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ABSTRACT

Monopolistic Competition, Dynamic Inefficiency and Asset Bubbles*

We emphasize the importance of the market structure to determine whether dynamic inefficiency is possible in a closed economy. We analyse alternative monopolistic competition frameworks where the existence of some pure profit involves the presence of an asset market. When entry is blockaded, dynamic inefficiency is ruled out because every single firm uses a discount rate higher than the output growth rate to evaluate the stream of future profits. When entry is free but involves a sunk cost constant over time, we need to distinguish between the possibility of asset bubbles and dynamic inefficiency, the condition for the latter being more stringent. If the entry cost increases with productivity, dynamically inefficient equilibria are possible only when the population grows.

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Keywords: dynamic inefficiency, asset bubbles, distortions

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NON-TECHNICAL SUMMARY

Even if several alternative exogenous growth models have been used to elaborate on dynamic inefficiency and on the role of asset bubbles, the literature has overlooked deviations from perfect competition. Since monopolistic distortions are empirically important, we incorporate their effects in an overlapping generations framework.

We study a monopolistic competition set-up where aggregate output is obtained by means of a number of imperfectly substitutable intermediate inputs, each of which is produced by a single firm. Following a widespread practice, we use an aggregator involving a constant elasticity of substitution between any two goods. This aggregator also implies that the 'degree of monopolistic power' is stationary over time, since mark-ups are independent both of income and of the number of goods (and firms). Our model draws attention to two general aspects involved with any imperfectly competitive set-up: the presence of some 'rent' and the need to assess the interaction between the monopolistic distortion and the one involved with the finiteness of agents' lifetimes.

As in any dynamic model of imperfect competition, we need to introduce some assumptions specifying the possibility, for new firms, of entering the market. This issue proves to be of central importance to assess whether the steady state may be dynamically inefficient and how asset bubbles affect the economic system.

Since the presence of some pure profit implies that the value of each firm, as assessed on the stock market, is given by the stream of its discounted future cash flow, we find that, when entry is restricted, the economic system may never be dynamically inefficient. This happens because every firm grows at the aggregate rate and all future rents are capitalised. Hence, the stock market forces the interest rate to be higher than the growth rate and it serves the same purpose as the transversality condition in an infinite-horizon growth model.

The hypothesis of free entry has very different implications. Since the value of any firm must be equal to the fee that it sustains to enter the market, the firms are worthless before they sink the cost, and the economic system behaves as if it could not capitalise on advance future rents. This helps to explain why the hypothesis of free entry (at a cost) allows for dynamic inefficiency.

More specifically, when entry is free and the one-off entry cost is proportional to output, being related for example to wages, steady states are efficient only if population growth is negligible. In fact, existing firms grow, in the long run, at the speed of *per capita* output. Therefore, in discounting future profits, firms take account of productivity growth, but not of the increase in population: this structure for the sunk cost prevents the existence of dynamic inefficient equilibria when population is stationary.

If the sunk cost is constant over time, the size of any existing firm does not grow in the steady state; accordingly, firms do not modify the interest rate with the growth rate to discount their future profits. Hence, the long-run interest may be lower than the output growth rate with either population or exogenous productivity growth. However, in this case, the ‘golden rule’ of accumulation needs to be modified to take account of the monopolistic distortion: *per capita* consumption is maximised when the interest rate is a fraction of the growth rate for output. In fact, profits, i.e. the reward for the introduction of a new variety, are too low, since they do not correctly reflect the effect of an increase in the number of goods on aggregate output. Hence, the market-determined interest rate, which is positively related to profits, is low, too. The important implication is that asset bubbles can be welfare-reducing, as happens in endogenous growth models, for a relevant interval in the values of the steady-state interest rate. It turns out that, under the assumption of a constant entry fee, the condition for a dynamic inefficient long-run equilibrium is much more stringent than the one for the presence of asset bubbles, since it is required that the interest rate is a fraction of the growth one.

Notice that when the market structure rules out rational Ponzi games, it excludes the presence of asset bubbles and hence the possibility of rolling over the public debt. On the other hand, when the presence of unbacked assets is possible, it does not need to be optimal, as it is in perfectly competitive models. Hence, the market structure becomes an essential ingredient to evaluate the welfare consequences of public debt.

1. Introduction

In exogenous growth models, dynamically inefficient steady states call for Pareto improving policy actions, therefore, it is not surprising that Diamond's (1965) contribution has inspired a large number of investigations of this issue. [1]

Even if several alternative frameworks have been used to elaborate on dynamic inefficiency, this stream of literature has overlooked deviations from perfect competition. Since monopolistic distortions are empirically important,[2] we believe that it is relevant to incorporate their effects in a framework characterised by the finiteness of agents' lifetimes.

Once the safe anchorage of perfect competition has been abandoned, one may move in many directions. In this paper, we study a monopolistic competition framework where aggregate output is obtained by means of a number of imperfectly substitutable intermediate inputs (varieties), each of which is produced by a single firm. Following a widespread practice, we use an aggregator of the type proposed by Dixit and Stiglitz (1977) and Ethier (1982). This specification not only involves a constant elasticity of substitution between any two goods, but it also implies the stationarity over time of the "degree of monopolistic power", since mark-ups are independent both from income and from the number of goods (and firms). While these features are of great help in providing an analytical solution, they may seem restrictive. Nevertheless, our model draws the attention on two general aspects involved by any imperfectly competitive set-up: the presence of some "rent" and the need to assess the interaction of the monopolistic distortion with the one involved by the finiteness

[1] With endogenous growth, the picture changes dramatically: a reduction in the capital stock cannot make everybody better off since it is harmful for growth (see Kohn and Marion (1993) and King and Ferguson, (1993)). The interest rate may still be lower than the growth rate, giving room to bubbles, but these, in general, are detrimental to society (Grossman and Yanagawa, (1993)). In this paper, we do not study the implications of endogenous growth models.

[2] To quote only an influential paper, Hall (1988) estimated, for the US economy, the ratio of the difference between price and marginal cost to price in various sectors and found it significantly different from zero.

of agents' lifetimes.[3]

As in any dynamic model of imperfect competition, we need to introduce some assumptions specifying the possibility, for new firms, of entering the market.

This issue proves to be of central importance to assess whether the steady state may be dynamically inefficient and how asset bubbles affect the economic system. We find that, when entry is restricted, the economic system may never be dynamically inefficient. When entry is free, steady states are efficient when the one-off entry cost is proportional to output and population growth is negligible. Notice that, in these cases, the market structure, ruling out rational Ponzi games, excludes the possibility of rolling over the public debt.

