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Abstract

In a simple 2 sector general equilibrium macromodel profit maximization by a representative firm leads to multiple long-run non-Walrasian equilibria with excess profits and excess capacity. The model is reduced to two non-linear differential equations. Using calibration and simulation it is shown that yearly non-agricultural price and output series for the Indian economy are reproduced along dynamic medium-run adjustment trajectories approaching one or other of the equilibria. Alternative mark-up hypotheses are tested. The simulations show that the medium-run mark-up is counter-cyclical but has little variation. This behaviour of the mark-up plays an important part in maintaining stability, and explaining the historical price and output series. The model therefore helps to provide a microfoundation for structuralist macroeconomics.

JEL Classification: D58, E32

Key words: Microfoundations, countercyclical mark-ups, stability

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1. INTRODUCTION

A. Objectives and motivation

The aim of the paper is to see whether a structuralist-type macromodel, can explain the actual behaviour of price and output series for the Indian economy. The special features of the analysis are twofold: first it seeks more explicit microfoundations than is normally the case, and second it analyses medium-run dynamic adjustment path. The technique used is that of calibration and simulation, of a simple dynamic model reduced from an underlying general equilibrium two-sector macromodel. The use of such techniques is now widespread in macroeconomics. There is a need to explore such techniques as they (i) form a possible answer to the Lucas critique (ii) are better able to handle structural policy regime change, such as the India economy is going through now.

Benassy (1993) in a recent survey of the generalization of Walrasian theory to cases where markets do not clear, remark that it is a synthesis of three important paradigms: Walrasian, Keynesian and imperfect competition. This paper attempts to add two more paradigms: structuralist economics and dynamic adjustment paths. The motivation while elaborated in greater detail in the section below, can be summarized as follows. The Walrasian paradigm allows for general equilibrium, inter market spillover effects and microfoundations. The Keynesian for realistic non-clearing markets and quantity adjustments. The imperfect competition paradigm makes it possible to do away with the mythical auctioneer. Agents can set prices themselves and no longer take them as given. Structuralist economics adds the intersectoral structure and other institutional features essential to an understanding of an underdeveloped macroeconomy. The focus on dynamics adds realism by allowing the analysis to move beyond comparative statics or steady states. In this paper restrictions on the mark-up are derived from the firm's dynamic optimization, so that microfoundations of structuralist economics are obtained. As the mark-up can also be interpreted as a profit share and enters both savings and investment decisions, medium-run non steady growth can be explained.

B. Relationship to the literature

In developing the analytical frame we have drawn upon a number of distinct streams of literature. Firstly, the general equilibrium macroeconomic as exemplified in the work of Malinvaud (1980). This stream attempted to provide a microfoundation for Keynesian macroeconomic models. It showed that non-market clearing equilibria with excess profits and excess capacity could exist, in a Walrasian general equilibrium system, where quantity as well as price signals affected the decision-making of agents. In the pure Walrasian model only relative prices mattered. These models were widely criticized in that the results depended on price rigidities that were imposed on the otherwise sophisticated maximizing structure. The other problem was that many of the models were tatonnement models where trade took place only at equilibrium. It was natural that the next step should be to address these problems. An early beginning was made by Benassy (1982) who modelled price setting by monopolistic firms. He justified this assumption in a general equilibrium or macroeconomic context, by quoting Arrow's (1959) famous assertion that in disequilibrium even a competitive firm would have monopoly power—disequilibrium being understood here to refer to any situation where a unique market-clearing Walrasian equilibrium does not prevail. Monopolistic price setting could be regarded as an as if assumption that allowed the macroeconomic implications of the full range of existing market structures to be examined. In any case in modern industry some kind of imperfect competition is the norm.

Further developments, in the eighties, can be classified in the New Keynesian Economics stream. Mankiw and Romer (1992) have an excellent collection of the important papers in this area. The general methodology was to explain Keynesian lack of coordination and waste by relaxing the assumptions of perfect markets and information made in the Walrasian system. The focus shifted to the decision making of the firm. A major attempt to explain nominal and real price rigidities from aspects of industry cost and structure in the presence of nominal rigidities, demand shocks can have real effects, but for a firm to be willing to supply more output rather than raise prices in response to a demand shock, marginal costs must be constant. If marginal cost is increasing, mark-ups must be countercyclical. A number of models were developed showing why one or both would occur.

The mark-up is also the profit share. Structuralist macromodels for developing countries had always focused on the mark-up, but they had taken it as determined by income distributional conflict rather than profit maximizing. As a consequence their use of a constant mark-up was attacked as being theoretically ad-hoc. While these models had the disaggregated structure necessary in the analysis of dual developing economy models, they were largely static in confining attention to a short-run or steady-state equilibrium.

The New Keynesian models in general neglect the dynamic aspects of interaction between investment and savings. The mark-up enters both the firm's pricing decision and as the profit share affects its capital stock or investment decision. We exploit this and the fact that it also influences savings to develop a dynamic model determining the levels of and changes in the mark-up and capacity utilization.

There has been an explosion of interest in methods of modelling dynamic issues in macroeconomics. In the rational expectation stream, Kydland and Prescott (1982) have calibrated an intertemporal optimization model and used it to “build and aggregate fluctuations.” Greenwald and Stiglitz (1993) remark that the same sort of exercise should be undertaken for non-market clearing models. A recent attempt to do this for France and the United States is Hairault and Portier (1993). A number of theoretical New Keynesian Models are dynamic in the sense of generating multiple equilibria and analyzing the switches between them, (Diamond and Fudenburg, 1989). However, these are normally very special micromodels that are difficult to generalize to the analysis of macroaggregates. Non steady-state adjustment paths in a market clearing context, are analyzed in macrodynamic exercise as in Judd (1982), and in the endogenous growth literature.

Ours is also an attempt at dynamic macromodelling. As the NKE models we concentrate on the decision of the firm. Steady-state non-Walrasian multiple equilibria exist, but the analysis is restricted to a medium-run in wbich they are not reached. The representative firm maximizes profits over dynamic trajectories approaching these equilibria. High and low growth paths can be explained by switches between these trajectories, caused by endogenous amplification of exogenous shocks. Simulations with the calibrated theoretical model are found able to reproduce the historical price and output paths of the Indian economy.

Malinvaud (1983) suggested that multiplier instability tamed by lags may provide an explanation for virtuous growth paths, which cannot be satisfactorily accounted for, by perfect foresight steady state growth processes. In this paper, multiplier instability and price-setting by firms in the absence of an auctioneer together generate (a) endogenous virtuous growth trajectories (b) an explanation for the fact the mark-ups adjust less than fully to demand shocks. Virtuous or vicious growth paths emerge through bifurcations in the dynamic flow of the system.

Stability in a general equilibrium system exists only under stringent assumptions (see Fisher, 1976). The past two centuries have shown periods of rapid growth, accompanied by non-market clearing relative prices. The model in this paper indicates a possible link between both, and an explanation for stable yet rapid growth.

In this section we have painted in broad strokes. Such a picture provides a different but perhaps still useful kind of illumination. There is a cost in terms of detail, which is inevitable given the constraints on space.

C. The structure of the paper

The hypothesis is made that the firm's perception of expected aggregate demand over dynamic adjustment paths, helps to explain its price-setting behaviour. This behaviour, in turn, is responsible for generating stable non-Walrasian equilibria and smooth dynamic adjustment trajectories that can characterize medium term growth paths.

The hypothesis is proved first in a simple theoretical macromodel, with aggregate demand and supply derived from the optimizing behaviour of representative agents, and then further verified when empirical simulations with the model, successfully explain, aggregate price and output trends for the Indian economy. In order to focus on the medium run, aggregate macro quantity variables are normalized by capital stock.

