 (0.846)	1.856 (0.183)
Functional form	0.193 (0.963)	7.051 (0.000)

B. Quarterly data (sample period: 1959.1-1998.1)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.204 (0.066)	-0.906 (0.316)
Industrial production growth rate (-2)	0.040 (0.059)	-0.164 (0.282)
Industrial production growth rate (-3)	0.047 (0.063)	0.133 (0.300)
Real stock returns (-1)	0.020 (0.015)	0.426 (0.072)
Real stock returns (-2)	0.027 (0.015)	-0.054 (0.070)
Real stock returns (-3)	0.053 (0.014)	0.199 (0.069)
Constant	0.167 (0.131)	0.854 (0.624)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	0.907 (0.478)	0.706 (0.620)
Normality Chi-square	7.620 (0.022)	2.420 (0.298)
Heteroscedasticiy	0.636 (0.808)	0.619 (0.823)
ARCH test	0.582 (0.676)	1.870 (0.119)
Functional form	0.656 (0.897)	0.598 (0.938)

Notes: See Table 1. Dummies for 74.1, 74.2, 75.1, 87.4 are included in the quarterly data specification.

TABLE 7. UNITED STATES

Annual data (sample period: 1951-1997)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	-0.169 (0.131)	-1.242 (0.412)
Real stock returns (-1)	0.186 (0.046)	0.271 (0.144)
Constant	3.063 (0.787)	8.922 (2.473)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	0.900 (0.414)	0.568 (0.571)
Normality Chi-square	2.267 (0.322)	0.394 (0.821)
Heteroscedasticiy	1.019 (0.410)	0.130 (0.970)
ARCH test	0.479 (0.493)	0.034 (0.855)
Functional form	0.926 (0.475)	0.571 (0.722)

B. Quarterly data (sample period: 1960.4-1998.2)

Dependent Variable	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.425 (0.072)	-0.827 (0.386)
Industrial production growth rate (-2)	-0.142 (0.074)	-0.062 (0.402)
Industrial production growth rate (-3)	0.243 (0.075)	-0.051 (0.402)
Industrial production growth rate (-4)	-0.129 (0.066)	-0.515 (0.358)
Real stock returns (-1)	0.065 (0.014)	0.394 (0.077)
Real stock returns (-2)	0.008 (0.016)	0.010 (0.088)
Real stock returns (-3)	0.047 (0.016)	0.062 (0.088)
Real stock returns (-4)	-0.020 (0.016)	0.149 (0.086)
Constant	0.427 (0.117)	1.848 (0.629)
Misspecification tests (significance level in parentheses)		
LM test for serial correlation	2.420 (0.039)	0.418 (0.835)
Normality Chi-square	0.812 (0.666)	3.287 (0.193)
Heteroscedasticiy	0.830 (0.650)	1.172 (0.301)
ARCH test	1.327 (0.263)	0.565 (0.689)

Functional form	0.655 (0.939)	1.351 (0.116)

Notes: See Table 1. Dummies for 74.1, 74.2, 75.1, 87.4 are included in the quarterly data specification.

TABLE 8. CAUSALITY TESTS

Annual data	FROM REAL STOCK RETURNS TO INDUSTRIAL PRODUCTION GROWTH RATE	FROM INDUSTRIAL PRODUCTION GROWTH RATE TO REAL STOCK RETURNS
Canada	4.173 *	1.638
France	2.007	0.397
Germany	5.385 *	1.429
Italy	0.350	0.344
Japan	8.711 **	2.247
UK	14.348 **	5.940 *
USA	16.617 **	9.085 **
Quarterly data		
Canada	11.699 **	0.734
France	1.719	1.039
Germany	2.004	4.038 *
Italy	1.668	1.588
Japan	6.998 **	0.997
UK	3.583 *	3.442 *
USA	8.717 **	3.372 *

*Notes: * denotes significance at the 5% level and ** at the 1% level.*

<u>TABLE 9.</u> EMPIRICAL RESULTS WITH ALTERNATIVE ESTIMATES OF Q FOR THE U.S.

MODEL VERSION	***I***		***II***		***III***	
Dependent variable	*Industrial production growth rate*	*Real stock returns*	*Industrial production growth rate*	*Real stock returns*	*Industrial production growth rate*	*Real stock returns*
Industrial production growth rate (-1)	0.247 (0.130)	-1.241 (0.619)	-0.158 (0.145)	-1.212 (0.381)	-0.287 (0.116)	-0.774 (0.209)
Real stock returns (-1)	0.293 (0.047)	-0.092 (0.222)	0.194 (0.056)	0.124 (0.148)	0.148 (0.057)	0.299 (0.103)
Constant	3.294 (0.831)	2.077 (3.958)	3.671 (0.914)	6.846 (2.400)	4.972 (1.124)	6.827 (2.029)
Misspecification tests (significance level in parentheses)						
LM test for serial correlation	0.368 (0.698)	0.320 (0.731)	0.143 (0.867)	0.590 (0.560)	2.379 (0.099)	0.117 (0.889)
Normality Chi-square	1.061 (0.588)	2.551 (0.279)	3.902 (0.142)	0.883 (0.643)	8.920 (0.012)	11.499 (0.003)
Heteroscedasticiy	0.451 (0.770)	0.527 (0.718)	0.420 (0.793)	1.011 (0.417)	1.060 (0.382)	8.657 (0.000)
ARCH test	7.316 (0.016)	0.525 (0.479)	0.056 (0.814)	0.035 (0.853)	8.068 (0.006)	7.021 (0.097)
Functional form	0.585 (0.711)	0.846 (0.543)	0.419 (0.832)	1.321 (0.282)	0.862 (0.511)	6.856 (0.000)

Notes: See Table 1. Model I is estimated with Brainard et al. (1991) q vsariable for sample period 1964-1985, and Models II and III are estimated with Blanchard et al. (1993) q variable for sample period 1951-1990 and 1901-1990, respectively. Dummies for 1914-18, 1930-32 and 1940-45 are included in Model III specification.

TABLE 10. **MODEL FORECASTING PERFORMANCE**

		OUTPUT			REAL STOCK PRICES		
Country/ Frequency	*Criterion*	*VAR model*	*AR model*	*Score*	*VAR model*	*AR model*	*Score*
Canada/	RMSE	2.26	2.94	*1.30*	10.81	11.78	*1.09*
Annual	MAE	1.83	2.38	*1.30*	8.27	8.98	*1.09*
Canada/	RMSE	0.76	0.71	*0.93*	6.23	6.28	*1.01*
Quarterly	MAE	0.60	0.58	*0.97*	4.54	4.66	*1.03*
France/	RMSE	3.47	3.61	*1.04*	8.03	7.44	*0.93*
Annual	MAE	2.57	2.83	*1.10*	5.94	5.51	*0.93*
France/	RMSE	0.91	1.03	*1.13*	6.85	6.94	*1.01*
Quarterly	MAE	0.72	0.83	*1.15*	5.59	5.64	*1.01*
Germany/	RMSE	3.51	3.99	*1.14*	6.05	8.07	*1.33*
Annual	MAE	2.67	3.11	*1.16*	4.42	7.09	*1.60*
Germany/	RMSE	1.59	1.57	*0.99*	4.46	4.37	*0.98*
Quarterly	MAE	1.28	1.24	*0.97*	3.90	3.52	*0.90*
Italy/	RMSE	3.54	3.70	*1.05*	15.84	16.24	*1.03*
Annual	MAE	2.71	2.80	*1.03*	12.25	12.54	*1.02*
Italy/	RMSE	1.28	1.31	*1.02*	11.52	11.59	*1.01*
Quarterly	MAE	0.89	0.91	*1.02*	8.79	8.78	*1.00*
Japan/	RMSE	3.11	3.90	*1.25*	16.85	16.79	*1.00*
Annual	MAE	2.65	3.14	*1.18*	13.87	13.78	*1.00*
Japan/	RMSE	1.06	1.25	*1.18*	7.92	7.91	*1.00*
Quarterly	MAE	0.84	1.03	*1.23*	5.95	6.23	*1.05*
UK/	RMSE	1.25	1.47	*1.18*	4.59	5.66	*1.23*
Annual	MAE	0.83	0.93	*1.12*	3.48	4.53	*1.30*
UK/	RMSE	0.67	0.58	*0.87*	2.43	2.95	*1.21*
Quarterly	MAE	0.47	0.39	*0.83*	1.75	2.22	*1.27*
USA/	RMSE	1.61	1.26	*0.78*	11.64	11.56	*1.00*
Annual	MAE	1.39	0.93	*0.67*	8.77	8.36	*0.96*
USA/	RMSE	0.69	0.42	*0.61*	5.51	5.75	*1.04*
Quarterly	MAE	0.53	0.33	*0.62*	4.68	4.87	*1.04*

Notes: RMSE denotes Root Mean Squared Error and MAE denotes Mean Absolute Error. See Tables 1-7 for the definiton of the VARs. AR is an AR(1) for the annual data and an AR(4) for the quarterly data (except for the US where an AR(2) model was used for quarterly output).

