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NATURE, NURTURE AND ECONOMIC GROWTH

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Abstract

This paper develops an endogenous growth model to examine the influence that heterogenous entrepreneurial ability between individuals and between countries can have upon economic growth. Entrepreneurial ability is argued to be a function of the combined influence of societal, psychological, and genetic factors, the net effect of which upon any individual remains difficult to forecast. Failure by financial markets to accurately identify true entrepreneurial ability ex-ante can result in unfulfilled expectations ex-post. Overestimation of true entrepreneurial ability by imperfectly informed financial institutions causes a divergence between fundamental and market values with the subsequent emergence of a speculative bubble – as consistent with the recent US stock market experience. That said, the news isn't all bad. Even though speculative bubbles may result in a mis-allocation of capital from a rational expectations standpoint, there is still a net benefit of knowledge spillovers generating a higher growth outcome even when over-investment exists. Again, this may be consistent with the experience with the recent bubble with the US equity market.

♣ The author would like to acknowledge comments by Robert Dixon, Jim Robinson, and Jim Thompson. Any errors and omissions remain the responsibility of the author. Mailing Address: Bartholomew F. Dowling, Merrill Lynch, 2 King Edward St, London, UK, EC1A 1HQ Ph +44 (0) 20 7996 3655, Email: Dowlibar@exchange.uk.ml.com.

INTRODUCTION

'where the supply of entrepreneurs remains limited "secular stagnation" occurs, with low or even zero levels of economic growth.

Rostow (1956) pp. 26

It is the purpose of this paper to analyse the impact of heterogenous entrepreneurial ability upon the pace of economic growth using an endogenous growth framework similar to that developed by Grossman and Helpman (1991). Within the model, increasing returns are a function of knowledge spillovers contributing to the productivity of human capital in the research sector of the economy. Similar endogenous growth models have been developed by Lucas (1988), Romer (1989 and 1990) and Buiter and Kletzer (1991). The model developed in this paper makes the contribution of linking innovation success not only to the presence of knowledge spillovers but also the ‘natural’ level of entrepreneurial ability that a particular economy may posses.

It is a contention of the paper that the higher the value a particular society places upon entrepreneurship, the higher the base level of ‘natural’ entrepreneurial ability and thus the higher the achievable rate of economic growth. Maley (1983) has identified that entrepreneurial insight will be limited in a society where entrepreneurs are not rewarded sufficiently to elicit motivation; entrepreneurs are technically legal but socially devalued; entrepreneurial skills are lacking; entrepreneurs access to industries and resources is difficult or prohibitive in cost; if resources may be expropriated; there are countervailing inducements to direct effort away from the production of wealth; there are radical uncertainties about the outcome of effort; or, where the organisational milieu is sub-optimal. It is argued that societal/institutional conditions such as these have the potential to alter the natural level of entrepreneurial talent that emerges in any one economy. In this respect the paper contributes to the growing branch of literature that has focused on the importance of cultural/societal/institutional factors as important determinants of the pattern of long-term economic growth such as North (1981, 1990 and 1991), Redding (1990), Alesina and Roubini (1997), Greif (1994), and Zak and Park (2000).

An additional contention of the paper is that differences emerge in natural entrepreneurial ability not only between economies but also within economies. Saracheck (1978), Powell (1987), Mclure (1990), and Blanchflower and Oswald (1990) have all identified certain psychological/genetic traits which are generally common to successful entrepreneurs. Characteristics such as ‘alertness to profit-making opportunities’ (Ronen, 1983), ‘need achievement’ (McClelland, 1961) or ‘unforthcomingness syndrome’ (Blanchflower and Oswald, 1990) are generally regarded to be preconditions for entrepreneurial success. The list is by no means exhaustive and while many studies have highlighted the psychological/genetic element as a determinant of entrepreneurial success, there still considerable controversy regarding what are the definitive persona characteristics which ensure that an individual can be accurately labelled an incipient entrepreneur. For example, Saracheck (1978) has identified that the psychological stress from the loss of a father when young generates a need for social recognition which is at times consistent with entrepreneurial drive. While interesting, I was loathe to develop a model advocating the selective harvest of fathers as a means to promote a higher growth outcome! Such points aside, it appears that the general consensus of these studies is that differences in the allocation of genetically/psychologically determined abilities result in the emergence of a heterogeneous distribution in natural entrepreneurial ability between individuals within any given economy. In fact, Kamien and Schwartz (1982) have argued that ‘entrepreneurial ability, as other characteristics, is not uniformly distributed across the population’.[1]