In periods of rapid growth, investment induced by output can exceed induced savings. Such Keynesian multiplier instability should lead to unstable fluctuations in output. Periods of multiplier instability arose, in the non-agricultural sector, when public sector investment was high. The latter in turn, coincided with periods when foreign inflows, and agricultural output, were rising.

As the mark-up or the profit share enters both investment and savings decisions, adjustments in it, can lead to smooth output growth, even when induced investment is high. At the same time, the analysis provides an endogenous explanation for the mark-up. The empirical application made possible a test of alternative mark-up behaviour. Only if the medium-run mark-up was counter-cyclical, but varied little, could the historical medium-run mark-up series be reproduced.

It is found that neither price, nor quantity adjustments are completed in the period of analysis. The economy moved along the medium-run adjustment trajectories. The dynamic growing sector that is endogenously modelled was able to pull resources from other sectors to meet ex-post macroeconomic balance requirements, when it invested more than it saved.

The next section sets out the dynamic model. Section three examines its stability properties. The price-setting behaviour of the representative firm is further analyzed in section four. After that the hypotheses linking Indian growth trends to the model are spelt out, and then corroborated by the results of empirical simulations with the model. Section six concludes.

2. THE DYNAMIC MODEL

A two equation non-linear dynamic system is reduced from an underlying simple two sector general equilibrium model (see Goyal, 1989). Non-agricultural output, y. normalized by capital, k, changes as a function of the normalized investment, I, minus savings, S, gap (equation (3)). At the goods market equilibrium, with investment equal to savings, $\dot{u} = 0$, where u = y / k, and the dot indicates a time derivative. Equation (3) and (9) define the aggregate demand conditions facing the representative non-agricultural firm. The mark-up change equation (4) and its equilibrium condition, equation (10), model the supply relation of the firm. They give the combination of τ(mark-up) and u that maximizes profits, so that the rum has no incentive to change its actions.

The underlying structural model is a stylized representation of the Indian economy, with four goods, agricultural and non-agricultural output, labour, and money. The agents include a representative (or identical) firm(s) and government. Among consumers we have to distinguish between profit earners, and agricultural and non-agricultural workers. All profits are distributed to capitalists. The latter include the rentier class, who earn interest income.

Simplifying assumptions are made:

1. Surplus labour and an exogenously given money wage time series. Demand for labour determines employment.

2. Endogenous money and credit, that, together with resource flows from external sectors, fills any gap between investment and savings, so that stock equilibria are only implicitly modelled. To quote Barro and Fischer (1976, pp. 147), ".. the effective demand for money can be (arbitrarily) defined so that Walras Law holds in a formal sense". External sectors, include the parallel economy, speculative trading activities, as well as the rest of the world. These resource inflows respond to profitability differentials, so that inflows into the non-agricultural sector would exceed outflows when profitability is high. Inflationary effects of monetary and credit expansion constrain public sector investment through the government budget constraint.
3. The Keynesian assumption that all wages are consumed, and a fixed proportion of profit income is saved. This can be derived by utility maximization by the representative consumers subject to employment and liquidity constraints, with real balance effects of a low order of magnitude. A large part of wage income is assumed to leak away as demand for agricultural products.
4. Exogeneity of agriculture output and price, and assumptions regarding the composition of flows between agriculture and industry, including that all investment goods are produced in the industrial sector.
5. Exogenously given rates of change for labour-output and capital-output coefficients.

These assumptions imply that feedback links from agricultural and credit sectors can be subsumed in the exogenous terms, and investment and savings functions can be derived as endogenous functions of τ and u[1]. General equilibrium spillovers are then largely intertemporal, and arise from the investment and savings decisions.

$$\pi = (1 - a\frac{W}{p})y = \tau y \tag{1}$$

$$r = \frac{\tau y}{k} = \tau u \tag{2}$$

$$\underline{u} < u < \overline{u}, \underline{\tau} < \tau < \overline{\tau}$$

For $y < \overline{y}$:

$$\dot{u} = f\left(\frac{i}{k}(u,\tau) - \frac{s}{k}(u,\tau)\right) = f(u,\tau) \tag{3}$$

$$f_u, f_\tau, f_{\tau u} > or < 0, f_{\tau\tau} = 0, f_{uu} = 0, |f_u| > |f_\tau|$$

$$\dot{\tau} = g(u,\tau) \tag{4}$$

[1] These, and other issues are examined in a more detailed 14 equation model with behavioural, sectoral investment and savings functions derived from constrained maximizing behaviour, as part of Goyal (1989).

$$u = \overline{u} \qquad (5)$$

$$\tau = f(u, \tau) \qquad (6)$$

Equation (1) defines profit income π, as the excess of value added y, over wage payments, or the mark-up, τ, as the share of profits in value added. See Marglin and Bhaduri (1988) for a similar derivation. All real variables are in lower case letter and nominal in upper case. The nominal wage rate is W, the price level is P, and the labour-output coefficient is a. Equation (2) gives the rate of profit on aggregate real capital, k.

The investment function in equation (3) is the sum of private and public sector investment. Private investment is derived by the maximization of expected returns from capacity expansion by the representative firm[2]. It is an increasing function of expected profits and capacity utilization as the latter variable affects the probability of making future sales. Expected profits are some function of normalized current profits, τu. Private investment will respond more to u than to τ as the former variable influences both profitability and expected sales. This implies the restriction on the partial derivatives $|f_u| > |f_\tau|$. Subscripts always indicate partial derivatives.

Public sector investment in India has relied largely on domestic borrowing. The latter is modelled as an increasing function of domestic savings, and implies that public sector investment also rises with normalized profits. Where public sector investment depends mainly on resources and private sector on expected profitability, there can be periods when induced investment exceeds savings induced out of profit income, so that $f_u > 0, f_\tau > 0$. Typically these would be high growth periods, when expected profits rise, and so does the response of private investment to current profits. Exogenous factors, such as favourable agricultural outputs, exports, or foreign inflows, could be the cause. In the model, this would lead to a bifurcation in the dynamic flow, as f_u and f_τ change from negative to positive, and u rises. In the Indian economy in the mid-seventies such a bifurcation occurred, when a large inflow of remittances from abroad, lead to accumulating foreign exchange reserves, and

[2] Greater realism may be introduced by having a number of firms with separate individual demand. Aggregate demand would also influence firm decisions. Ng (1985) who attempts this, finds that the non-traditional case holds. A shift in aggregate demand leaves price unchanged and increases quantity, for individual labour demand curves. He also proves, using a general equilibrium analysis with n firms, that a representative firm, defined as a simple weighted average, exists and provides a good approximation of the response of the economy to any economy-wide changes in demand.

public sector investment, financed by domestic borrowing, was raised to run down these reserves.

The restrictions on the second order partial derivatives of equation (3), follow from the fact that, τ and u enter multiplicatively in the investment and savings functions, so that the *IS* curve (equation 7) would be hyperbolic or convex to the origin. The upper and lower units of $u, \underline{u}$ and $\overline{u}$ arise from technology and feasibility requirements. An unstable Keynesian multiplier implied by f_u and f_τ greater than zero should lead to violent fluctuations in output. However, if the firm sets mark-ups as in equation (4), with $g_\tau < 0, g_{\tau\tau} < 0$, smooth dynamic adjustment trajectories are generated, by the dynamic system comprising equations (3) and (4). If $g_u < 0$ the trajectories approach equilibria. This is proved below.