FIGURE 1.
Growth rates of output and real stock prices in G7 countries (annual data)

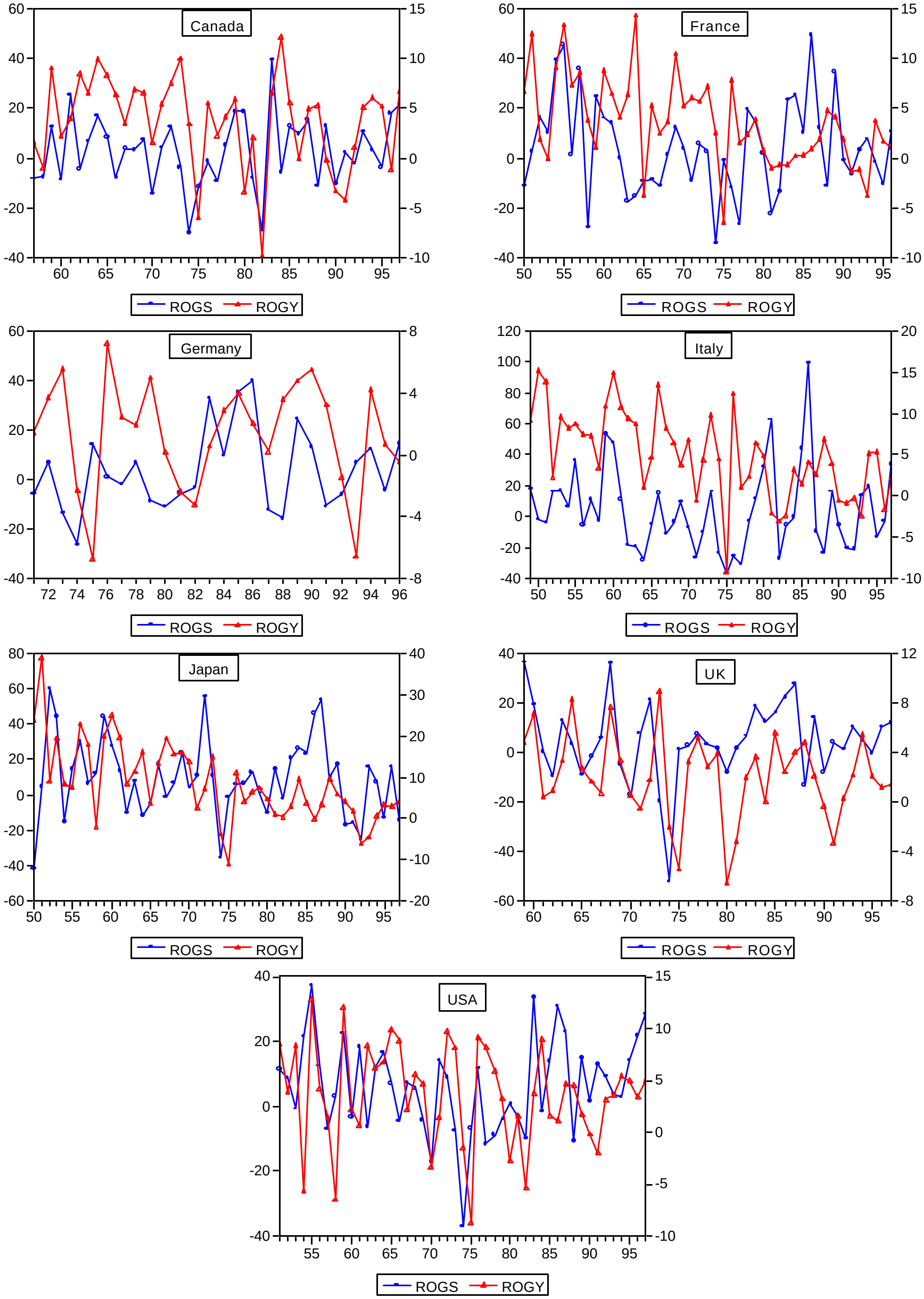


FIGURE 2.
Growth rates of output and real stock prices in G7 countries (quarterly data)

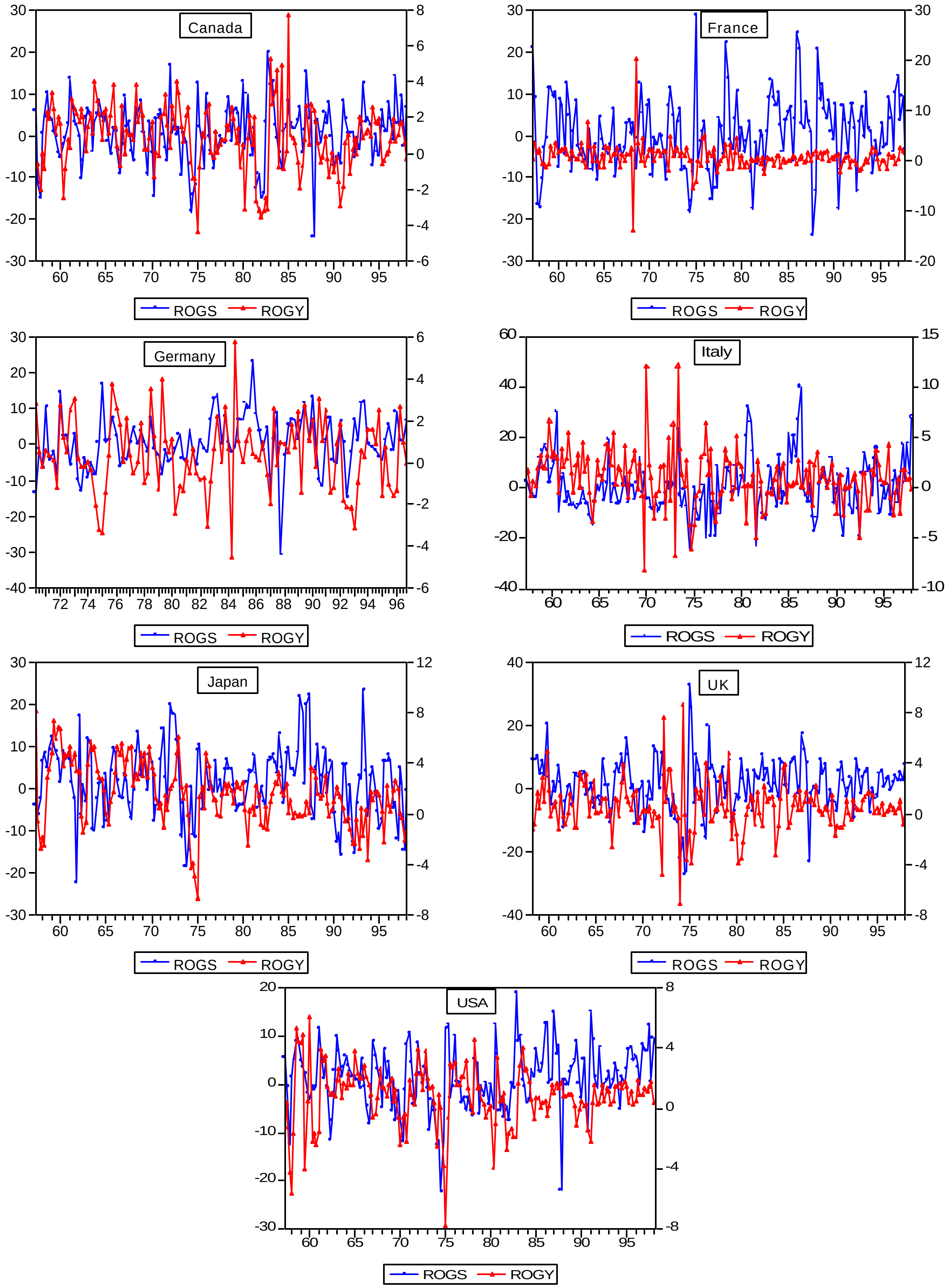
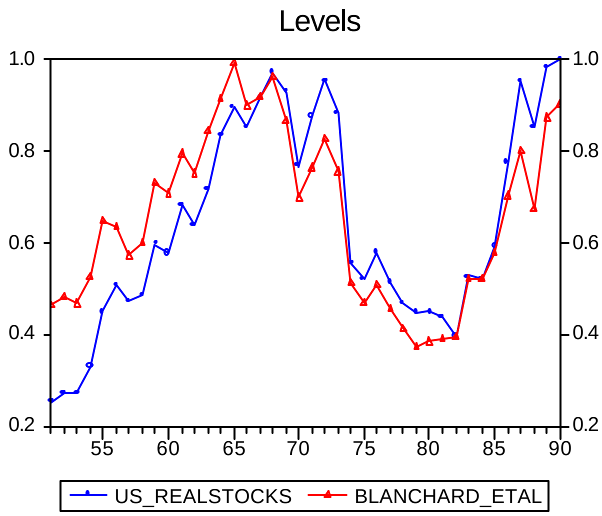
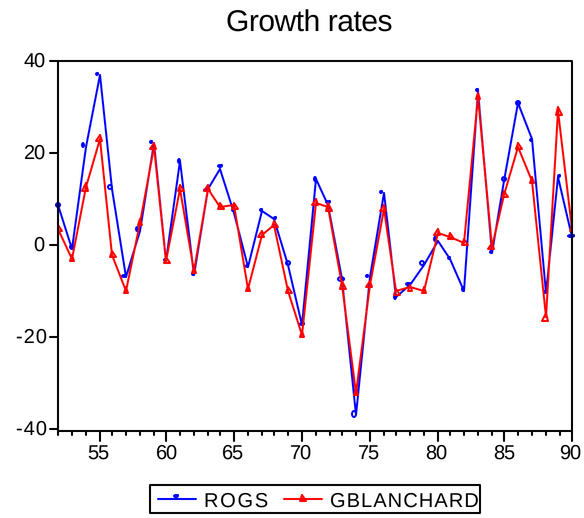