When the entrant firms must bear an entry cost that is constant over time, we find that the interest rate may be lower than the growth rate when either productivity or population increase. However, in this case, the "golden rule" of accumulation must be modified to take account of the monopolistic distortion: per capita consumption is maximised when the interest rate is a fraction of the growth rate for output. Hence, asset bubbles can be welfare-reducing, as it happens in endogenous growth models (see, in particular, Grossman and Yanagawa, (1993)). Notice that, under this assumption, the market structure becomes an essential ingredient to evaluate the welfare consequences of public debt.

The presence of "rents" links our work with the one by Tirole (1985). A brief summary of some results developed within the stream of literature originated by that paper is helpful to grasp the intuitions for our findings.

Tirole studies, in an otherwise standard version of Diamond's model, not only the possibility of bubbles but also the implications of an asset that brings a real rent. He shows an important result: if rents per period are capitalised in advance and increase at the (asymptotic) rate of economic growth, any perfect foresight equilibrium must be efficient.

[3] Notice that the issue of studying the interplay of two sources of inefficiency, the one related to the finiteness of agents' horizons and the other arising from market incompleteness, characterises also some recent works dealing with uncertainty in overlapping generations growth models (see Bertocchi and Kehagias, 1995, and the literature quoted there)

Were this not true, the rent per period would grow at a rate exceeding the rate of interest; hence, its market value would be infinite.[4]

Tirole underscores a second essential point: since rents are created over time, often they cannot be capitalised before their creation. In his own words (1985, p. 1080): "For example a painting to be created by a 21st century master cannot be sold by the painter's forebears." In such cases, bubbles (and dynamic inefficiency) need not be inconsistent with rents per period growing at the same rate of the economic system, since the flow of rents stemming from a single asset does not grow and must be capitalised using the interest rate.

McCallum (1987) and Homburg (1991) provide an important application for the first criterion: they assign to land an explicit role in aggregate production and rule out inefficient equilibria. In fact, in their models, the marginal product of land (the rent) grows at the asymptotic growth rate of output.[5] Dechert and Yamamoto (1992) use an overlapping generations model with no population growth to analyse the case of a technology characterised by decreasing return to scale at the aggregate level. In their setting, rents are distributed to shareholders in the form of dividends and these agents, who are old, sell (non-bubbly) stocks to the young. In absence of technical progress, the share of dividends asymptotically reaches its steady state value; since the equities value is the capitalisation of future rents, the economic system is dynamically efficient. Therefore, Dechert and Yamamoto conclude that "the stock market serves the same purpose as the transversality condition in an infinite-horizon growth model (1992, p. 399)." [6]

[4] However, most of his analysis is performed assuming that the aggregate quantity of rent is exogenously fixed in terms of output. In this case, dynamic inefficiency remains possible, and so does the presence of asset bubbles.

[5] A similar point has been made by Muller and Woodford (1988, p. 962) while considering a model where finitely and infinitely lived agents coexist. Clearly, this result depends on the characteristics of the aggregate production function; it does not hold, as suggested by O'Connel and Zeldes (1988, p. 441-2, fn. 19), whenever the land income share vanishes in the long run. Homburg (1991) and Rhee (1991) provide two different formalisations for this point. Moreover, Rhee notes that the decline in the US land income share, during the post-war period, has not been quick enough to be conclusive.

[6] Dechert and Yamamoto's model is stochastic, but their point concerning dynamic efficiency can be easily

As already remarked, when we assume that the entrance of firms producing new varieties is blockaded, we find that the economic system is dynamically efficient. This happens because all the future rents are capitalised, as in Dechert and Yamamoto, and hence the stock market forces the interest rate to be higher than the growth rate. The hypothesis of free entry bears very different implications. Since the value of any firm must be equal to the fee that it sustains to enter the market, the firms are worthless before they sunk the cost, and the economic system behaves as if it could not capitalise in advance future rents. This helps explaining why the hypothesis of free entry (at a cost) allows for dynamic inefficiency.

In what follows, we start summarising the “consumers' side”, adopting Buiter's (1988) continuous time framework, which allows both for a positive probability of death at the individual level and for agents disconnectedness in the sense of Weil (1989). In a context where the entrance of new firms plays an important role, it seemed natural to avoid the rigid timing involved by the standard two periods overlapping generations model. However, our results hold true also in a standard framework *à la* Diamond. In Section 3, we present our monopolistic competition framework; we then discuss the role of the asset market under various assumptions concerning the structure of sunk costs and the entry possibility for firms (Section 4). For simplicity, we assume away, throughout the paper, government debt, public expenditure and hence taxation. Section 5 concludes.

2. Aggregate consumption and asset accumulation

Following Blanchard (1985), we assume that each individual agent faces a constant instantaneous probability of death, λ, that also represents, due to the law of large numbers, the fraction of each cohort that dies at every instant. This hypothesis, together with the one of

restated in a deterministic framework. Notice that their model does not endogenously determines the number of firms; moreover, in case of population growth, the share of rents on output would continuously grow over time, a rather counterfactual implication.

a constant birth rate β, as in Buiter (1988), has the relevant merit of allowing aggregation.

2.1. Individual consumption. To keep the analysis as simple as possible, we adopt a logarithmic specification for the time separable utility function of each agent. Thus, any individual born at time s maximises, at time t:

$$U(t,s) = \int_t^\infty ln[c(\tau,s)]\, e^{-(\theta+\lambda)(\tau-t)} d\tau$$

$$\text{s.t. } \dot{a}(t,s) = [r(t)+\lambda]a(t,s) + w(t,s) - c(t,s)$$

where $c(t,s)$ is consumption, $a(t,s)$ the stock of assets and $w(t,s)$ labour income, all considered at time t for the individuals born at time s; θ and $r(t)$ are, respectively, the intertemporal time preference rate and the interest rate. A dot over a variable denotes, as usual, its derivative with respect to time. The usual Blanchard-Yaari actuarially fair insurance mechanism is at work. Also, the following "no-Ponzi game" condition holds:

$$\lim_{\tau\to\infty} a(\tau,s)\, exp\left(-\int_t^\tau [r(z)+\lambda]dz \right) = 0$$

We assume, as in Blanchard, (1985, p. 235), that the effect of retirement can be stylised by letting the labour income decline with age at a constant rate ρ. With logarithmic preferences, a necessary condition for dynamic inefficiency in Blanchard's model is a sufficiently high ρ, namely, $\rho>\theta$, a hypothesis that we maintain.[7]

Following usual methods, it is possible to show that the consumption behaviour, at the individual level, is described by the following equation:

[7] With C.E.I.S. preferences, the necessary condition becomes $(1-S)\lambda+\rho>S\theta$, where S is the elasticity of intertemporal substitution. Hence, the lower S the less tight becomes this condition.

$$c(t,s) = (\theta+\lambda)[a(t,s)+h(t,s)]$$

where $h(t,s)$, human wealth, is defined as:

$$h(t,s) = \int_t^{\infty} w(\tau,s) \exp\left(-\int_t^{\tau} [r(z)+\lambda]dz \right) d\tau$$

2.2. Population dynamics and aggregation. Given our assumptions concerning death and birth rates, the population at time t is: $N(t)=N(0)e^{nt}$; we set $N(0)=1$ with no loss of generality; $n=\beta-\lambda$ is the constant population growth rate.