In a competitive equilibrium, with constant returns to scale, the rate of return to capital *r* would be related to the price cost margin or mark-up, as in equation (2) with zero excess profit and no excess capacity. In disequilibrium, however, the firm will face constraints on sales and be unable to assume infinite demand elasticity at a parametrically given price. There is no auctioneer so the firm has to set own price, or mark-up. In such circumstances the profit maximizing pricing decision may not be, that mark-ups should rise with excess demand or $g_u < 0$. This is shown in section 4. Excess profits and excess capacity would occur in disequilibrium.

The upper and lower bounds on mark-up, $\overline{\tau}$ and $\underline{\tau}$ can be interpreted as sociologically determined limits on the share of capital in output. The restrictions on the partial derivatives $g_\tau < 0$, and $g_{\tau\tau} < 0$, arise from non-linear adjustment to these bounds. The mark-up would be changed relatively faster at lower than at higher levels. The equilibrium supply relation of the firm (equation 8) would be convex to the origin and downward sloping if $g_u < 0$, and convex to the τ axis and upward sloping if $g_u < 0$. In the simulations in section 5, a test of the hypothesis $g_u \gtrless 0$ is set up.

The fact that u rather than y enters the $\dot{\tau}$ adjustment function means that the firm changes prices or mark-up only in response to persistent, longer-run changes in demand conditions. This is consistent with firm behaviour if (a) prices are changed only at discrete intervals, because of menu costs involved in frequent price changes, (b) a learning process, where normalization implicitly models the smoothing of short-run shocks in the firm's price-setting process. If prices are set with a lag, a short-run mark-up, can be obtained, which differs from the medium-run mark-up determined in equation (4) (See Goyal, 1989). In the current paper, with the period of analysis taken to be one year, and no lags, there is only one mark-up.

Equations (3) and (4) give the system dynamics if output is less than the capacity output $\overline{y}$. The system endogenously generates output as equal to demand or capacity. When demand exceeds capacity, output is now restricted by capacity, that is, equation (5), and the mark-up responds to excess demand pressures as in equation (6).

3. STABILITY

At an equilibrium of the dynamic system, when $y < \overline{y}$, we would have:

$$\dot{u} = f(u, \tau) = 0 \tag{7}$$

$$\dot{\tau} = g(u, \tau) = 0 \tag{8}$$

so that, neither u nor τ would change.

The slopes and shapes of the isoclines, or the curves where the combinations of u and τ are such that either equation (7) or equation (8) holds, are given by:

At $\dot{u} = 0$:

$$\frac{du}{d\tau} = \frac{f_\tau}{f_u} < 0, \;\; if \;\; f_u > 0, \quad f_\tau > 0 \tag{9}$$

$$or \;\; f_u < 0, f_\tau < 0$$

$$\frac{d^2u}{d\tau^2} > 0, \;\; if \;\; f_{u\tau} > 0, \quad f_u > 0, f_\tau > 0$$

$$or \;\; f_{u\tau} < 0, f_u < 0, f_\tau < 0$$

At $\dot{\tau} = 0$:

$$\frac{du}{d\tau} = -\frac{g_\tau}{g_u} \quad < 0, if \;\; g_u < 0 \tag{10}$$

$$> 0 \;\; if \; g_u >$$

$$\frac{d^2u}{d\tau^2} \;\; > \;\; 0 \;\; if \; g_u < 0$$

$< 0 \; if \; g_u > 0$

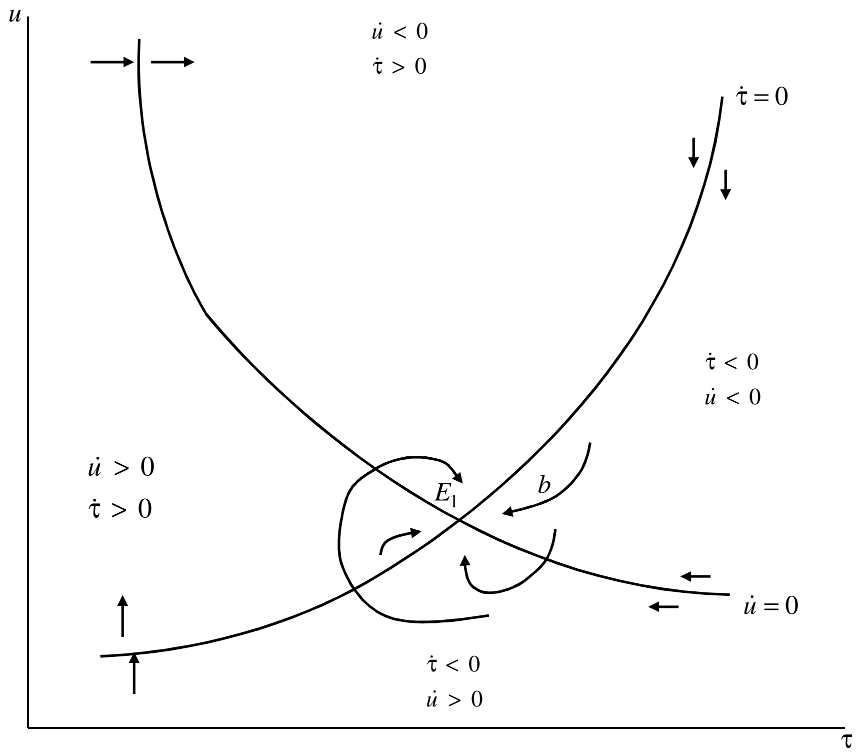

Figure 1: The stable equilibrium with $g_u > 0$

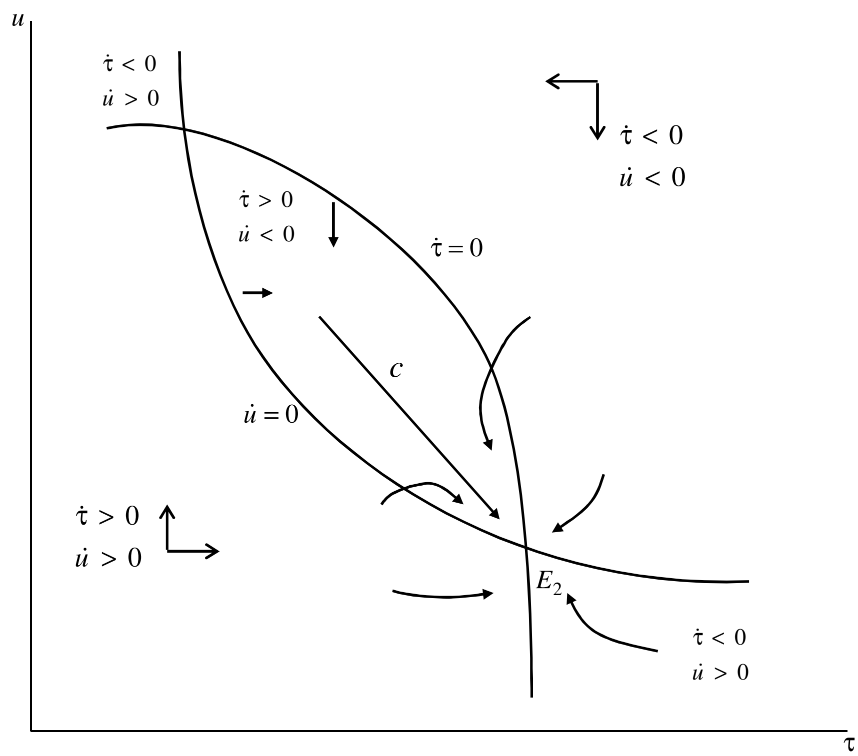

Figure 2: The stable equilibrium with $g_u < 0$

The slope of the IS curve, or $\dot{u} = 0$ isocline is negative even if multiplier instability holds[3]. This is because since u rises with τ, if one increases the other must fall, for the goods market to be in equilibrium. Now, however, u would tend to increase continuously above the IS curve, and fall below it. See Figure 3 or 4.