The paper therefore models the emergence of heterogenous entrepreneurial ability *between* economies in response to differences in societal/institutional conditions and *within* economies in response to the uneven distribution of psychological/genetic traits. It is found that the combination of these three factors - society/psychology/genetics - forms the basis of a natural entrepreneurial resource constraint which limits the rate of growth that can be achieved within any given economy at a particular point in time. Accurately determining the boundary of this entrepreneurial resource constraint can pose a major problem for financial markets. To illustrate this, the paper identifies two alternative scenarios.

The first scenario assumes that financial markets have complete information regarding the natural ability level of all entrepreneurs within an economy and as a consequence, financial market expectations of the return on entrepreneurial equity are fully realised at each point in time. Such a hypothesis is consistent with deterministic models of knowledge acquisition as developed by Romer (1986 and 1990) and Lucas (1988). The second scenario assumes that natural entrepreneurial ability remains an unknown, forcing financial markets to adopt the conservative stance of assuming an average of current profit rates on entrepreneurial equity are representative of future profit rates. This is more consistent with studies which postulate that the outcome of entrepreneurial behaviour is unknown, such as Aghion and Howitt (1992) and Corriveau (1994). In making such an assumption, it will be displayed that when financial markets project average current profit rates forward there is a tendency for consistent overestimation of the rate of return on

[1] See Kamien and Schwartz (1982), *Market Structure and Innovation*, pp. 29.

entrepreneurial equity and correspondingly, a consistent overestimation of the true level of natural entrepreneurial ability. The subsequent disparity between overly optimistic *ex-ante* financial market expectations and the actual *ex-post* outcome generates the existence of a speculative bubble and can contribute to a higher growth outcome. In this respect, the model builds upon earlier endogenous growth studies such as King and Levine (1993) and Holtz-Eakin, Joulfaian and Rosen (1994) which highlighted the importance of capital markets evaluating, managing and funding entrepreneurialism but with the introduction of the added element of uncertainty. In particular, the model developed in this paper makes the contribution of focusing on the financial market assessment procedure of natural entrepreneurial ability and how success or failure in this assessment will influence economic growth.

Section I of the paper provides an outline of the necessary elements of the model. Section II examines the equilibria conditions of the model under the two alternate expectational regimes; perfect knowledge on behalf of financial markets and limited knowledge. It is seen that under the presumption of perfect knowledge, the model's results are generally consistent with the standard Grossman and Helpman (1991) analysis with the exception of the inclusion of an additional growth determinant - natural entrepreneurial ability. However, when financial markets are not fully informed of individual natural entrepreneurial ability but instead need to rely upon a rule-of-thumb indicator such as the current rate of return on existing entrepreneurial ventures, then a divergence between fundamental and market values eventuates. This causes a speculative bubble to appear.

I. THE MODEL

The model is a simple two sector framework for the economy comprising a manufacturing sector and a research and development (R&D) sector. Section *(a)* of the paper provides the foundations for linking entrepreneurial innovation to intertemporal consumer utility. Sections (*b*) and *(c)* examine the production and R&D sectors (respectively). Constant returns to scale apply in the manufacturing sector and for any individual enterprise engaged in R&D. Knowledge spillovers from private research contribute to the stock of public knowledge which raise the future rates of productivity for entrepreneurial agents engaged in research and form the basis of economy-wide increasing returns. It is these knowledge spillovers which drive endogenous growth. Section *(d)* of the model introduces heterogeneous entrepreneurial ability. Differences in societal/institutional conditions are argued to generate between economy differences in natural entrepreneurial ability while psychological/genetic traits form the basis of within economy differences. Sections *(e)* and *(f)* provide the necessary solutions for general equilibrium by examining the financing of innovation and the labour market (respectively). It is seen in section *(e)* that failure by financial markets to adequately assess the combined influence of society/psychological/genetic factors result in the emergence of a speculative bubble.