Since logarithmic preferences imply, at the individual level, a consumption function that is linear in total wealth, it is straightforward to obtain its aggregate counterpart:[8]

$$C=(\theta+\lambda)(A+H) \tag{1}$$

Notice that, from equation (1) on, we take as understood the time index t whenever this is not confusing. Using standard techniques, we obtain also the differential equations for assets and human wealth.

$$\dot{A} = rA + W - C \tag{2}$$

$$\dot{H} = (r + \beta + \rho)H - W \tag{3}$$

The absence of the λA term in equation (2) is due to the insurance companies' activity, which transfer resources from those who die to those who survive: clearly, this process is not affected by the birth rate. The βH term in equation (3) reflects the fact that all the agents,

[8] Recall that the population aggregate corresponding to any individual stock or flow variable $x(t,s)$ is defined as: $X(t)= \int_{-\infty}^{t} x(t,s)\beta e^{\beta s} e^{-\lambda t} ds.$

even the new-born, have the same life expectancy (Buiter, 1988, p. 283). As intuition suggests, the discount rate of human wealth is enhanced by ρ, the rate of decline of labour income.

Differentiating with respect to time equation (1) and exploiting equations (2) and (3), we get the law of motion for consumption:

$$\dot{C} = (r+n+\rho-\theta)C - (\theta+\lambda)(\beta+\rho)A \qquad (4)$$

It is useful to compare this equation with the corresponding one in the Ramsey model with population growth (see e.g. Blanchard and Fischer, 1989). In that framework, the second addendum on the right hand side is missing and per capita consumption is multiplied by (r-θ). The presence of the n term in our equation reflects the fact that existing agents are not concerned about the unborn people: at the per capita level, consumption is not affected by population growth. Equations (2) and (4) summarise the aggregate behaviour of our continuum of disconnected families.

3. A monopolistic competition framework

In what follows, the economy is composed of $v(t)$ firms, each producing an intermediate good, $x_i(t)$, which is an imperfect substitute for the others. National income, $Y(t)$, is regarded as a flow of output obtained by means of the specific goods; we impose, at any time, an equal and constant elasticity of substitution between any pair of the intermediate products, so that each firm has some monopolistic power:

$$Y(t) = \left(\int_0^{v(t)} x(t)_i^{\mu}\, di \right)^{1/\mu} \qquad 0<\mu<1 \qquad (5)$$

Notice that an increase in the number of varieties implies, ceteris paribus, a more than proportional increase in aggregate output, which is often though of as a consequence of the convexity of the production function.

We could have introduced monopolistic competition assuming a time separable utility function characterised by a sub-utility involving a "taste for variety", as in the literature that follows Dixit and Stiglitz (1977). However, this approach requires that the investment demand functions for intermediate goods are forced, for tractability, to have the same elasticity of consumption demands (see e.g. Kiyotaki, 1988, p. 700); the production side of the economic system must be accordingly constrained. Similar problems are implied by the presence of government expenditure.

Considering then (5) as a "production function", we determine the demand of every single intermediate good solving a time-separable cost minimisation problem:

$$\min_{\{x_i\}} \int_0^v p_i x_i \, di$$

where (5) is the static constraint; p_i is the price of the i-th specific good.

Using standard techniques (for a well known example, see Grossman and Helpman, (1991, p. 45-7), we obtain the following system of demand functions:

$$x_i = Y \left(\frac{p_i}{P}\right)^{1/(\mu-1)} \tag{6}$$

where

$$P = \left(\int_0^v p_i^{\mu/(\mu-1)} di \right)^{(\mu-1)/\mu} \tag{7}$$

is both a price index and the aggregate price level.[9] In a symmetric equilibrium, all the firms produce the same amount of output and charge the same price, hence, from (5) and (7)

9 Notice that $\int_0^v p_i x_i \, di = PY$ if x_i is given by (6).

respectively, $Y=vx^{1/\mu}$ and $P=p_i\, v^{(\mu-1)/\mu}$.

Before considering the optimisation problem for the representative firm, we introduce the constraints it faces. The first one is a linear in labour production function:

$$x_i(\tau)= \gamma L_i(\tau)e^{g\tau} \tag{8}$$

Notice that we allow for an exogenous rate of productivity growth, g. The arguments of the production function do not include capital, since it prevents, in general, the attainment of an explicit solution. In fact, in equilibrium $Y=xv^{1/\mu}$ and hence an increase in the number of varieties acts as "Hicks neutral" technical progress. The special case of the Cobb-Douglas technology, where one can easily translate "factor augmenting" into "labour augmenting" progress, is, of course, of some interest; we will briefly comment on it at the end of each subsection. The firms must also take account of the inverse demand function for x_i, equation (6).

The firm's problem is then the constrained maximisation, at time t, of the discounted stream of its cash flows:

$$max\ Q_i(t) = max \int_t^{\infty} [p_i(\tau)x_i(\tau) - w(\tau)L_i(\tau)]\ exp\left(-\int_t^{\tau} r(z)dz\right)d\tau \tag{9}$$

where L_i is labour used by the i-th firm, and w is the nominal wage. Notice that we allow the supply of labour to be different from population; this is consistent with the downward sloping profile for individual labour income, if the decline is due to a reduction of individual supply, in efficiency terms, related to age. However, we let the aggregate labour supply to increase at the population growth rate.