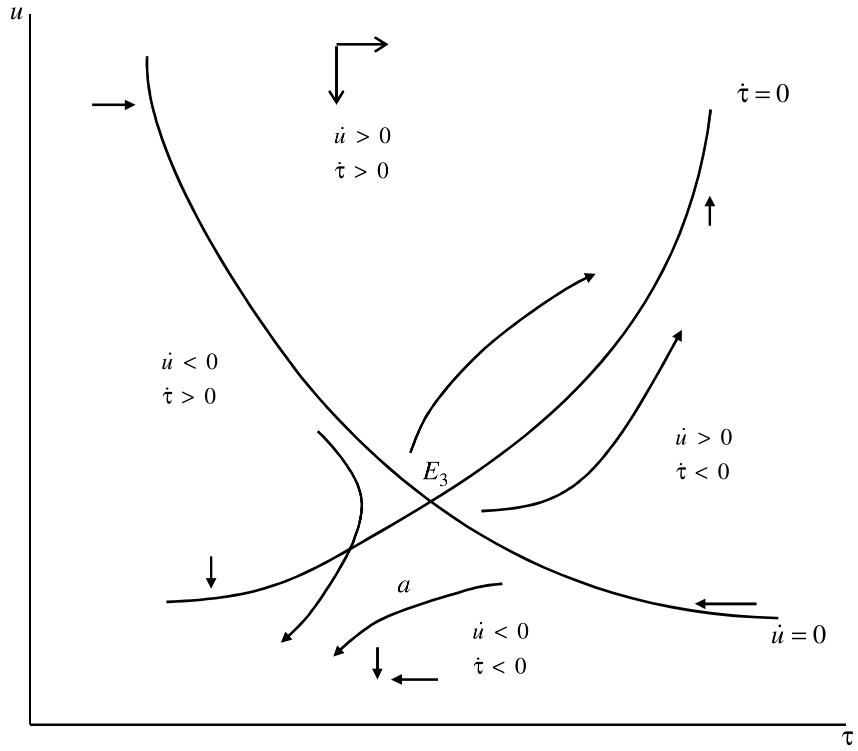

Figure 3: The unstable equilibrium with $g_u > 0$

An equilibrium point would occur at an intersection of the two isoclines. In order to examine the local stability of these equilibria, we use Taylor's expansion, to get a linear approximation of (7) and (8) at an equilibrium point. The conditions for local stability then are that trace of the Jacobian of the system must be negative, and the determinant positive, that is:

[3] The $\dot{u} = 0$ curve could be upward sloping if the effect of demand on investment was large so that $f_u > 0,\ f_\tau < 0$. However, this does not affect the flow of the system. The dominant trajectories are upward sloping if $g_u > 0$, and downward sloping if $g_u < 0$.

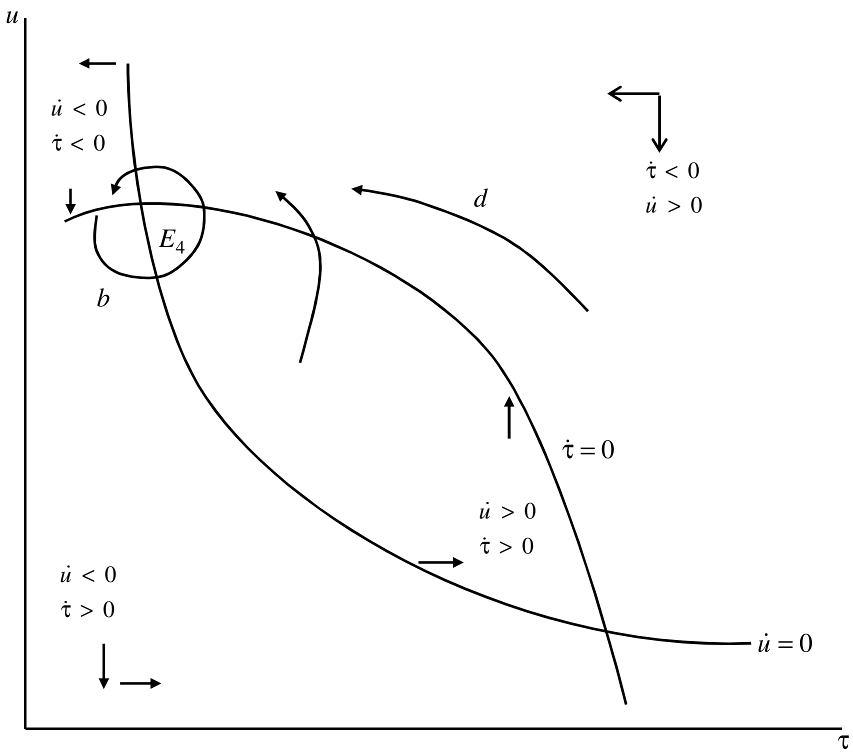

Figure 4: The unstable equilibrium with multiplier instability and $g_u < 0$

$$f_u + f_\tau < 0 \tag{11}$$

$$f_u g_\tau - g_u \ f_\tau > 0 \tag{12}$$

These conditions will be satisfied even if there is multiplier instability (or $f_u > 0, f_\tau > 0$), only if $g_u < 0$, and $|g_\tau| > |f_u|$. The latter condition implies small changes in mark-up, or inflexible relative prices. In Figure 4, at *E*$_4$, where,

$$\frac{g_\tau}{g_u} > -\frac{f_\tau}{f_u} \tag{13}$$

or the absolute value of the slope of the IS curve exceeds that of the aggregate supply curve, $\dot{\tau} = 0$, condition (12) is satisfied, and the equilibrium is stable.

Similarly, it can be shown that for the case of multiplier instability, *E*$_3$ (Figure 3), with an upward sloping $\dot{\tau} = 0$ curve is unstable. Where, multiplier stability holds if $f_u < 0, f_\tau < 0$, both *E*$_1$ (Figure 1) for an upward sloping $\dot{\tau}$ isocline, and *E*$_2$ (Figure 2) with $g_u < 0$, are stable.

The diagrams show the flow of the dynamical system in each phase space. The equation of the trajectories is given by:

$$\frac{du}{d\tau} = \frac{f(u,\tau)}{g(u,\tau)} \tag{14}$$

Inspection of the direction of flow in each phase space in Figure 1 to 4, shows that, for equilibria E_1 and E_3, with an upward sloping aggregate supply curve, trajectories with a positive slope dominate, in the sense that, trajectories in all other phase lead to them. For E_2 and E_4, with $g_u < 0$, trajectories with a negative slope dominate. Only these do not point into other phase spaces. In this case,$du/d\tau < 0$, except for transitional trajectories.

When multiplier instability prevails the firm's price setting behaviour would be such that *d* (Figure 4), approaching the only stable equilibrium E_4, of high *u* and low τ, would be the dominant trajectory: In case of a fall in investment propensities so that now $f_u < 0, f_\tau < 0$, it can be shown that a profit maximizing firm will set mark-ups so that trajectory *c* approaching E_2 (Figure 2),with $g_u < 0$, rather than *b* approaching E_1 (Figure 1), with $g_u > 0$, would be the dominant trajectory. See Goyal (1993a) for a rigorous analysis of the global flow.