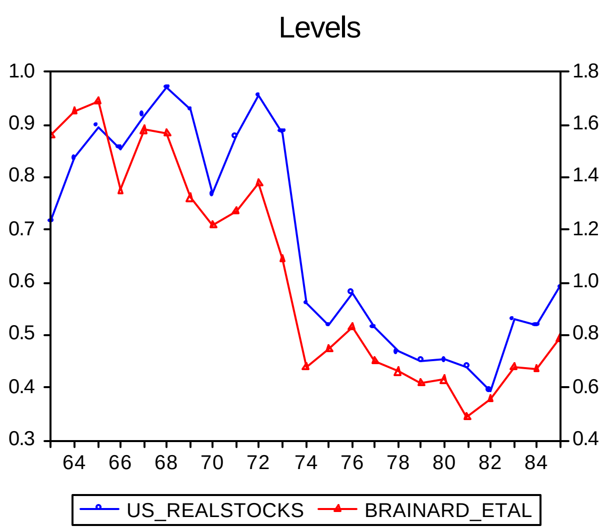
FIGURE 3.
USA real stock prices and alternative measures of Tobin´s q

A. Comparison with Blanchard et al. (1993) q variable (Sample period 1951-1990)





B. Comparison with Brainard et al. (1991) q variable (Sample period 1963-1985)



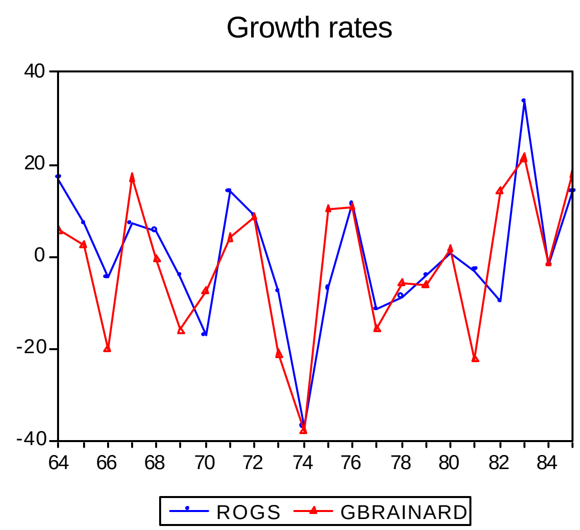
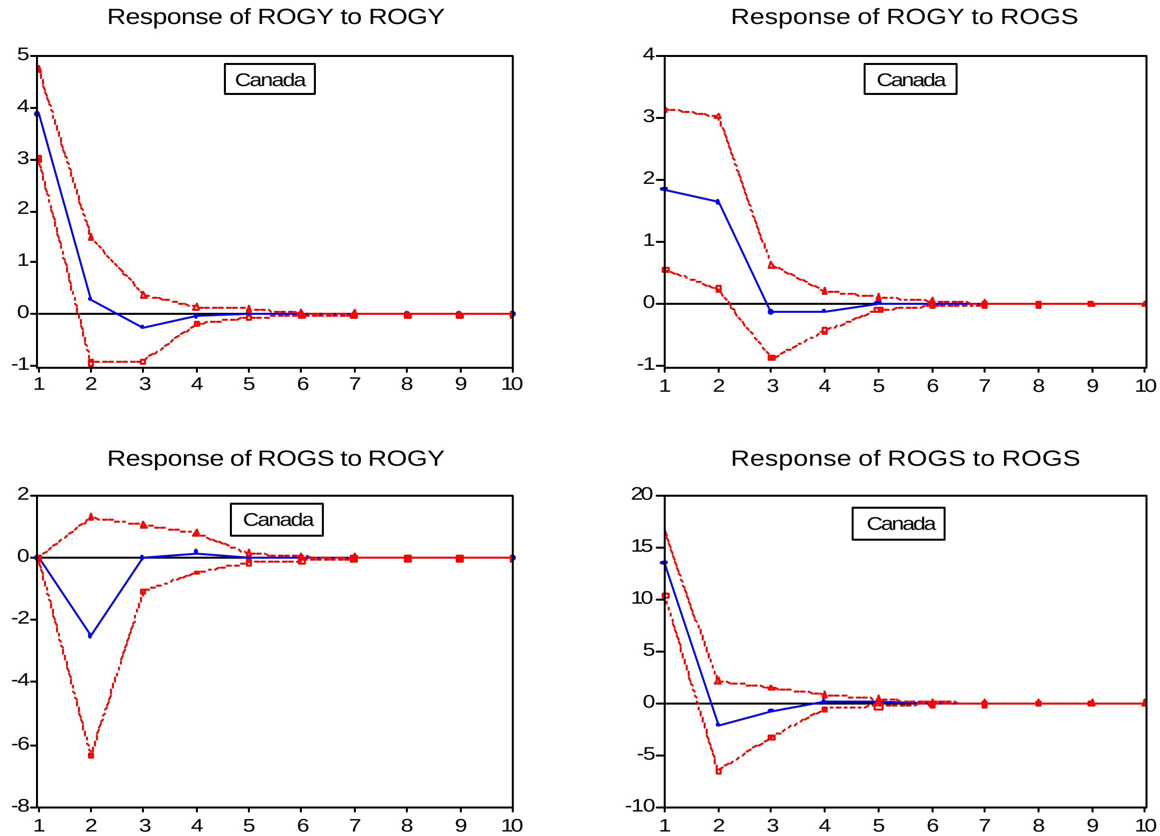