Since there are no dynamic constraints, problem (9) can be reduced to a sequence of static optimisations:

$$\max_{\{L(\tau)_i\}} \frac{P(\tau)\, x_i(\tau)^{\mu}}{Y(\tau)^{\mu-1}} - w(\tau)L_i(\tau)\,, \qquad \tau\in[t,\infty)$$

whose first order conditions are:

$$\frac{\mu\gamma e^{g\,\tau}P(\tau)\, x_i(\tau)^{\mu-1}}{Y(\tau)^{\mu-1}} - w(\tau) = 0, \qquad \tau\in[t,\infty)$$

Hence, in a symmetric equilibrium, $w(\tau)/P(\tau) = \mu\gamma e^{g\,\tau} v(\tau)^{(1-\mu)/\mu}$

We may now set, with no loss of generality, $P=1$ (which is consistent with our analysis of the consumer's problem) and $p_i = {}^{(1-\mu)/\mu}$, $i\in[0, v]$. In a symmetric equilibrium $L_i=L/v$, hence, using our expression for wages and exploiting the normalisation above, we transform (9) into:

$$Q_i = \int_t^{\infty} (1-\mu)\gamma e^{g\,\tau} \frac{L(\tau)}{v(\tau)} v\,(\tau)^{(1-\mu)/\mu} \exp\left(-\int_t^{\tau} r(z)dz\right) d\tau$$

which, in differential form, is:

$$\dot{Q}_i = -(1-\mu)\gamma e^{gt}\frac{L}{v} v^{(1-\mu)/\mu} + rQ_i \tag{10}$$

Hence, we have found an arbitrage equation which prices our assets, requiring that capital gains plus rents equate what could be obtained investing the value of the firm on the bond market. From (10) it is clear that the interest rate cannot be negative, as in Dechert and Yamamoto (1992); however this is no longer a sufficient condition to rule out dynamic inefficiency, since productivity and population grow.

Notice that the value of each firm depends only on future profits; hence, in a symmetric equilibrium, it is equal for every firm, regardless to the diversity in the dates at which they entered the market.

4. The role of the asset market

We now tie together the analysis of Sections 2 and 3, studying the implications of the firm pricing equation (10) on the aggregate behaviour.

Maintaining our assumption of no government debt, the outstanding stock of assets is given by:

$$A = vQ_i$$

Differentiation of this equation with respect to time gives:

$$\dot{A} = \dot{v}Q_i + v\dot{Q}_i$$

Substitution of equation (2) for the left-hand side and of equation (10) in the right hand side yields:

$$rvQ_i + \mu\gamma L\, e^{gt} - C = \dot{v}Q_i + rvQ_i - (1-\mu)\gamma e^{gt}\, Lv^{(1-\mu)/\mu}$$

Therefore, we obtain a differential equation for the number of firms:

$$\dot{v}Q_i = \gamma e^{gt} L v^{(1-\mu)/\mu} - C \qquad (11)$$

So far, we have developed three dynamic equations (eq. (4) and (10-11)). Since the model contains four unknowns (consumption, interest rate, number of varieties and value of a firm), we need a further relation to close the model. A hypothesis concerning the possibility, for new firms, of entering into the market provides the missing equation. In what follows, we examine several alternative assumptions.

4.1. Entry is blockaded. If the number of varieties is given and firms compete à la Bertrand within the market of each differentiated good, any type of lump-sum entry cost, however small, is sufficient to lock the number of firms.

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Dynamic system with no entry. To slightly simplify the notation, we assume v=1; hence, aggregate output is given, using (8), by: $Y=\gamma L_0 e^{(n+g)t}$, where $L_0 \equiv L(0)$. Since output grows at the exogenous rate $n+g$, to deal with variables approaching time-independent values in the long run, it is convenient to introduce two auxiliary variables who "deflate" consumption and the value of the representative firm. Hence, we define $c=C/e^{(n+g)t}$ and $q=Q_i/e^{(n+g)t}$. Differentiation with respect to time gives $\dot{c} = \frac{\dot{C}}{e^{(n+g)t}} - (n+g)c$ and $\dot{q} = \frac{\dot{Q}_i}{e^{(n+g)t}} - (n+g)q$.

In this economic system, no investment activity can be carried out; hence, from (11), since v=1, $c=\gamma L_0$ and $\dot{c}=0$. Exploiting equation (4) we get:

$$(r+\rho-\theta-g)\gamma L_0=(\theta+\lambda)(\beta+\rho)q \tag{12}$$

As for the value of the firm (in per worker "efficiency units") we obtain, using (10):

$$\dot{q} = -(1-\mu)\gamma L_0 + (r- n- g)q \tag{13}$$

This equation makes apparent that the steady state is dynamic efficient, since q may not be negative. In this case, each firm increases its production at the economic system growth rate. Hence, the discount of the flow of future profits is performed using the interest rate reduced by the aggregate rate of economic growth: dynamic inefficiency becomes impossible. Since all the future rents are capitalised, the presence of the stock market plays the same role of the transversality condition in an infinite-horizon growth model, as it happens in Dechert and Yamamoto.

Characterisation of the steady state equilibrium. Equation (12) may be used to explicit the interest rate:

$$r = \frac{(\theta+\lambda)(\beta+\rho)}{\gamma L_0} q +(\theta+g-\rho)$$

Introducing this expression into (13), we obtain the differential equation describing the solution of the system:

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$$\dot{q} = -(1-\mu)\gamma L_0 - (n+\rho-\theta)q + \frac{(\theta+\lambda)(\beta+\rho)}{\gamma L_0} q^2$$

The phase diagram for this equation makes evident that there is a unique meaningful steady state, which is unstable. Since q is not predetermined, we notice the absence of transitional dynamics: the system immediately jumps to its perfect foresight equilibrium, q^*.

[Figure 1 about here.]

Following Blanchard (1985, 237-38) we show that the long-run interest rate, r^*, is lower than $\beta+\theta+g$. This can be proved by contradiction. If $r^* \geq \beta+\theta+g$, it follows that $(r^*+\rho-\theta-g)\gamma L_0 \geq (\beta+\rho)\gamma L_0$. Hence, $(\beta+\rho)\gamma L_0 \leq (\theta+\lambda)(\beta+\rho)q$, or $c^* \leq (\theta+\lambda)q^*$. Equation (13) and the assumption $r^* \geq \beta+\theta+g$, imply that, in steady state, $q^* = \frac{(1-\mu)\gamma L_0}{(r-n-g)} \leq \frac{(1-\mu)\gamma L_0}{(\theta+\lambda)}$. Therefore $c^*(=\gamma L_0) \leq (1-\mu)\gamma L_0$, a contradiction.

We have extended this version of the model to encompass the use of capital in production of varieties, using the constant-returns Cobb-Douglas technology. In this case, the monopolistic distortion implies under-accumulation of capital. Hence, the introduction of an unbacked asset, can never be Pareto-improving not only because it does not ameliorate the intertemporal allocation of consumption, since $r^*>g+n$ as in the model above, but also because, rising the long-run interest rate, it depresses the steady state level of capital.