4. PRICE SETTING

It is possible to view the price-setting process of the firm as taking place in two stages that may correspond to an initial period when prices are fixed, and a subsequent one when they are changed. This would allow short-run fluctuations in mark-up, as a result of changes in costs with prices fixed.

The flex price period can also be divided into two stages viewed as an artificial deconstruction of a continuous maximizing process. Simplifying assumptions on choice sets and probability distributions permit 'certainty equivalence' (see Simon 1956, Theil 1957). The complex decision process can be broken into maximizing over technology and tastes, under the assumption that the decision maker knows the future with certainty. The same type of profit maximization can then be applied to derive the decision rule for changes in the environment and expectations. Here we follow the latter course.

In stage one, the firm in maximizing profits with respect to short-run variable costs, subject to demand or supply constraints, sets up the Lagrangean:

$$L = Py - Wl + \tau\,[\min(Pd, P\overline{y}) - Py] \tag{15}$$

Where P is the price level, y output, W nominal wages, l labour inputs, d demand for output, $\bar{y}$ capacity output. Assuming a Leontief production function with a as the coefficient of value added per unit labour input, the first order condition when $d < \bar{y}$, yields the equation:

$$\tau = 1 - \frac{aW}{P} \tag{16}$$

The mark-up on unit costs, τ is derived from constrained profit maximization and therefore can be seen to determine the virtual price (Neary and Roberts, 1980), that makes it optimal for the firm to produce at the output constraint (Ize, 1984). The mark-up is not ad-hoc, and need not be a reflection of monopoly power, but arises since in disequilibrium the firm cannot make the competitive conjecture. Namely, that it can sell whatever it produces at a given price. As nominal wages are exogenous, once the mark-up is determined, so are prices. In stage one we have assumed that the firm knows the demand facing it with certainty. In actuality the firm has an expectation of aggregate demand and its elasticity, and of the relation between the mark-up it sets and aggregate demand. It stage two, the firm's maximization problem becomes:

$$Max \;\; Py - Wl \tag{17}$$

subject to

$$y \leq E\, y\, (\tau) \tag{18}$$

where the right hand side of the inequality models expected aggregate demand as a function of τ[4].

When demand is less than capacity, so that the equality holds, tile first order condition for a maximum gives:

$$P\left[1 - \frac{1}{\phi\varepsilon(\tau)}\right] = Wa \tag{19}$$

where $\varepsilon(\tau) = -\delta y/\delta\tau \;(\tau/y)$, and ϕ is a multiplicative factor of uncertainty affecting the aggregate demand elasticity.

Comparing equation (19) with (16), we get:

$$[1 - \tau] = \left[\frac{1}{\phi\; \varepsilon\;(\tau)}\right] \tag{20}$$

[4] Benassy (1982) has competitive firms that set prices subject to perceived demand curves. However, the expected demand facing the firm is not related to aggregate demand signals, dynamic adjustment paths, or the determination of the mark-up.

$$or \quad \tau = \frac{1}{\phi \ \varepsilon \ (\tau)} \tag{21}$$

So that the mark-up for a profit maximizing firm should vary inversely with the expected elasticity of demand.

Remembering that $y = uk$, we have

$$\frac{|\delta y|}{\delta \tau} = \left(u \ \frac{|\delta k|}{\delta \tau} + \frac{k \ |\delta u|}{\delta \tau} \right) \tag{22}$$

Investment, or δk, is an increasing function of profit income or τu. Keeping that and the equation of a trajectory (14) in mind, we know that both $|\delta \ k / \delta \ \tau|$ and $|\delta \ u / \delta \ \tau|$ increase with f_u and f_τ. A switch from $f_u > 0, f_\tau > 0$ to $f_u < 0, f_\tau < 0$, or from trajectory *d* to *c* would lead to a lower $|\delta \ y / \delta \ \tau|$ and $\varepsilon(\tau)$, at a point in the phase space, and a fall in *u* from equation (3). In such circumstances, to reach the equilibrium relation (20), the firm should increase τ or g_u should be less than zero in the mark-up adjustment equation (4).

It can easily be seen, that the alternative dominant trajectory *b* [Figure 1], would imply falling τu and contradict the maximization (17). This arises in the stable case, if $g_u > 0$ and the supply curve slopes upward. Further, under uncertainty, risk-averse firms would never cut mark-ups in the neighbourhood of an unstable equilibrium for fear of a recessionary trajectory such as *a* in Figure 3. The shift in parameters required for a bifurcation in the growth path could be caused by changes in public investment propensities, or in other exogenous factors, leading to reinforcing adjustments in private expectations (Goyal 1993a). When demand exceeds capacity, the inequality would hold in equation (18). Now $y = \bar{y}$, and will not respond to changes in τ.

5. THE MODEL AND THE INDIAN ECONOMY

5.1 Some hypotheses

The framework developed above offers suggestive insights for analyzing and understanding endemic features of Indian economic growth.

It can be surmised that, in the beginning of planned growth, in the fifties, as there was a large increase in public investment, capacity was the operative constraint. In an era of low prices, the socially acceptable mark-up was also rather low. As large planned increases in capacity began to fructify, induced investment remained large. We can therefore conjecture that the economy moved along a trajectory such as *d* approaching E_4 Capacity utilization remained high and mark-ups low, with rising agricultural prices beginning to exert pressure on them. In the middle and late sixties, increasing defence expenditures and a foreign exchange crisis squeezed public investment and successive adverse monsoons caused agricultural prices to soar. Short-run shocks lead to a rightward shift in the IS curve. A resource constraint reduced public investment. Private investment induced by profit income fell because of adverse expectations. The new growth trajectory prevailing by the late sixties was something like *c* leading to E_2 (Figure 2), with a low u and high τ.

Firms that had initially not reduced mark-ups in the face of falling u because of a fear of the depression that would result if multiplier instability prevailed (for example, trajectory *a* in Figure 3), did not decrease them as fallen investment propensities lead to lower expected elasticity of aggregate demand. Excess capacity and stringent import restrictions probably raised monopoly power. The firm's conjectures were therefore 'reasonable' in the sense of Hahn (1978), and these conjectures changed both from observation as well as some experimentation. By the mid-seventies, public and private investments rose, and import restrictions were eased, as remittances from the Gulf countries flowed in and agricultural inflation decreased. The economy switched to a higher growth trajectory such as *d* approaching stable E_4 once again, so that u was rising and τ falling. If mark-ups were increasing in this period, along with u, then the economy would be on the trajectory receding from unstable E_3 (Figure 3).

5.2 Empirical Tests

The model and the hypotheses made were tested by seeing if historical time series of the endogenous variables could be replicated, with a priori theoretically expected parameter values. Functional forms were chosen compatible with the behavioural restrictions on the partial derivatives. The equations and parameters obtained are listed in the appendix. The two equation non-linear dynamic system was solved numerically with the classical fourth order method of Runge- Kutta. Simulations were run, using Indian economic data for the exogenous variables[5], over the period 1960/61 to 1984/85. Parameter values commensurate

[5] Data sources mainly comprise C.S.O., R.B.I., and Government of India publications. The non-agricultural sector stands for organized and unorganized manufacturing including services. A number of macroeconomic studies for the Indian economy were surveyed to isolate a range of likely parameter estimates. The exogenous e series were obtained as residuals from historical data series.

with the historical series and theory, were successfully isolated, and confirmed by sensitivity analysis, using varying parameter values.