a) Consumption Behaviour

Assume each economy is populated by a continuum of agents each living a finite time interval *T*. The age distribution is uniform and the population *(N)* is constant with an equal number of newborns replacing people who die. For simplicity, an assumption is made that individuals share identical utility preferences and consume their entire lifetime income. The lifetime utility of an individual born at time *t* is given by:

$$(1) \qquad U_t = \int_t^{t+T} e^{-\rho(\tau - t)} \log D(\tau) d\tau$$

where $D(\tau)$ represents an index of consumption at time τ and ρ is the subjective discount rate. This utility function is the natural analog to the utility function of an infinitely lived representative agent who maximises utility over an infinite horizon[2]

(2) $$U_t = \int_t^{\infty} e^{-\rho(\tau - t)} \log D(\tau) d\tau \ .$$

Utility is directly related to product variety with consumer preferences extending over an infinite range of products indexed by $j \in [0, \infty)$. If products in the range $[0, n]$ are available, then the consumer utility index is specified as

(3) $$D = \left[\int_0^n x(j)^{\alpha} dj \right]^{1/\alpha} \qquad 0 < \alpha < 1$$

where *x(j)* denotes consumption of brand *j* and α is the elasticity of demand (marginal utility) for this particular good.[3]

Assuming static equilibrium conditions hold, maximising subject to a budget constraint *(E)* identifies that intertemporally the level of spending depends on the interest rate (*r)* at time t and the subjective discount rate applied to the variety of goods and services on offer, (ρ). Normalising aggregate spending so that real variables grow in exact proportion to nominal variables *(E=1)* at every moment gives the familiar consumption maximisation condition for the representative agent of

(4) $$r(t) = \rho \qquad \text{for all } t.$$

[2] Transversality conditions are satisfied by *T* for the last generation coinciding with the terminal condition.
[3] For an exposition of the properties of this form of utility function, refer to Dixit and Stiglitz (1977).

This is the same result as the consumption maximisation condition for the finite lived individual. Proof of this result is contained in the Appendix.

b) The Production Sector

For simplicity it is assumed that production is purely a function of labour input, L. Under conditions of general equilibrium α represents both the marginal utility and the marginal product of a particular good. Within the production sector there is constant returns and the production function is of the form

$$(5) \qquad Y = L\alpha .$$

Using this production function, entrepreneurs manufacture a series of differentiated products. It is assumed that each differentiated product is manufactured by a single, atomistic firm controlled by a single entrepreneur. Under monopolistic competitive conditions, price is modelled as a multiple of unit cost giving

$$(6) \qquad p(j) = \frac{w}{\alpha} .$$

c) The Research and Development Sector

Not all entrepreneurial agents are engaged in production. Only entrepreneurs who are successful in bringing an innovative product to market earn the right to enter into the production process. Competitors do not try to undertake the production of existing goods because it is assumed that imitation is costly and incumbent producers engage in Bertrand Oligopolistic restrictive pricing behaviour or ‘limit pricing’. This implies that at any point in time entrepreneurs are either manufacturing products they have previously developed, they are engaged in employment, or they are managing the allocation of labour in the R&D sector with the aim of developing new product varieties. When incipient entrepreneurs decide to forsake employment and attempt to develop a new product variety they incur an up-front cost for R&D. Within the model this up front cost is regarded as a fixed cost of production.

In the R&D sector increasing returns apply since it is assumed knowledge spillovers contribute to the stock of public knowledge (K_n) which in turn raises the output of innovations per unit of labour input (η) in the R&D sector. Public knowledge accumulation is thereby incorporated into the model via a reverse engineering process with innovations being introduced to the market having the effect of transforming private knowledge into public knowledge; patent rights are assumed to be non-existent. To quantify the impact that K_n has upon η, it is helpful to make the simplification assumption that the factor proportion relationship between an additional unit of public knowledge accumulation and an additional product innovation is one to one, thus

(7) $$K_n = n.$$

For any individual entrepreneur however, investment in research remains on a constant returns to scale basis and also reflects the entrepreneur's own innate natural entrepreneurial ability. Therefore an entrepreneur who devotes l units of labour to the pursuit of research has an expected innovation output of

(8) $$\dot{n} = l\eta\varpi_i$$

where ϖ_i represents his or her ‘natural’ entrepreneurial ability.

d) Heterogenous Nature Determined Entrepreneurial Ability

Within the model it is assumed that entrepreneurs who either work for themselves or work for another entrepreneur will vary in their natural ability (ϖ_i) to produce innovations. To formalise this, it is necessary to distil the numerous behavioural studies which have identified specific psychological/genetic entrepreneurial characteristics into a series of 'nature' determined traits which are inherited involuntarily from one's parents. Focusing on the role of the parent in this way is convenient in the respect that it allows for the dual presence of both genetic and parental environment factors to influence an individual's persona. This overcomes a significant problem which pervades the behavioural studies regarding whether entrepreneurial ability is shaped more by genetic characteristics or more by the parental environment in which they are raised. The approach taken in this model is to avoid this issue by classifying trait inheritance from one's parents not only in terms of genes but also in terms of parental environment.