FIGURE 4.
Canada: Impulse responses in annual and quarterly data

A. Annual Data



B. Quarterly Data

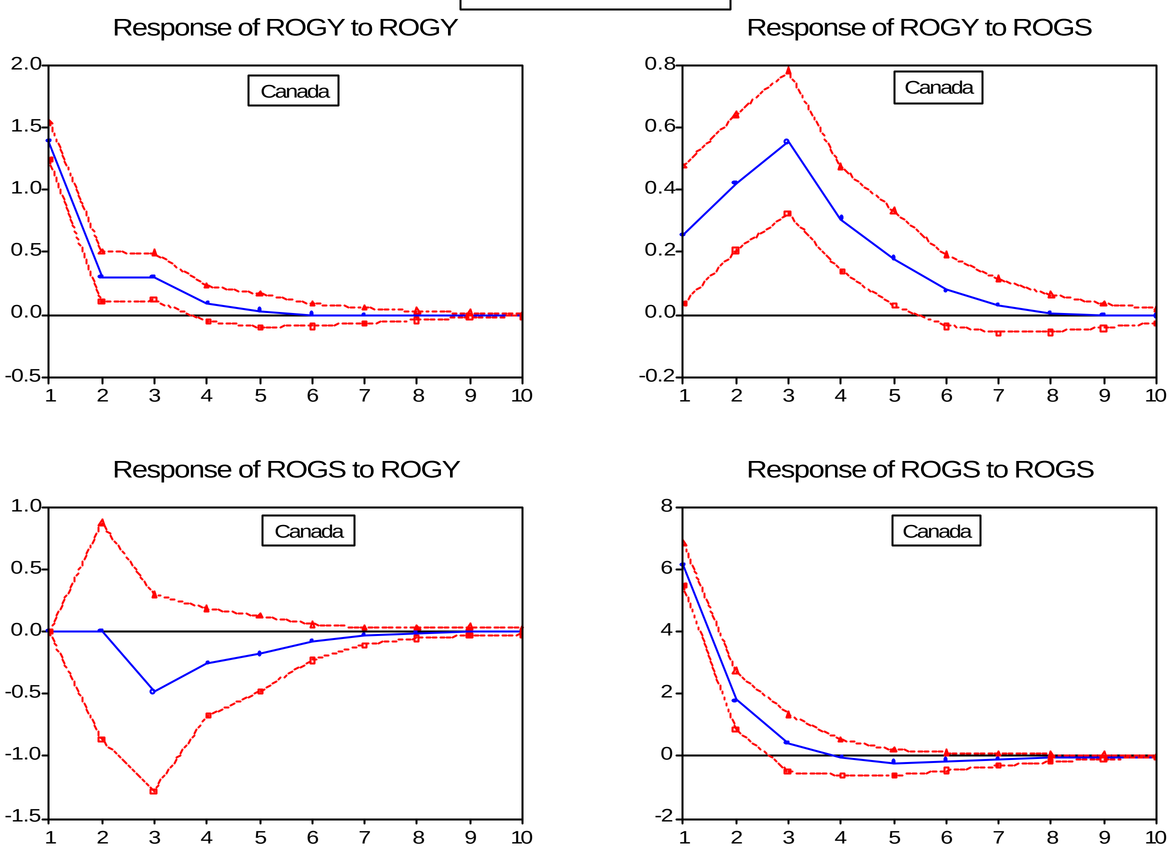
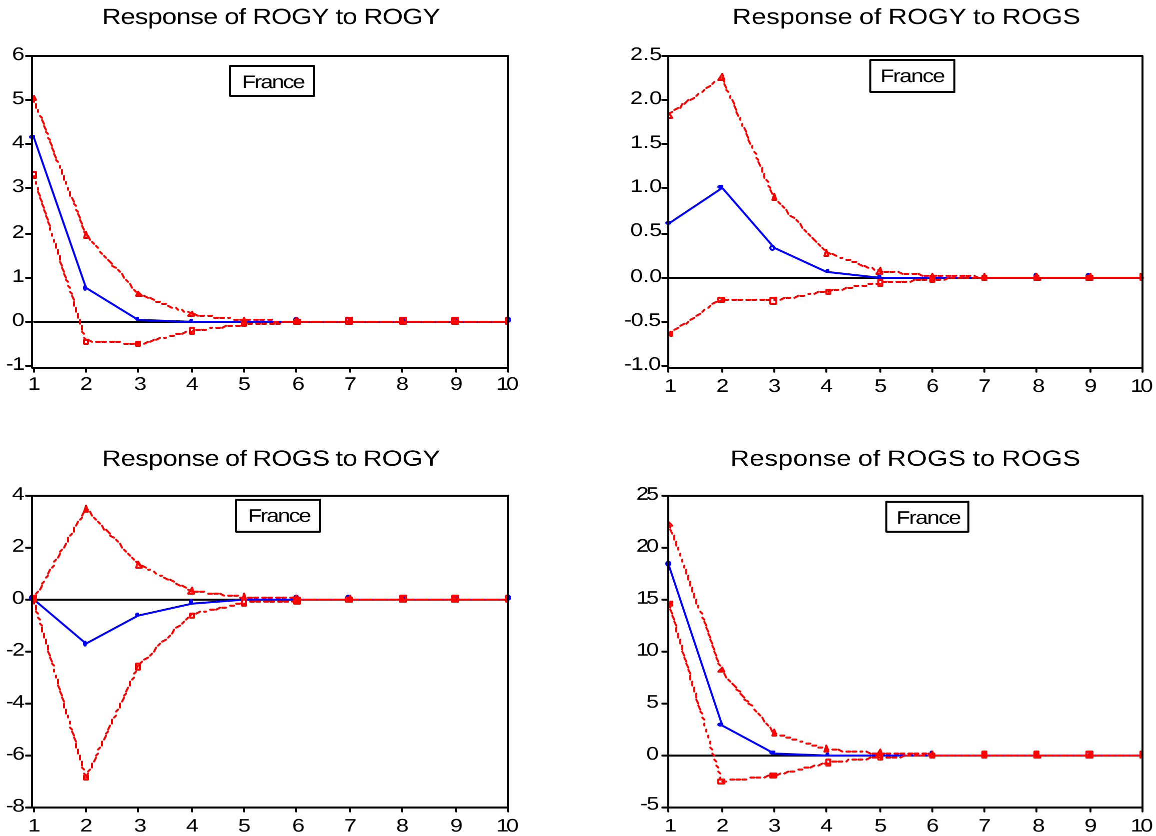