The historical time series (H) for u and τ are quite closely reproduced by the simulated series SI and S3 (Figure 5). The trend of the τ (H) series is captured, as only the medium-run mark-up is modelled in this paper. Short-run fluctuations in τ are explained by lags in price setting, in other simulations. The τ (H) series, being derived from inadequate data are not very reliable, especially after 1974/75, although a number of alternative series derived as a check all share the same trend[6].

REDUCED FORM SIMULATIONS

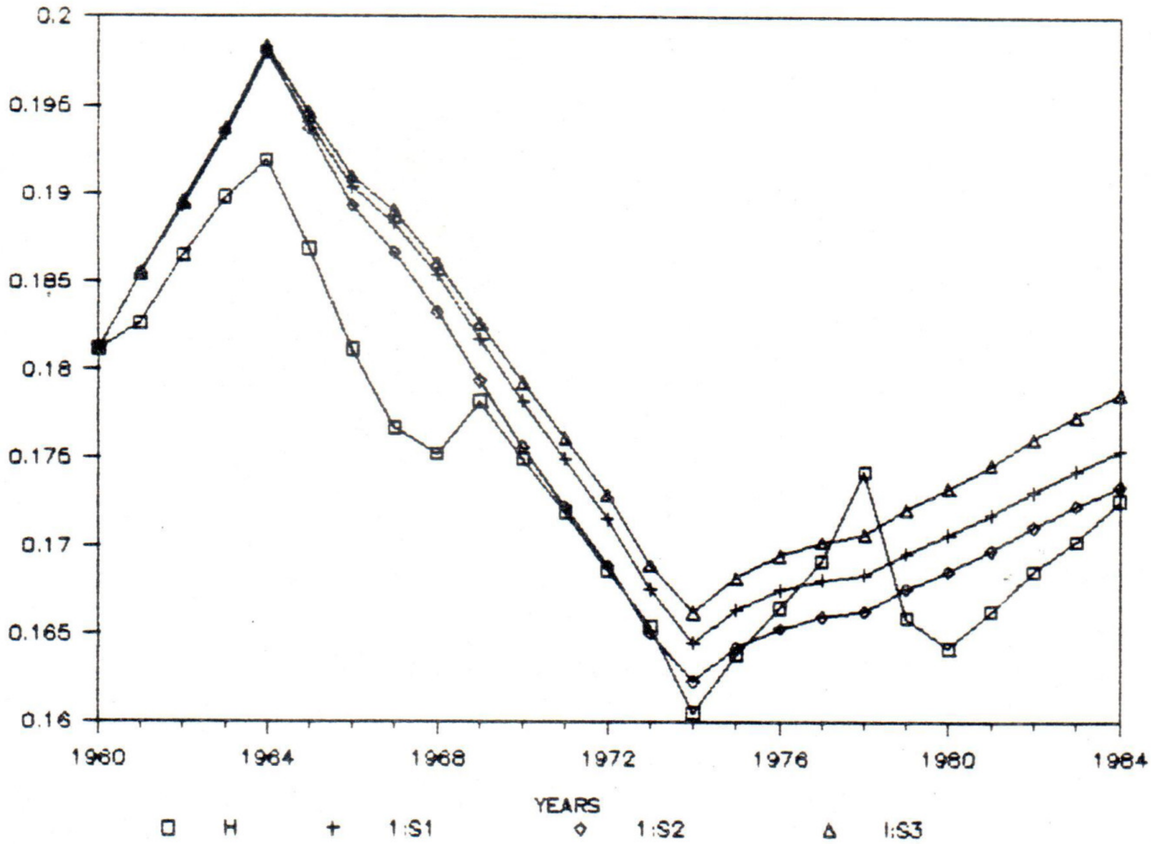

Figure 5(u)

[6] The C.S.O. real wage index used to deriving the mark-up series was not available after 1977/ 78. The B.S.I.E. real wage index used after that is not so reliable.