Proposition 1. Assume there are a finite number of nature determined entrepreneurial traits which an individual can inherit from their parents and the probability of being born with any one of these nature determined traits is both constant and independent. Under these conditions, the distribution of nature determined entrepreneurial ability in an economy can resemble a bell-shaped Binomial distribution provided the number of individuals within the economy (N) is sufficiently large.

Proof: using z to denote the constant probability of being born with a particular nature determined entrepreneurial trait and q=1-z as the probability of not acquiring this ability from one's parents, it is possible to describe the population (N) as a series of Bernoulli 'trials'. Appealing to the Binomial distribution allows for the identification of probabilities $b(k;N,z)$ for the occurrence of any specific number of individuals (*k*) who possess a particular nature determined entrepreneurial trait *z* within the population *N*. This gives

$$(9) \qquad b(k;N,z) = \binom{N}{k} z^k q^{N-k}.$$

Using the law of large numbers as described in Feller (1968) allows the mapping of the finite range of individual trait Binomial distributions across all individuals within an economy. Allowing z^* to denote the probability of an individual being born with an 'average' amount of entrepreneurial traits, the law of large numbers illustrates the central tendency of the Binomial distributed range of entrepreneurial abilities. That is, the probability of selecting an individual whose nature determined entrepreneurial ability departs from the population average (Nz^*) by some error term *(e)*, approaches zero as *N* increases;

$$(10) \qquad P\{Nz + e > Nz\} \to 0 \qquad\qquad N \to \infty.$$

This is an important result for the model because it implies that most individuals will be born with an average amount (z^*) of psychologically/genetically determined entrepreneurial traits. Likewise, the tails of the distribution will represent the relatively small proportion of individuals who have acquired a large (or small) number of genetic entrepreneurial traits from their parents and whom thus constitute the high (or low) natural entrepreneurial ability classes.

Having described what determines heterogeneity in natural entrepreneurial ability within an economy, it is next important to examine between economy differences. To do this, it is necessary to introduce an additional entrepreneurial trait which an individual may acquire via birth. This trait will reflect differences the sociological/institutional conditions which predominate in the economy into which an individual is born.

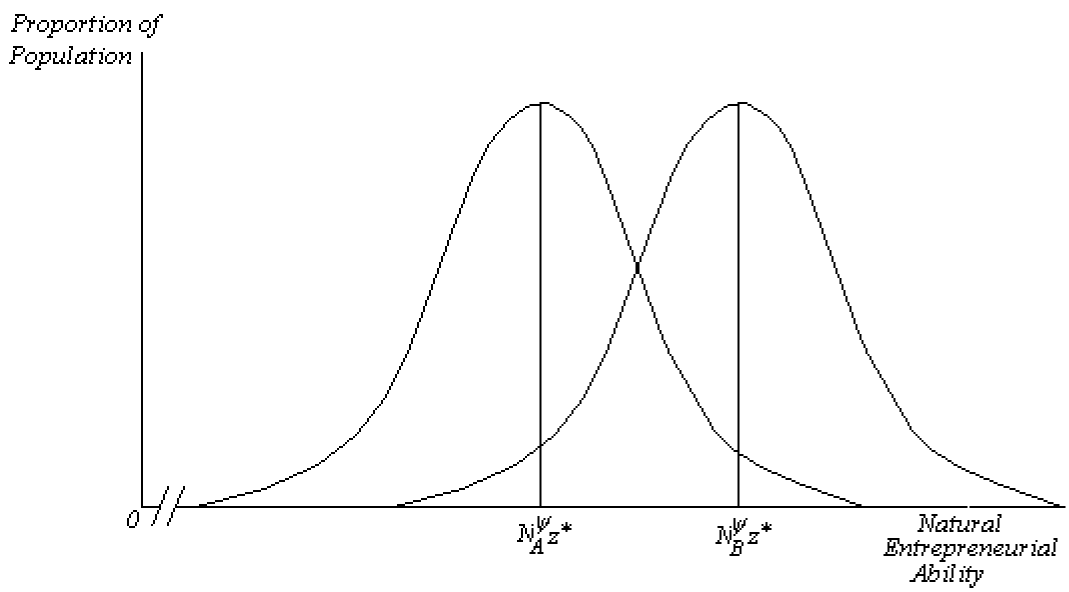
Proposition 2. Assuming psychological/genetic conditions are constant between economies and the probability of being born into any one economy is constant, equal and independent, then differences between economies regarding socio/institutional conditions result in differences in the point of central tendency for any given Binomial distributed range of natural entrepreneurial abilities.