FIGURE 5.
France: Impulse responses in annual and quarterly data

A. Annual Data



B. Quarterly Data

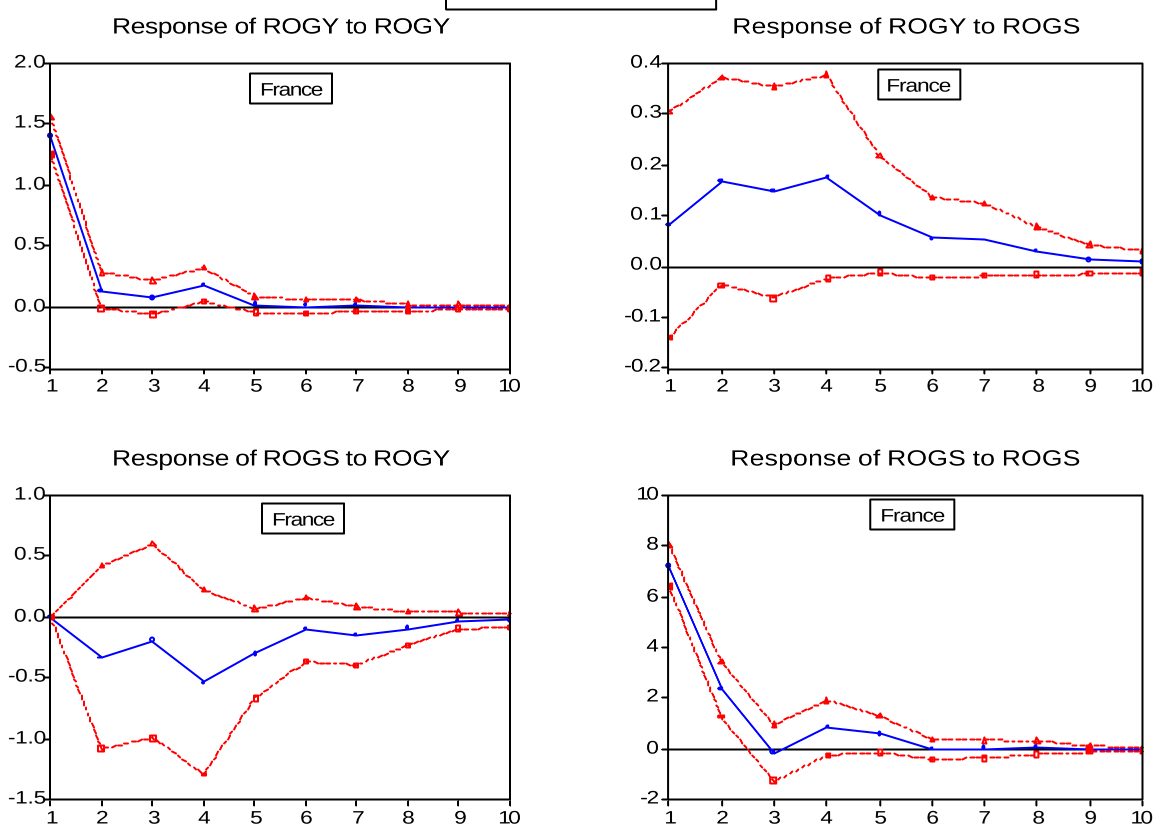
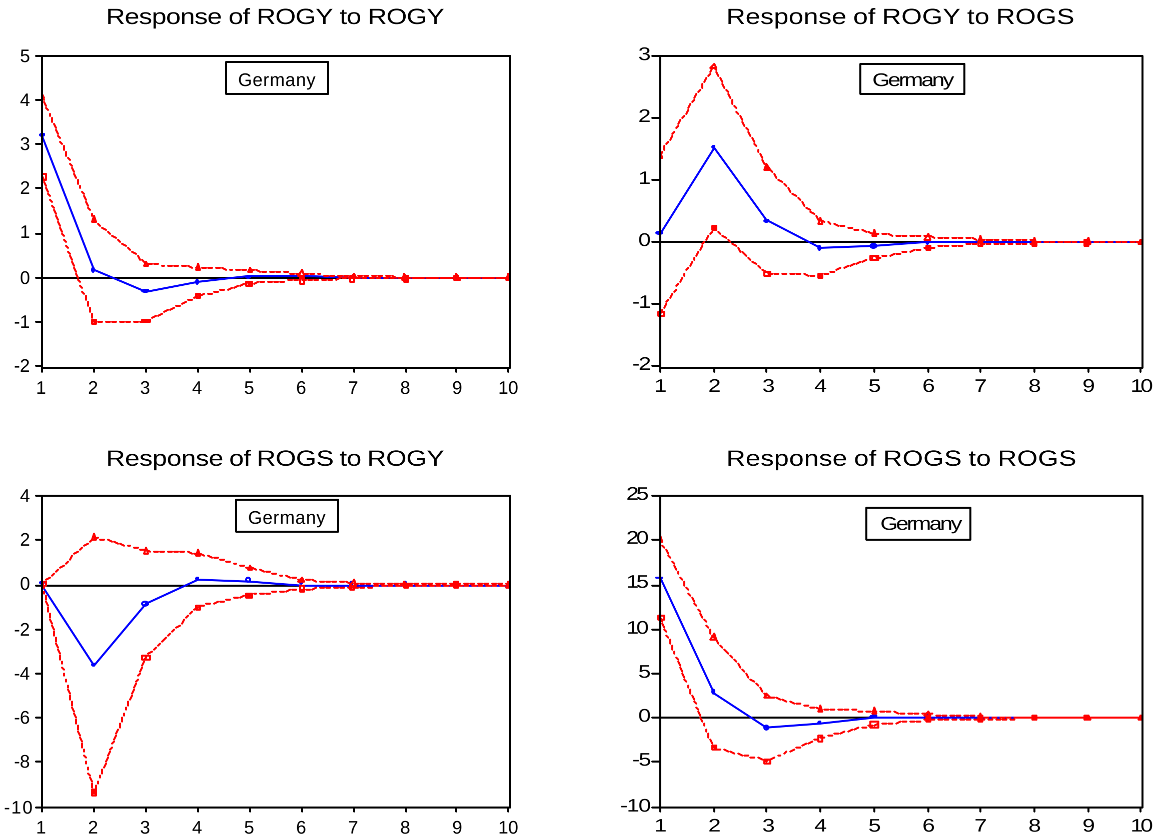


FIGURE 6.
Germany: Impulse responses in annual and quarterly data

A. Annual Data



B. Quarterly Data

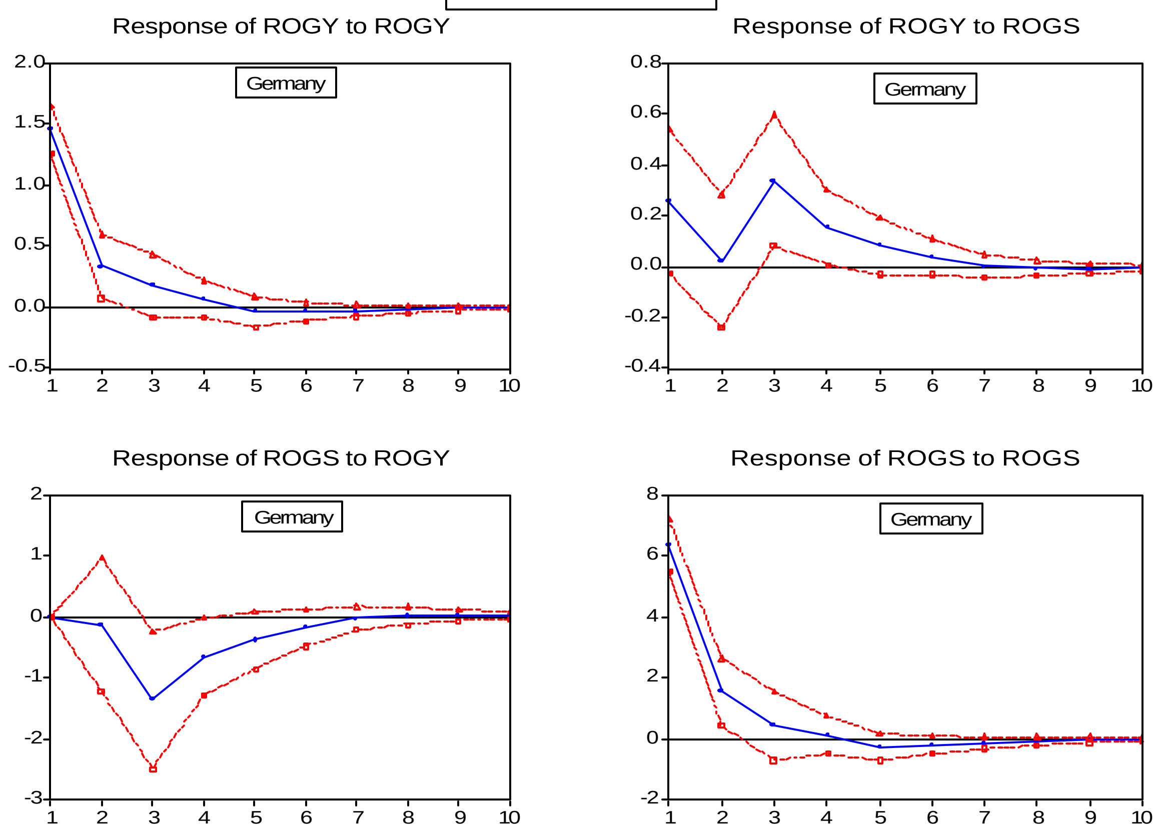
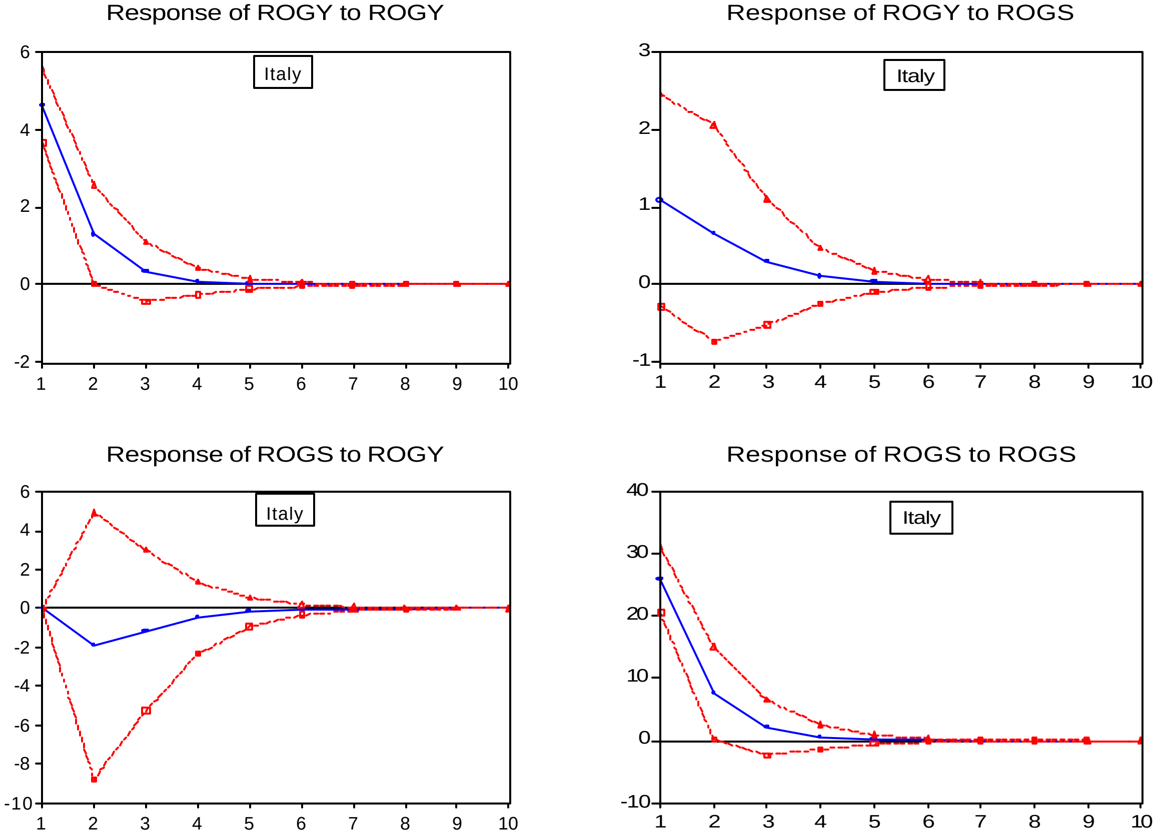