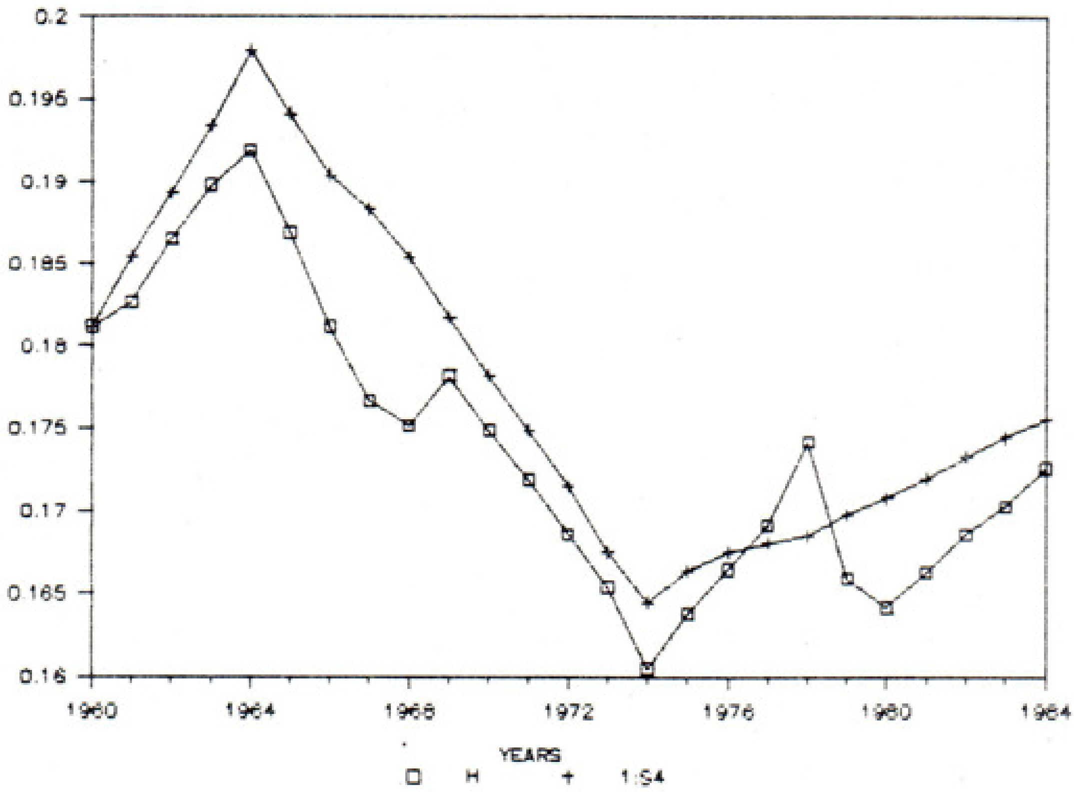

Figure 5(u) contd

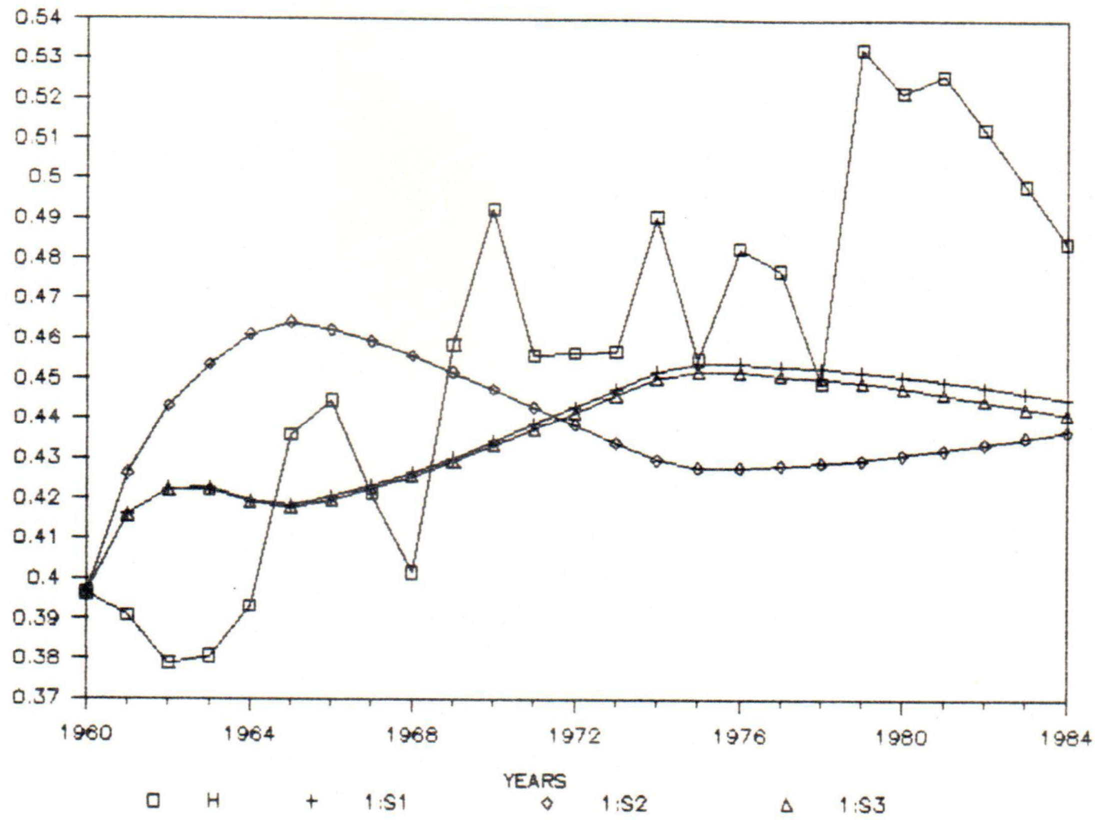

Figure 5(τ)

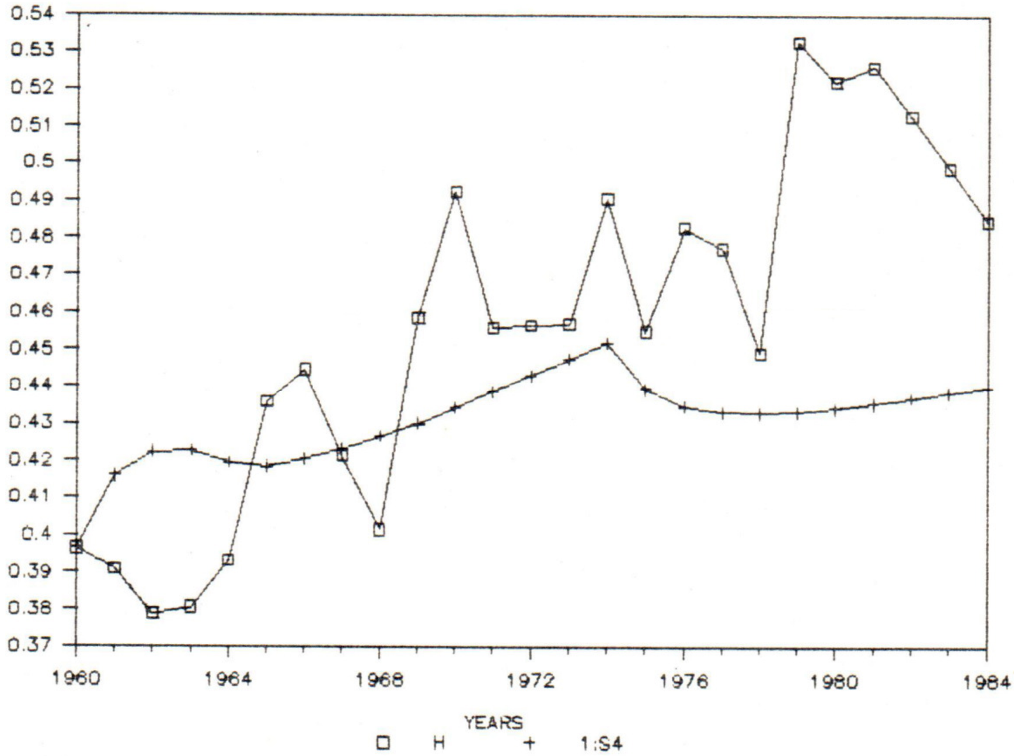

Figure 5(τ) contd

As hypothesized in section 5.1 the trajectories comprising S3 approach stable E_4 (for the pre 1965/66 period), stable E_2 (for 1965/66 to 1974/75), and E_4 again post 1974/75. Figure 6 shows these simulated trajectories in the u, τ phase space. Series SI has a similar pattern. These series are generated by parameter values (A4). In SI the parameters are such that there is a greater response of private investment to expected demand as compared to profits, so that the IS curve is upward sloping. The trajectories now recede from an unstable equilibrium after 1974/75 as $f_u > 0$ and $f_\tau < 0$. However, the dominant trajectories are equivalent to those of SI. The supply relation is downward sloping or $g_u < 0$ for SI and S3. Also shown in Figure 5 are series S2 (generated by (A.3), but with $g_u > 0$, so the trajectories switch from unstable E_3 to stable E_1 and back again), and S4 with $g_u > 0$ only after 1974/75.

The simulations reported in Figure 5(τ) verify that only mark-up behaviour with $g_u < 0$ is capable of reproducing the historical τ series for the period 1965/66 to 1974/75. In the late seventies, if S4 were to hold, τ would be increasing (after a rather unlikely and large initial decrease). If S3 or SI held, τ would be decreasing. The τ (H) series after 1974/75 is not sufficiently reliable to discriminate between these series. Even so, the simulations are unable to falsify the weak hypothesis that (i) when the firm faces declining demand, in the neighbourhood of unstable multipliers, it will not decrease mark-ups, for fear of unstable price and output decreases, (ii) if expected aggregate demand elasticity falls, it will increase mark-ups in order to maximize expected profits.

The strong hypothesis that the firm always fixes mark-ups so as to remain on a stable trajectory would however, be falsified if it is established that the trend of the mark-up was upwards in the early eighties, as S4 would then fit the data. On the grounds of correspondence with historical data, it is not possible to choose among the series after 1974/75. On theoretical grounds, if the strong hypothesis is accepted S3 with $g_u > 0$, would be preferable. Irrespective of whether $g_u \gtrless 0$ the mark-up or price-setting behaviour modelled is essential for stability in the sense of prevention of large fluctuations in output. This is proved in simulations with the full model, where fixed prices lead to violent short-run fluctuations in output.