Proof: introducing the additional nature determined entrepreneurial trait ψ which denotes the socio/institutional conditions attributable to a particular economy, and given the probability of being born into any one economy $\left(z^{\psi}\right)$ is both equal and constant (where $0 < z^{\psi} < 1$ and $\sum z^{\psi} = 1$), then it is possible to describe each separate population N^{ψ} as a distinct Binomial distribution $N^{\psi}z^{*}$. Furthermore, assuming each economy differs in its socio/institutional composition and entrepreneurial migration between economies is restrictive, then $N^{\psi}z^{*}$ will represent a unique outcome for the distribution of natural entrepreneurial ability.[4] Under these conditions, the distribution of the natural entrepreneurial ability $\left(\varpi_i\right)$ within a population is determined specifically by psychological/genetic traits and for each economy will resemble the characteristic bell-shaped Binomial distribution centred around z^{*}; but the positioning of this distribution along the continuum of natural entrepreneurial ability is determined primarily by societal/institutional arrangements as reflected in the unique value of $N^{\psi}z^{*}$. This is illustrated in figure 1 where $N_A^{\psi}z^{*}$ represents the average natural entrepreneurial ability for economy *A*, but because of unfavourable socio/institutional conditions this is

[4] Obviously, a free-flow of 'trade' between economies in entrepreneurial agents has the potential to raise the growth potential of one economy relative to another and, as Rivera and Romer (1991) have illustrated, to the extent that trade results in enhanced spillovers there is the potential for the net well-being of all societies to rise in response to such trade liberalisation.

significantly less than the natural entrepreneurial ability exhibited in economy *B*, $\left(N_A^{\psi} z^* < N_B^{\psi} z^*\right)$.

Figure 1: The Distribution of Natural Entrepreneurial Ability Both Within and Across Economies[5]



Subsequently, it is the combination of society/psychology/genetics which forms the basis of a natural entrepreneurial resource constraint (ϖ_C) which limits the rate of growth that can be achieved within any given economy at a particular point in time. Since equation (8) has highlighted that ϖ is directly related to innovation success, it is imperative for financial markets to try and form some assessment of this important factor.

e) Financing Innovation

[5] It may be possible that certain educational criteria are conducive to the appearance of entrepreneurs – see for instance, Lazear (2002). Should this be the case, then it may be possible that for certain economies to lift their growth potential by pursuing particular education agendas – an interesting policy perspective from this line of reasoning.

There are assumed to be two forms of financial instruments available within the economy; bonds issued by individuals, and equities issued by entrepreneurs. The household-based capital market uses the rate of return on both these financial assets to calculate the distribution of savings funds to facilitate lifetime consumption smoothing. The fixed pool of household savings constitutes the entire financial market; since it is assumed that there is no savings undertaken by firms. Stocks and bonds are assumed to represent perfect financial substitutes within households portfolio's. Equilibrium requires that the return from holding entrepreneurial equity is the same as the return from holding consumer issued bonds. The return on bond investment is simply the nominal interest rate (*r*) multiplied by the value of bonds held, *v*. The return on entrepreneurial equity however, has the potential to be much more uncertain.