4.2. Entry is free but it involves a fixed cost, constant over time. In a dynamic setting, the hypothesis of a constant number of firms (and of goods) is not the most convincing one: a large body of literature, not only on growth but also, for example, on international trade, largely relies on the stylised fact that the number of goods is increasing. We now allow for an expanding number of varieties by assuming free entry; moreover, to portray the need to purchase an estate, a plant and/or some machinery, we posit that the entrant firms must bear a one-off cost, constant over time. Notice that, as time goes by, the ratio between the fixed cost, α, and aggregate output decreases. The free entry assumption implies that the value of every firm must be equal to the entry fee, $Q_i=\alpha$.

Reformulation of the dynamic system. As before, we need to work with variables approaching, in the long run, time-independent values. Therefore, we divide consumption and the number of varieties by their growth rate. Since $Q_i=\alpha$, we notice, from equation (11), that the growth rate for the number of varieties can be constant in the long run only when it is equal to the growth rate of consumption and equal to: $\frac{1}{(1-\Phi)}(g+n)$, where $\Phi=(1-\mu)/\mu$.[10] Hence, the growth rate of output ($\equiv g_y$), which is equal to the one for the number of varieties, is now a multiple of the exogenous growth rate, due to the fact that an increase in the number of varieties acts as technical progress. We assume that μ is larger than one half, to allow for a positive asymptotic growth rate for output.

We now define $c_1=C/e^{g_y t}$ and $u_1=v/e^{g_y t}$; since $Q_i=\alpha$, the differential equation (10) reduces to the following ordinary one:

$$rv\alpha = (1-\mu)\gamma L_0 e^{(g+n)t}\, v^{\Phi} \tag{14}$$

hence, using the definition for u_1, we express the interest rate as a function of the transformed variables:

$$r = \frac{(1-\mu)\gamma L_0\, u_1^{\,(\Phi-1)}}{\alpha} \tag{15}$$

Notice, that when μ is higher (lower) than one half, an increase in the number of varieties (and hence in u_1) reduces (increases) the interest rate. Therefore, when $\mu<0.5$, the usual intertemporal allocation mechanism (summarised in our model by equation (4)) implies that the introduction of new varieties depresses consumption, which, in its turn, gives room to a

[10] From equation (11), the growth rate for the number of varieties is: $\frac{\dot{v}}{v} = \frac{\gamma e^{(g+n)t} L_0 v^{\phi} - C}{\alpha v}$; hence, for g_v to be constant, we need $g+n+(\Phi-1)g_v=0$, and $g_c=g_v$.

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further increase in the number of intermediate goods, leading to explosive behaviours. The stability analysis for the steady state equilibrium of our model will confirm this intuition: when $\mu<0.5$, our dynamical system proves to be unstable.

By differentiating c_1 with respect to time, using (4) and our definition for u_1, we obtain:

$$\dot{c}_1 = (r+n+\rho-\theta-g_y)c_1 - (\theta+\lambda)(\beta+\rho)\alpha u_1 \tag{16}$$

Differentiation of u_1 yields, by use of (11):

$$\dot{u}_1 = \frac{\gamma L_0 u_1{}^{\Phi} - c_1}{\alpha} - g_y u_1 \tag{17}$$

Therefore, one ordinary and two differential equations describe our economic system.

The "modified golden rule". Equation (17) implies that, in a long-run equilibrium, $c_1^* = \gamma L_0 \; u_1^{*\Phi} - \alpha g_y u_1^*$, hence $\frac{\partial c_1^*}{\partial u_1} = \Phi\gamma L_0 \; u_1^{*\,(\Phi-1)} - \alpha g_y$, and, by use of (15), $\frac{\partial c_1^*}{\partial u_1} = \alpha\left(\frac{r^*}{\mu} - g_y\right)$. This shows an important point: consumption, in per capita efficiency units, is maximised when $r^* = \mu g_y$, hence, the "golden rule" of accumulation needs to be modified to take account of the monopolistic distortion. To understand this result, consider that profit, which can be seen as the reward for the introduction of a new variety, affects the interest rate through equation (14). At each instant of time, the single firm profit's is $(1-\mu)\gamma L_0 e^{g_y t} v^{(\Phi-1)}$. Moreover, in a long-run (symmetric) equilibrium, output, net of investment in new varieties, is given by $xv^{*1/\mu} - \alpha\dot{v} = \gamma L_0 e^{(g+n)t} v^{*\Phi} - \alpha g_y v^*$, hence net output is maximised when the "marginal productivity" of v is equal to αg_y. However, the marginal effect of v on gross output is larger, by a factor $1/\mu$, than firm's profit; accordingly the interest rate, which is equal to the ratio between profit and entry cost (eq. (15)), must be lower that the growth rate to allow for net output maximisation. The source of our result is that factor prices do not correctly assess the effect of the number of varieties on consumption because such effect is external to firms.

The relevant implication is that, for $\mu g_y < r^* < g_y$, the emergence of asset bubbles (or the introduction of public debt), is unambiguously welfare-reducing, since it lowers the steady-state consumption (in per capita efficiency units). Nevertheless, an observer (or a government), evaluating the situation on the basis of a model grounded on perfect competition, could judge positively the presence of the unbacked assets. Our result about the possibility of welfare-reducing bubbles is reminiscent of the conclusions obtained by the authors who studied this issue in endogenous growth models. However, as clearly illustrated by Grossman and Yanagawa (1993), in those models, the presence of bubbly asset can *never* be Pareto improving, because the reduction in the growth rate will always damage some future generation.[11] In our framework, a positive value of the unbacked assets is undesirable only when $r>\mu g_y$.

Steady state: level of the interest rate and dynamic properties. We first check whether r^* may fall within the interval $(\mu g_y,\ g_y]$. The simplicity of system (15-18) allows the explicit calculation of the long-run interest rate. Notice, from (17), that in the steady state $c_1^* = \alpha u_1^*\left(\frac{\gamma L_0 u_1^{*(\Phi-1)}}{\alpha} - g_y\right)$; hence, by use of (15), $c_1^* = \alpha u_1^*\left(\frac{r^*}{(1-\mu)} - g_y\right)$. Substituting this expression for c_1^* into (16) yields a quadratic equation for the long-run interest rate. The only solution implying a positive steady-state consumption (in per worker efficiency terms) is[12]:

$$r^* = \frac{\theta - \rho - n + (2-\mu)g_y + \sqrt{(\rho+n-\theta-\mu g_y)^2 + 4(1-\mu)(\lambda+\theta)(\beta+\rho)}}{2}$$

The interest rate is lower that the growth rate when: $(1-\mu)(\lambda+\theta)(\beta+\rho)<\mu g_y(\rho+n-\theta)$. Therefore, the possibility of asset bubbles is compatible with our imperfect competition framework. However, the higher the degree of monopoly (the lower μ), the less significant is the set of values for β, λ, ρ, θ and g_y, involving $r^*< g_y$.