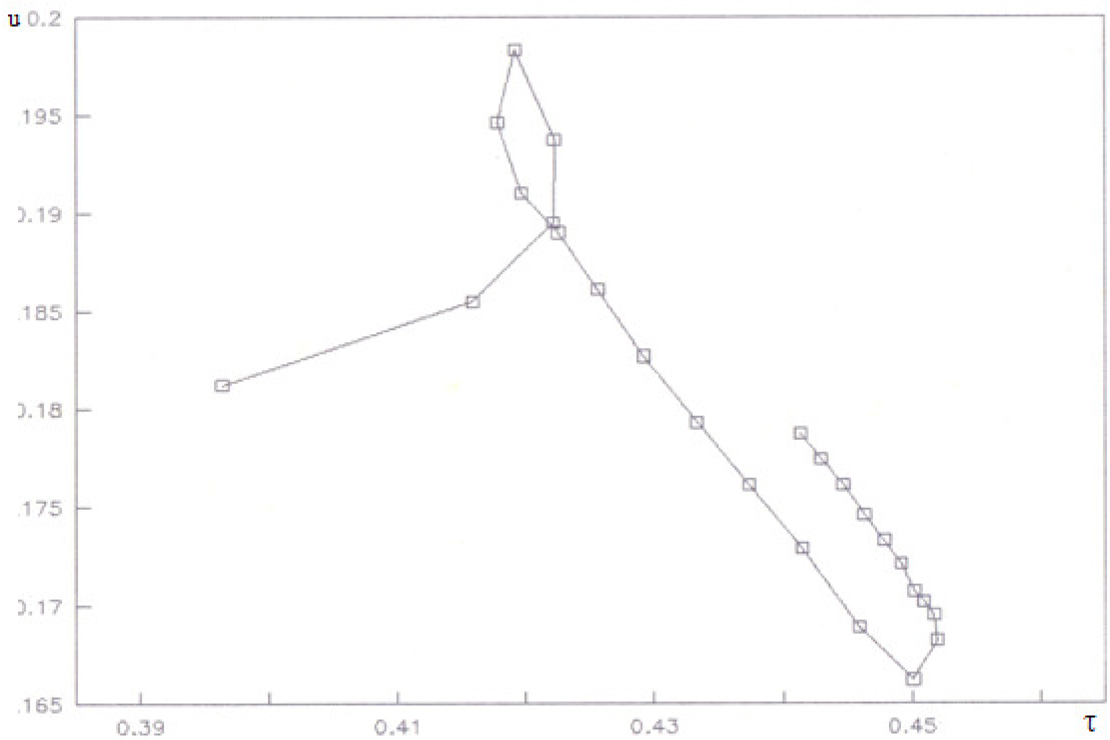

Figure 6: Simulated Trajectories

The parameter values established for the mark-up function in the calibration, lead to very gradual changes in mark-up. Lower (higher) values of g_τ give rise to a u which is lower (higher) than the historical series and also does not catch the turning points of the τ series accurately. Changes in the shift parameter (w_3) lead to similar problems. The conclusion is that, in the Indian economy over this period, while the IS curve was subject to shifts, the $\tau = 0$ isocline or equilibrium supply relation was relatively stable.

This analysis gives interesting insights to distributional issues:

1. The medium-run income distribution is determined by the system dynamics.
2. A change in nominal wages would not be able to influence real wages, except in a short-run, if prices change with a lag.

On a high growth path such as *d*, even though the profit share τ is decreasing, the rate of profit τu, would be increasing because *u* would rise more than τ fails, given the calibrated parameter values. Profit and wage income would both be increasing. On a low growth path such as trajectory *c*, although the wage share is failing, the rate of profit τu also falls.

An outward shift of the $\dot{\tau} = 0$ curve, or a lower equilibrium share of wages, would lead to lower u, and higher τ along the dominant trajectories. Comparative static analysis indicates that $E_4(E_2)$ would now occur at a higher (lower) *u* and lower (higher) τ. We may conclude that an equilibrium redistribution away from labour in the firm's aggregate supply relation would lead to lower *u*, and adversely affect potential profits, unless the propensity to invest is very high, and the economy is well on the way to E_4 where the equilibrium profit share would actually be lower.

Although highly aggregative and theoretical, the model gives a number of new insights on the actual growth process of the Indian economy. It makes a modest start at analyzing real time dynamic adjustment issues. Since alternative hypotheses are tested, the process of parameter calibration is more rigorous. As at the aggregate level demand has been than capacity in the Indian economy (see Goyal 1992) over the period studies, the analysis has been largely confined to this case.

6. CONCLUSION

A theoretically consistent determination of the mark-up is obtained. Growth paths, for the non-agricultural sector are generated by the disequilibrium adjustment trajectories, of a dynamic system, with simultaneous and interdependent variations in mark-up and output. Resource inflows from other sector help satisfy the ex-post income-expenditure identity.

Simulations with Indian data verify that Indian growth trends can be explained by switches from trajectories approaching towards or receding from different non-market clearing equilibria. The simulations also show that price setting by tile firm, and relative rigidity in mark-ups, plays an important part in maintaining stable price and output paths. Only a mark-up that varies inversely with capacity utilization can explain the trend of tile historical mark-up series.

Although the argument is in terms of investment and savings, it can be generalized to examine the relationship between any induced demand and corresponding leakage. By systematically relaxing the assumptions made different aspects of macroeconomic interactions in India can be analyzed. Goyal 1994a, 1994b, 1993b makes a beginning at this. As parameters can be changed in a theoretically consistent way, tile model in this paper is well adapted to examine periods of structural change. It would be feasible to extent the simulations beyond 1984-85, and analyze the possibilities of export led growth during structural adjustment.

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APPENDIX

Functional forms for the equations (3) and (4) compatible with the theoretically required restrictions on the partial derivatives are[7]:

$$u = e + \big((i_1 + g_1 \ s(l - f) - s)\tau + j\big)u \qquad (A.1)$$

$$\tau = w_1 u - w_2 \tau^2 + w_3 \qquad (A.2)$$

The parameters of equation A.1, derived from the underlying structural model are:

e: exogenous part of I-S, normalized by *K*

i_1: private propensity to invest out of profit income

s: private propensity to save out of profit income

g_1 *(1-f)*: public sector propensity to invest out of private savings

f: a dummy variable, capturing the effect of exogenous changes on public sector propensity to invest

j: private propensity to invest out of non-agricultural output, capturing the effect of expected sales on private investment, above that of expected profits.

In equation A.2, if $w_1 < 0, g_u < 0$. The shift parameter is w_3. A rise in this would mean a higher share of profits at every *u*, in the equilibrium supply relation or τ isocline.

The calibration of the model yielded the following values of these parameters:

For 1960/61 to 1974/75

$i_1 = 0.258$, $j = 0.002$, $s = 0.429$, $g = 0.5$, $w = 0.9$

with $f = 0$ for 1960/61 to 1964/65 and $f = 0.5$ thereafter

For 1975/76 to 1984/85:

$i_1 = 0.32$, $j = 0.002$, $s = 0.479$, $g_1 = 0.7$, $w_2 = 0.9$ with $f = 0.5$ throughout (A.3)

[7] Equation (A.2) is the equation of a parabola derived by taking the value of τ^{min} to be zero. If $\tau^{min} > 0$ the equation would be

(i) If $w_1 < 0$

$\tau = w_1 u \quad - \quad a\tau^2 + 2ah\tau - ah^2 + k, \quad h = \tau^{min}, \quad k = u^{max}, \ h, \ k, \ a > 0$

(ii) If $w_1 > 0$

$\tau = wu - a\tau^2 + 2ah\tau - ah^2 - k, \ h = \tau^{min}, k = u^{min}, \ h, k, \ a > 0$. The same analysis would apply

These, with $w_1 = -1$ and $w_3 = 0.3524$, generate series S3 and form the basis for many counterfactual simulations.

The parameters obtained are commensurate with the historical series on savings and investment, with theoretical expectations.

Series SI are generated by (A.3) except for the following changes:
Pre 1975/76: $i = 0.238$, $j = 0.01$
Pre 1974/75: $i_1 = 0.3$, $j = 0.01$ (A.4)

These indicate a higher response of private investment to expected demand, as compared to profits, and also match the data.

SI has (A.3) with $w_1 = 1$, $w_3 = 0$.