FIGURE 7.
Italy: Impulse responses in annual and quarterly data

A. Annual Data



B. Quarterly Data

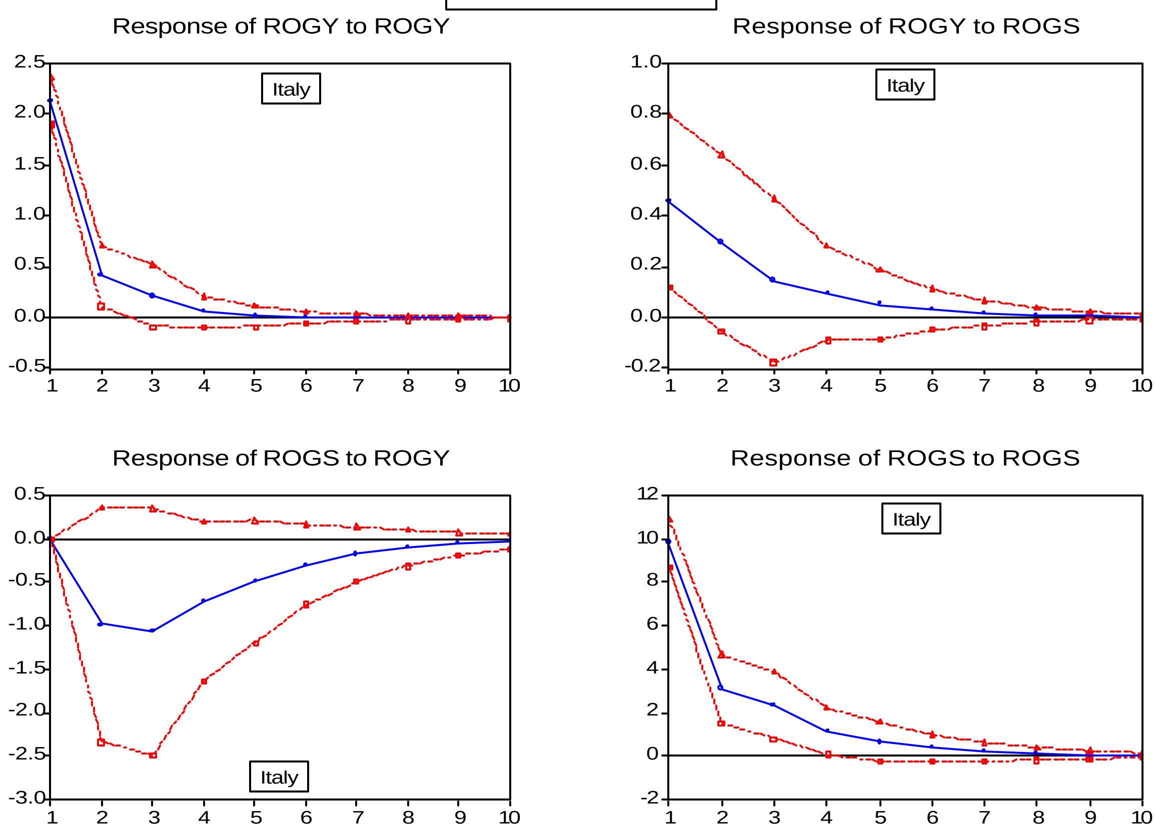
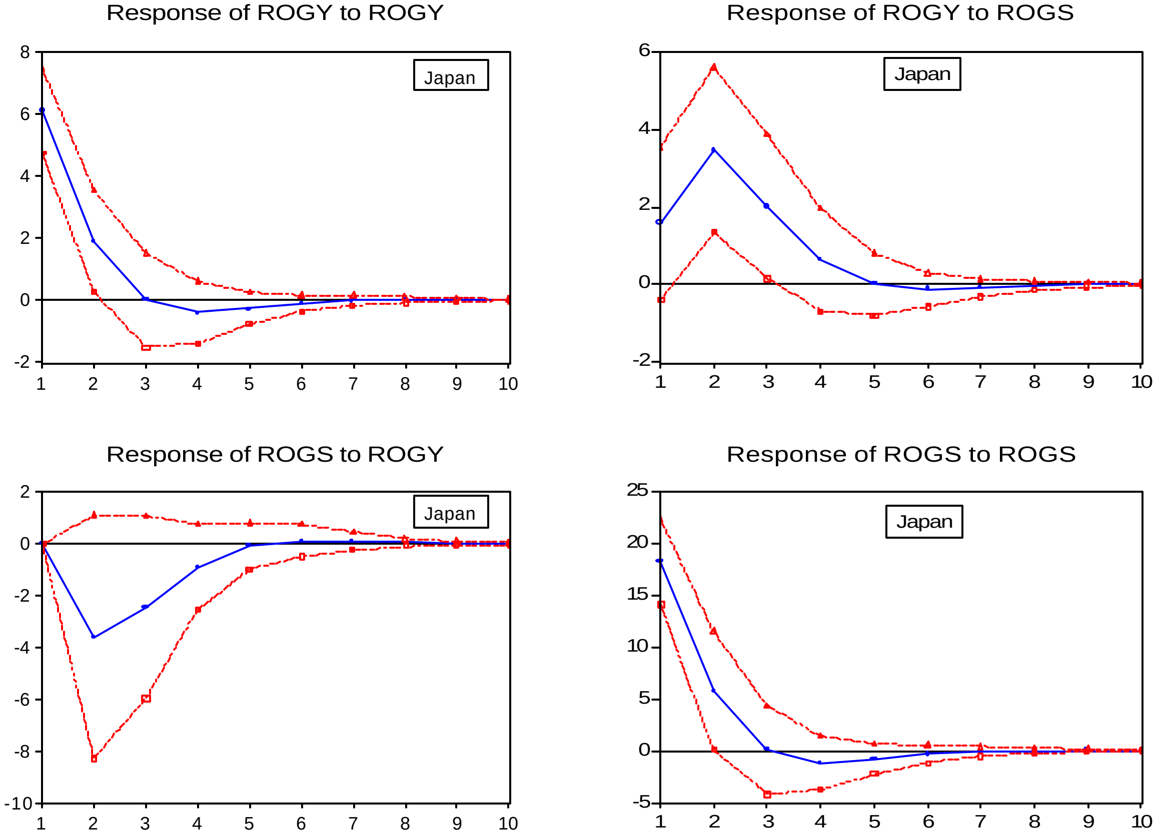