11 This mechanism is obviously strengthened by the sub-optimality of the growth rate that characterises many endogenous growth models.

12 If β and λ (and hence ρ) were naught, the interest rate would be $r=\theta+g$ which is its "Ramsey" value.

The economic intuition for the possibility of asset bubbles is simple. The structure of the entry cost implies that, in steady state, the growth rate of the number of firms is equal to the one for output. Hence, the existing firms do not grow over time; accordingly, in discounting future profits, firms do not modify the interest rate with the growth rate. The fact that, in our perfect foresight framework, rational agents could capitalise in advance the value of still non-existing firms is not relevant, since the value of the firms, before they sunk the cost, is naught. Hence, the economic system behaves as if it could not capitalise in advance future rents, as in Tirole's example of paintings.

As noted above, the parameters set involving an interest rate lower that the growth rate is small when the degree of monopolistic power is substantial. In fact, this implies a high overall asset value, which, in its turn, enhances consumption, and hence exerts an upward pressure on the interest rate.

By means of some algebra, one can also show that $r^{*} < \mu g_y$ when:

$$(1-\mu)(\lambda+\theta)(\beta+\rho) < \mu g_y(\rho+n-\theta) + (\mu-1)g_y(\rho+n-\theta) + g_y^2(1-\mu)(1-2\mu) \qquad (18)$$

Since $0.5<\mu<1$, the second and third addenda on the right hand side of equation (18) are negative, implying that, ceteris paribus, the condition for dynamic inefficiency is more stringent than the one allowing for the presence of asset bubbles.

We may restrict the interval for the steady state interest rate. It is immediate to notice that r^{*} is higher than $\max\{0, \theta+g_y-\rho-n\}$. From equation (15), it cannot be negative, an implication of the fact that it is used by firms to discount their future cash flow; equation (16) establishes that a positive level of consumption in per capita efficiency units in steady state implies $r^{*}>\theta+g_y-\rho-n$. [13]

Following again Blanchard, we show that the long-run interest rate is lower than $\lambda+\theta+g_y$. Again, we prove this result by contradiction. If $r^{*} \geq \lambda+\theta+g_y$, it follows that $(r^{*}+\rho+n-\theta-g_y)c_1^{*}$

[13] Hence, the economic system can never be dynamic inefficient ($r<\mu g_y$) if $(1-\mu)g_y < \rho+n-\theta$. This condition is consistent with the one presented in the main text: if $(1-\mu)g_y < \rho+n-\theta$, the right hand side of equation (18) is negative, which precludes the fulfilment of that condition, since the left hand side is always positive.

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$\geq (\beta+\rho)c_1^*$, hence, from (16), $(\beta+\rho)c_1^* \leq (\theta+\lambda)(\beta+\rho)\alpha u_1^*$, or $c_1^* \leq (\theta+\lambda)\alpha u_1^*$. However, from equation (17), we obtain that, in steady state, $c_1^* = \gamma L_0 u_1^{*\Phi} - \alpha g_y u_1^*$. Therefore $(\theta+\lambda)\alpha u_1^* \geq \gamma L_0 u_1^{*\Phi} - g_y u_1^*\alpha$ or $\gamma L_0 u_1^{*\Phi} \leq (\lambda+\theta+g_y)\alpha u_1^* \leq r^*\alpha u_1^*$. Recall from equation (15) that $r^*\alpha u_1^* = (1-\mu)\gamma L_0 u_1^{*\Phi}$, hence we derived a contradiction. In economic terms, our chain of (weak) inequalities implies that output, in per worker efficiency units, is lower than (or equal to) per period dividends, a clear impossibility.

To characterise the dynamic properties of steady state, we now substitute r out of equations (16-18), obtaining a system composed of two differential equations:

$$\dot{c}_1 = \left[\frac{(1-\mu)\gamma L_0 u_1^{(\Phi-1)}}{\alpha} + n + \rho - \theta - g_y\right] c_1 - (\theta+\lambda)(\beta+\rho)\alpha u_1$$

$$\dot{u}_1 = \frac{\gamma L_0 u_1^{\Phi} - c_1}{\alpha} - g_y u_1$$

One can show that, when $\mu>0.5$, the two loci $\dot{c}_1 = 0$ and $\dot{u}_1 = 0$ behaves qualitatively as depicted in Figure 2. The same figure suggest that the equilibrium is saddlepath stable, as can be verified by means of a non-negligible amount of algebra.

[Fig. 2 about here]

When capital is taken into account, using a Cobb-Douglas production function, the main results of this section are confirmed. In fact, the steady state interest rate is lower than the output growth rate for reasonable parameters values; also in this version of the model per capita consumption, in efficiency terms, is maximised when $r^*=\mu g_y$. Hence, when $r^* \in (\mu g_y, g_y]$ asset bubbles are welfare damaging. This result carries over to the presence of capital because the degree of monopoly, lowering the interest rate, affects to the same extent the reward for both the accumulable factors.

4.3. Entry is free but it involves a fixed cost proportional to per capita output. Consider an environment, similar to those discussed by Grossman and Helpman (e.g. 1991, chs. 3 and 5), where entrance requires the development of a new "blueprint", which must be achieved by the work of some "scientists". If their productivity is constant, their wage increase with output (i.e. with average wages) and the entry fee involves the assumed features.

Dynamic system. The free entry assumption implies again that the value of every firm must be equal to the fixed cost, $Q_i(t)=F(t)=\alpha e^{gt}v(t)^{\Phi}$. In this case, the differential equation (10) becomes:

$$g+\Phi\frac{\dot{v}}{v} = r - (1-\mu)\frac{\gamma L}{\alpha v} \qquad (19)$$

As in the previous section, to obtain a steady state, we need to divide consumption and the number of varieties by their growth rate. Since $Q_i= \alpha e^{gt}v^{\Phi}$, the growth rate for the number of varieties can be constant in the long run only when it is equal to the population growth rate, while consumption (and output) must grow at $g+(1+\Phi)n$, that is following population (n) and productivity ($g+\Phi n$).[14] Notice that the restriction $\mu>0.5$ is not required to allow for output growth.[15] Define the productivity growth rate as $g_p= g+\Phi n$, therefore, our auxiliary variables are: $u_2=v/e^{nt}$ and $c_2=C/e^{(g_p+n)\,t}$.

Differentiation of u_2 with respect to time gives

$$\dot{u}_2 = \frac{\dot{v}}{L} - nu_2 = \frac{\gamma L_0}{\alpha} - \frac{c_2}{\alpha\, u_2^{\Phi}} - nu_2 \qquad (17')$$

[14] In this case, the growth rate for the number of varieties is: $\frac{\dot{v}}{v} = \frac{\gamma\, e^{(g+n)t}L_0 v^{\phi} - C}{\alpha\ e^{gt}v^{(\phi+1)}} = \frac{\gamma L_0 e^{nt}}{\alpha v} - \frac{C}{\alpha\, e^{gt}v^{(\phi+1)}}$; hence, for g_v to be constant, we need $g_y=n$ and $g_c=g+(\Phi+1)g_v$.

[15] One may check that our current specification for the entry costs does not involve, for $\mu<0.5$, the "perverse" effect on the interest rate that we highlighted in the previous section. Also, the stability analysis does not require any restriction on μ.

where we have used equation (11) to substitute for $\dot{v}$.

Taking advantage of our definition for c_2 and u_2, we obtain, from equations (4) and (19):

$$\dot{c}_2 = (r+\rho-\theta-g_p)c_2 - (\theta+\lambda)(\beta+\rho)\alpha u_2^{(1+\Phi)} \qquad (16')$$

$$r = g + \frac{(1-\mu)\gamma L_0}{\alpha u_2} + \Phi\left(n+\frac{\dot{u}_2}{u_2}\right) = g_p + \frac{(1-\mu)\gamma L_0}{\alpha u_2} + \Phi\frac{\dot{u}_2}{u_2} \qquad (15')$$

The traditional "golden rule" re-established. The steady state level for consumption in per capita efficiency terms, from (17'), is:

$$c_2 = \gamma L_0\, u_2^{\Phi} - n\alpha u_2^{(\Phi+1)}$$

hence,

$$\frac{\partial c_2^*}{\partial u_2} = (\Phi+1)\alpha u_2^{\Phi}\left[\frac{(1-\mu)\gamma L_0}{\alpha u_2} - n\right] = (\Phi+1)\; u_2^{\Phi}\alpha\; (r-g_p-n)$$

where the last equality has been obtained exploiting equation (15'). Hence, consumption is maximised when the steady state interest rate is equal to the output growth rate.

To understand this result, notice the long-run level of output, net of investment in new varieties, is given by $\gamma L_0 e^{(g+n)t} v^{\Phi} - n\alpha e^{gt} v^{(\Phi+1)t}$: the number of varieties involves two externalities on output. The positive effect highlighted in the previous section is still operative, but we are now in presence also of a negative externality, embedded in the second addendum. In fact, an increase in the number of varieties makes now more costly any subsequent investment; our Dixit-Stiglitz specification implies that the two effects exactly compensate each other.[16]

Steady state level of the interest rate. Calculations show that the r^* is smaller that the growth

[16] For a similar result, see Grossman and Helpman, 1991, ch. 3, Appendix 3.

rate of output, g_p+n, if $(1-\mu)(\lambda+\theta)(\beta+\rho) < \mu n(n+\rho-\theta)$. Hence, dynamic inefficiency is possible, since $\mu\in(0,1)$ and $\rho>\theta$, when $n>0$. In this case, the entry cost increases at the exogenous productivity growth rate and the existing firms grow over time at the same speed. Therefore, when they discount their profits, they take account of productivity growth but not of the increase in population (equation (19)). Hence, when population does not grow, this market structure prevents the existence of a dynamic inefficient equilibrium. Notice that this result holds true for even for “very small” levels of monopolistic competition: what is important is the presence of some profits, not its dimension.

One can also show that a sunk cost proportional to output, i.e. an entry fee growing at the pace of productivity and population, would rule out dynamic inefficiency, since firms would grow at the output rate. This structure for the entry cost could be due to the necessity to set up an advertising campaign or a distribution network, if the wage for the labourers involved in this activity increases with productivity and their number grows linearly with the people who need to be contacted. Notice that what is relevant is, once more, the presence of an entry fee with the assumed features, not its dimension.

Coming back to the case of an entry fee growing with per capita output, we can show, by means of some algebra, that the steady state is unique and saddlepath stable; the long run interest rate is higher than g_p. This result comes from equations (15'). We demonstrate, again by contradiction, that the long-run interest rate is lower than $\beta+\theta+g_p$. If $r^* \geq \beta+\theta+g_p$, it follows that $(r^*+\rho-\theta-g_p)c_2^* \geq (\beta+\rho)c_2^*$, hence, from (16'), $(\beta+\rho)c_2^* \leq (\theta+\lambda)(\beta+\rho)\alpha u_2^{*(\Phi+1)}$, or $c_2^* \leq (\theta+\lambda)\alpha u_2^{*(\Phi+1)}$. From equation (17'), we know that, in steady state, $c_2^* = \gamma L_0 u_2^{*\Phi} - n\alpha u_2^{*\,(\Phi+1)}$. Therefore $(\theta+\lambda)\alpha u_2^{*(\Phi+1)} \geq \gamma L_0 u_2^{*\Phi} - n\alpha u_2^{*(\Phi+1)}$ and hence, $\gamma L_0 \leq (\theta+\beta)\alpha u_2^*$. Now recall from equation (15') that, in the steady state, $r^* = g_p + \dfrac{(1-\mu)\gamma L_0}{\alpha u_2^*}$, hence $\alpha u_2^* = \dfrac{(1-\mu)\gamma L_0}{r^*-g_p} \leq \dfrac{(1-\mu)\gamma L_0}{\theta+\beta}$. Substituting this expression into the last inequality, we get $\gamma L_0 \leq (1-\mu)\gamma L_0$ and therefore we obtain the desired contradiction. The economic intuition is the same we provided in the previous section.

The results of this subsection are affected by the introduction of capital among the arguments of the production function. One can show, using, as usual, a Cobb-Douglas technology at the single firm's level, that, *given a capital stock*, output per capita is maximised when r^* is equal to the output growth rate: when this condition is fulfilled, the number of varieties is optimal, conditionally on the capital level. This result is to be ascribed to the twofold external effect of varieties on production, highlighted for the simpler version of the model. However, the steady state capital stock depends upon the interest rate, which is a fraction μ of the marginal productivity of capital itself. Obviously, this suggests that the "golden rule" capital stock is attained when the interest rate is lower than the growth rate. One can show that per capita consumption (in efficiency terms) is maximised when the long-run interest is lower, but not significantly lower, than the growth rate for output.[17]

V. Concluding remarks

The present paper emphasises the importance of the market structure to determine whether dynamic inefficiency is possible in a closed economy with no outstanding public debt. Since the deviation from perfect competition implies the existence of some pure profit, the value of each firm is given by the stream of its discounted future cash flow, which adds a forward looking differential equation to the model. The level of the growth-corrected discount rate adopted by individual firms plays a key role. If the growth rate of each firm is lower than the aggregate one, an inefficient long-run equilibrium may emerge; on the other hand, if each firm takes account of the aggregate growth rate, dynamic inefficiency is ruled out.