FIGURE 8.
Japan: Impulse responses in annual and quarterly data

A. Annual Data



B. Quarterly Data

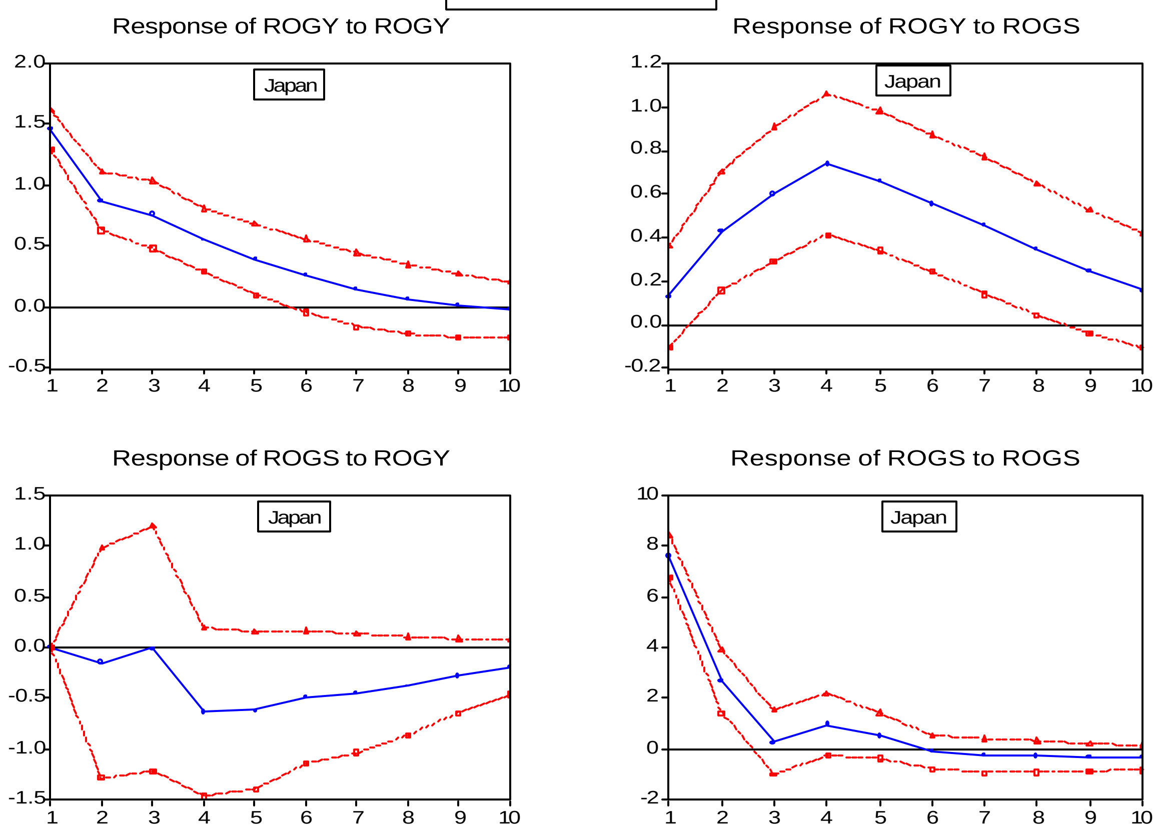
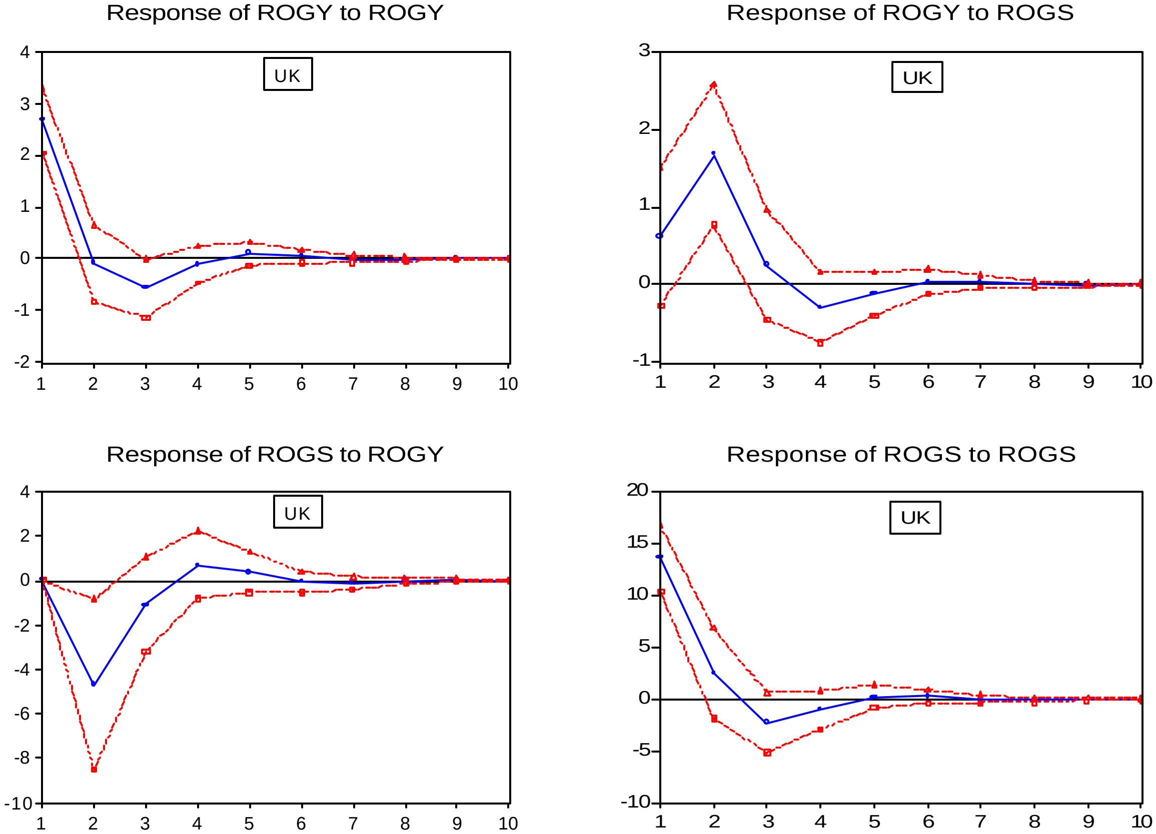