This is the reason why the assumption of blockaded entry makes dynamic inefficiency impossible: every firm grows at the aggregate growth rate, all the future rents are capitalised and hence the presence of the stock market serves the same purpose as the transversality condition in an infinite-horizon growth model.

With free entry, the number of existing firms has been determined through the

[17] Some simple numerical exercises showed that, for sensible parameters values, the "golden rule" r^* is always higher than the 92.5% of the growth rate.

introduction of a fee to be paid at the time of entrance into the market. The importance of the assumptions concerning the form of such cost is remarkable.

If the sunk cost is constant over time, the size of any existing firm does not grow in the steady state; accordingly, firms do not modify the interest rate with the growth rate to discount their future profits. Hence, the long-run interest may be lower than the output growth rate with either population or exogenous productivity growth. In this case, the "golden rule" of accumulation, needs to be modified to take account of the monopolistic distortion. In fact, profits, i.e. the reward for the introduction of a new variety, are too low, since they do not correctly reflect the effect of an increase in the number of goods on aggregate output. Hence, the market-determined interest rate, which is positively related to profits, is low, too. The important implication is that the presence of an unbacked asset is unambiguously welfare reducing, for a relevant interval in the values of the steady state interest rate. Under the assumption of a constant entry fee, the condition for a dynamic inefficient long-run equilibrium is much more stringent than the one for the presence of asset bubbles, since it is required that the interest rate is a fraction of the growth one.

Alternatively, if the entry cost increases over time, being related for example to wages, existing firms grow, in the long run, at the speed of per capita output. Therefore, in discounting future profits, firms take account of productivity growth, but not of the increase in population: this structure for the sunk cost prevents the existence of dynamic inefficient equilibria when population is stationary. If the entry fee grows at the rate of aggregate output, the discount rate used by firms is higher than the one for output and dynamic inefficiency is impossible.

In conclusion, our analysis suggests that dynamic inefficiency is not likely to be a problem in a dynamic economy characterised by some element of monopolistic competition. This is related to two distinct effects. First, the presence of some amount (however small) of profit affects the discount rate used by firms. If entry is blockaded, the discount rate is higher than the one for aggregate output growth; it is higher than productivity growth if the entry fee is proportional to wages. Second, when the sunk cost is constant over time, the monopolistic distortion, per se, causes an underinvestment problem and the condition for dynamic inefficiency becomes very stringent.

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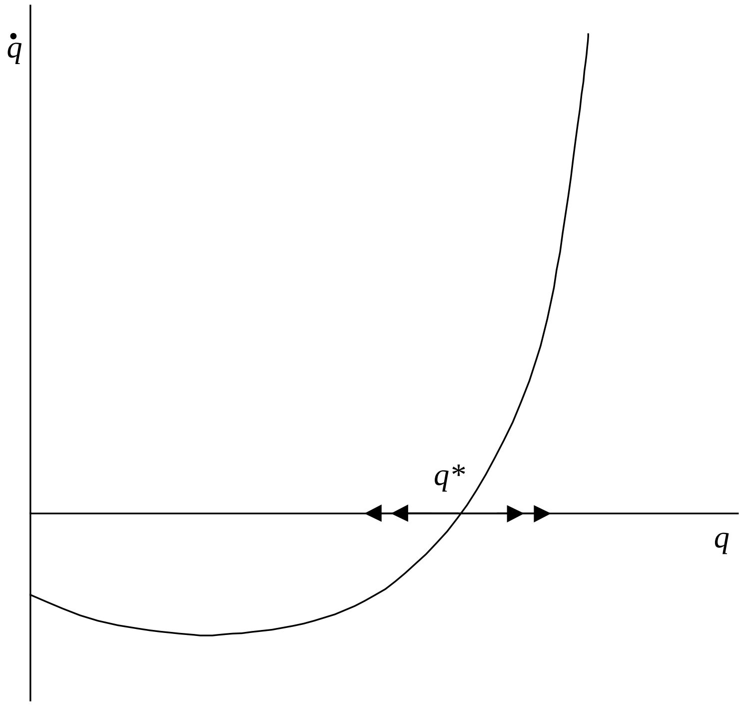

Figure 1

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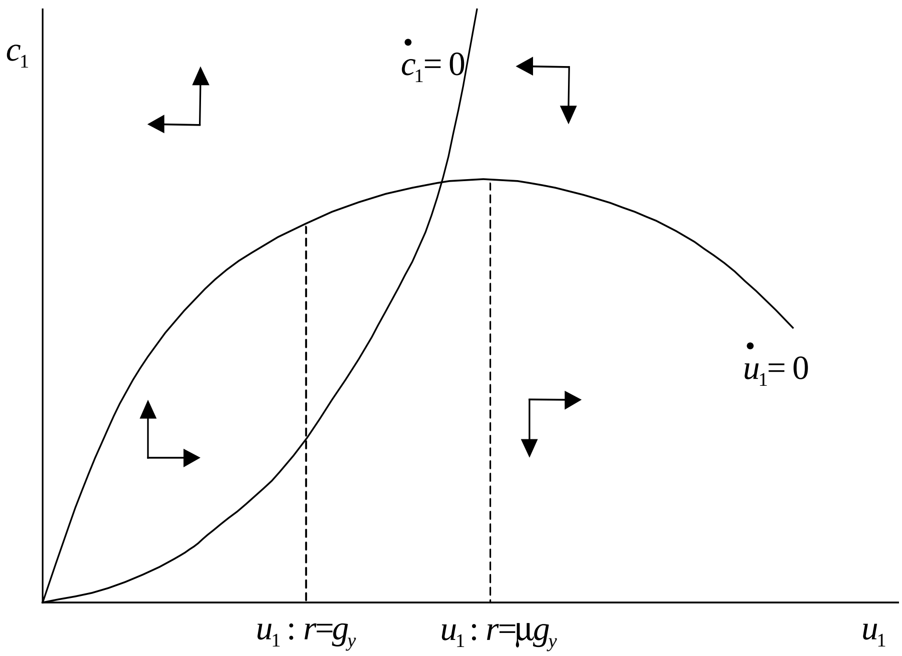

Figure 2