FIGURE 9.
United Kingdom: Impulse responses in annual and quarterly data

A. Annual Data



B. Quarterly Data

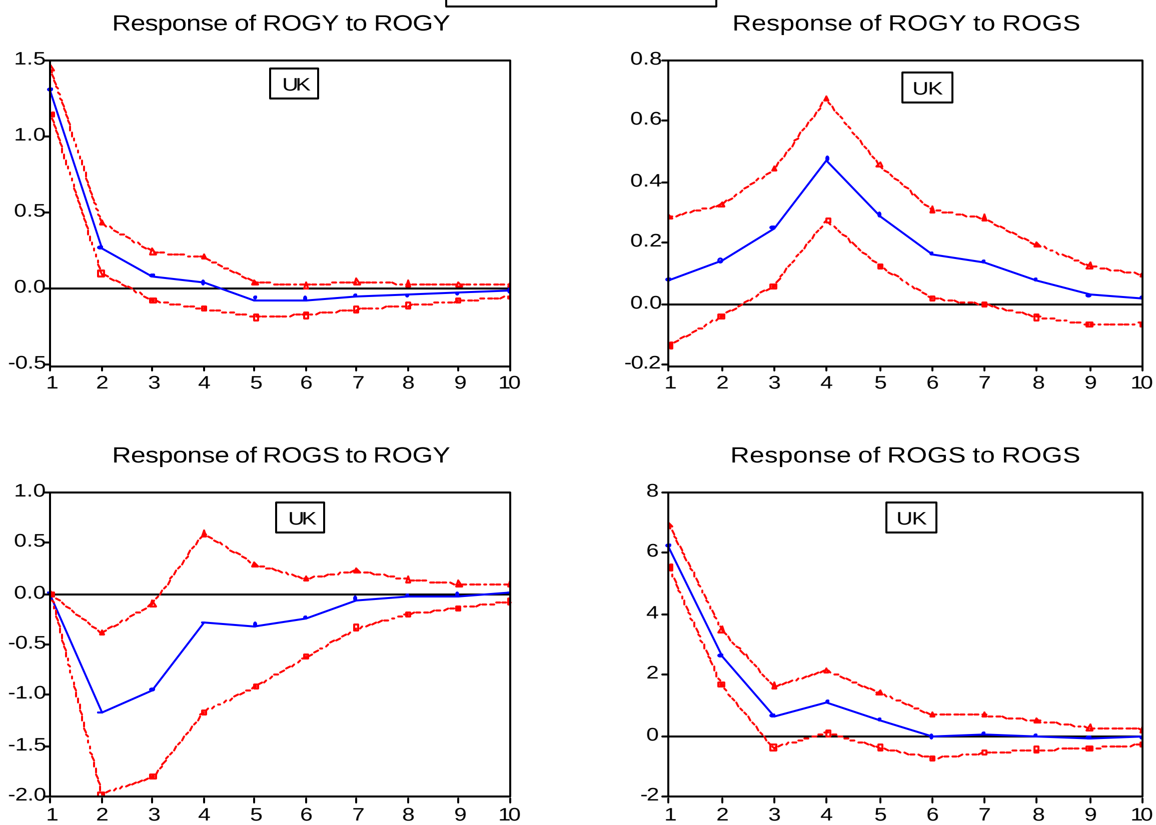
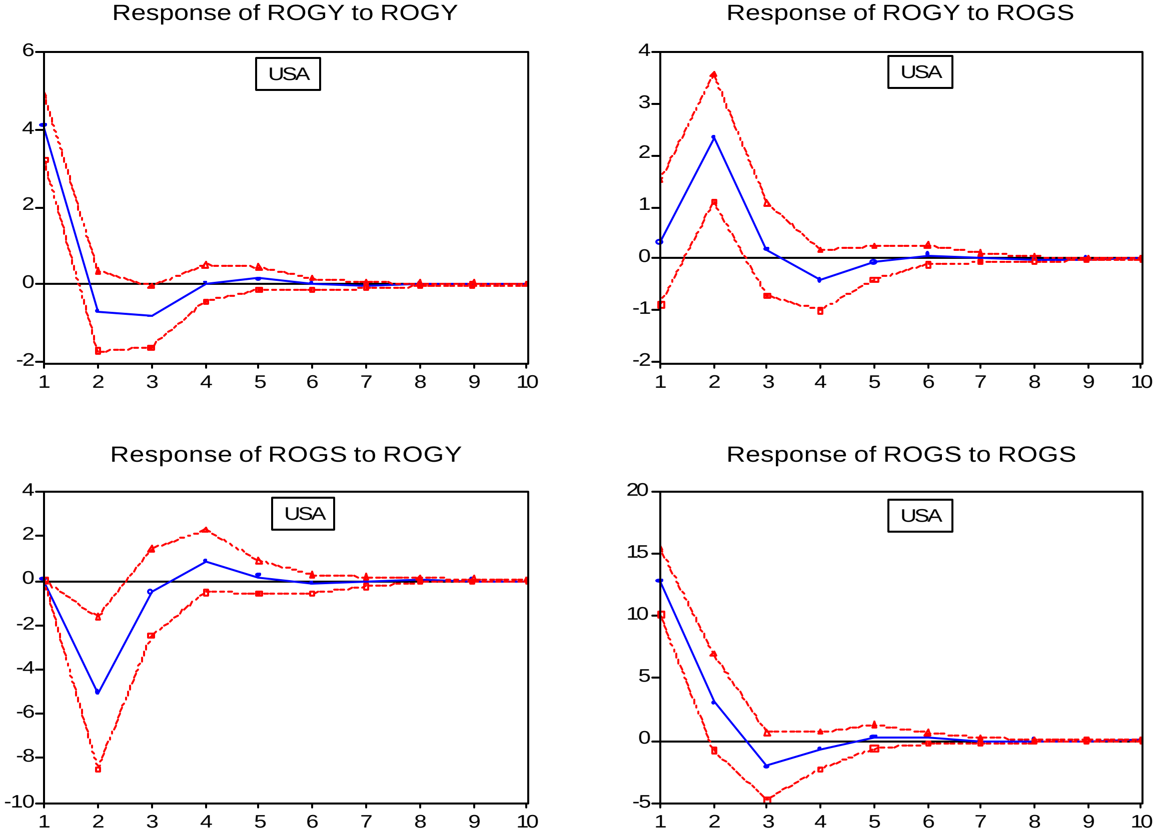
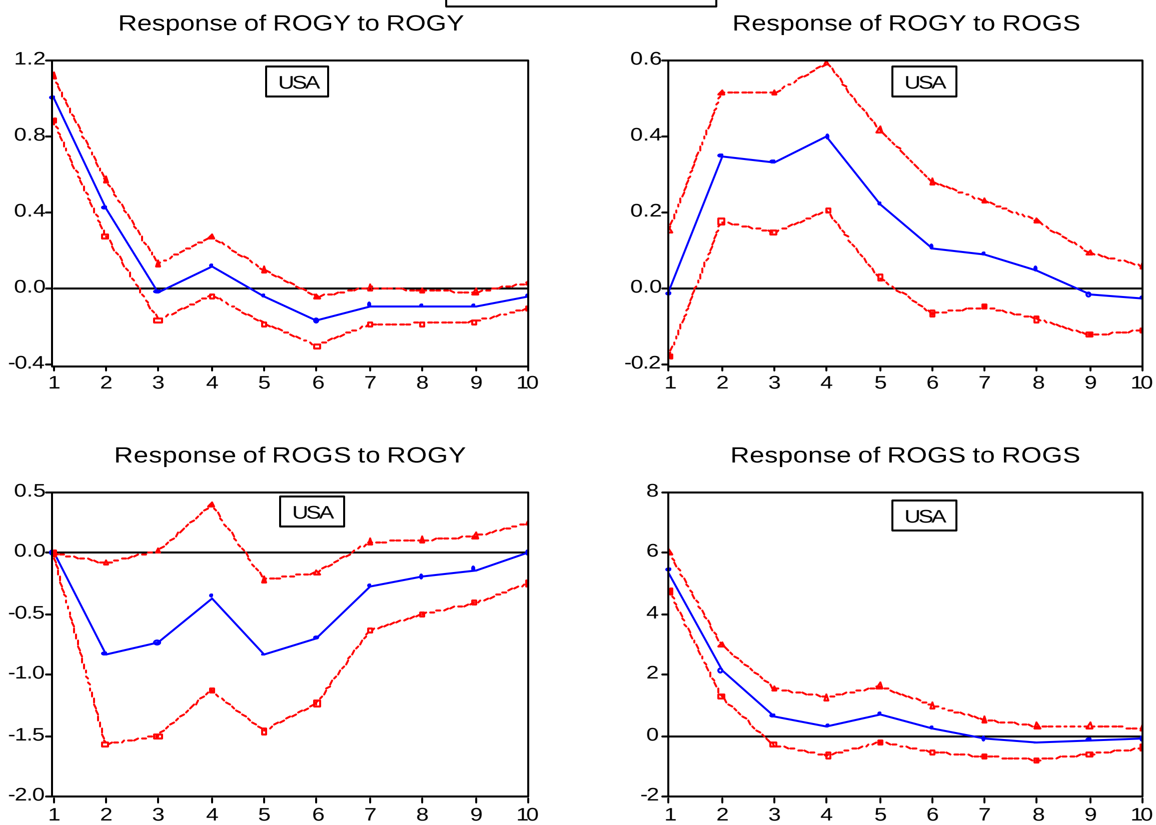


FIGURE 10.
United States: Impulse responses in annual and quarterly data

A. Annual Data



B. Quarterly Data



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