Entrepreneurs who successfully develop an innovation have an operating profit function (π_T) consistent with total revenue minus total cost

$$\pi_T(j) = p(j)x(j) - wx(j) \tag{11}$$

where it is assumed for simplicity that there is a one to one relationship between labour input and product output. Assuming symmetric demand conditions and given that *E=1*, competition ensures an average profit return (π_A) for each innovation of

$$\pi_A = \frac{1-\alpha}{n}. \tag{12}$$

Proof of this equation is contained in the Appendix. The average profit rate π_A is consistent with the average profit return from the investment in the diverse range of individual entrepreneurial abilities (ϖ_i) displayed in figure 1. The difficulty for financial markets is to determine whether π_A is representative of all future entrepreneurial ventures or whether it is better to form an alternate assessment of ϖ_i for each new venture and through this a more thorough prediction of the likely evolution of future profit returns.

i) Perfect Information Regarding Natural Entrepreneurial Ability

If the financial market were to posses perfect information regarding each individual ϖ_i (and subsequently their expectations of innovation output are fully realised), the return on entrepreneurial equity could then be represented as the average profit return (π_A), assuming all profits are paid in the form of dividends, plus any expected capital gains or losses, $\left(\dot{v}\right)$. Capital gains and losses are calculated as the discounted present value stream of future profit and need to be taken into account since the present value stream of future profit will decline as new innovations are brought into production and the market share of existing producers is diluted. Under such conditions, the functional form for equilibrium in the household-based capital market is

$$\text{(13)} \qquad \pi_A + \dot{v} = rv$$

where *rv* represents the return on bonds and the LHS of equation (13) represents the discounted present value stream of future profits $v^R(t,\tau)$; where

$$v^R(t,\tau) = \pi_A + \dot{v} = \int_t^{\infty} e^{-\rho(\tau - t)}\pi(\tau)d\tau \ .$$

Another way to establish financial market equilibrium is to consider the labour choice undertaken by individual entrepreneurs. From equation (8), an entrepreneur who devotes l units of labour to the pursuit of innovation acquires the ability to produce $dn = l\eta\varpi_i$ new varieties of product. Assuming perfect information, capital markets will place valuation on this labour choice equivalent to $v[\varpi_i l\eta]$. Value maximisation by entrepreneurs requires that l will be set as large as possible whenever the market valuation is greater than the labour cost, (wl). If the minimum market valuation condition holds, the labour demand by entrepreneurs for innovation activities is unbounded. Stability requires

$$v = \frac{w}{\varpi_i \eta}. \tag{14}$$

ii) *Imperfect Information Regarding Natural Entrepreneurial Ability*

If financial markets only posses imperfect information regarding ϖ_i, then they will be required to form a subjective assessment as to the likely return on each independent entrepreneurial venture via an examination of ϖ_i for each independent entrepreneur approaching them for finance. This brings into question the costs involved in such a procedure and how financial markets actually compose their judgements of an individual's natural entrepreneurial ability. Following Nyssen (1994) and assuming 'naïve' behaviour on behalf of financial markets in the respect that lenders use the average current profit rates $\pi_A(t)$ as the primary means of their assessment of future profit rates $\pi(\tau)$, then there is a tendency for consistent overestimation of the true average natural entrepreneurial ability (ϖ_C).[6] This is because by using $\pi_A(t)$ instead of $\pi(\tau)$, the expected present value in t of these future profits for all $\tau \in [t, \infty)$ is

$$v^e(t,\tau) = \int_t^{\infty} e^{-\rho(\tau - t)} \pi_A(t) d\tau = \frac{1-\alpha}{\rho n(t)} = v^e(t); \tag{15}$$

this implies that at any one point in time the equity valuation price $v^e(t,\tau) = \pi(t)/\rho$ is always in excess of the true fundamental value $v^R(t,\tau) = \int_t^{\infty} e^{-\rho(\tau-t)}\pi(\tau)d\tau$ since financial markets are not taking into account future capital gains or loses $\left(\dot{v}\right)$ In fact, under such

[6] Such a heuristic 'rule of thumb' is consistent with the behavioral finance literature – see for instance, Shefrin (1999).

naive behaviour financial markets are not only failing to take into account the heterogenous nature of individual entrepreneurial ability, but also any assessment of the outcome of future entrepreneurial ventures. A speculative bubble thus emerges in the respect that fundamental values diverge from market values. Since there is no money identified in the model, this speculative bubble is represented by an equivalent amount of resources being transferred from the final goods sector to the R&D sector.

Under these conditions, the equilibrium condition for the household-based capital market is similar to that expressed in equation (13) in that the return on entrepreneurial equity must equate to the return on bonds, however there is no longer any expected variation in the rate of return as denoted by $\dot{v}$. Consequently, the equilibrium condition for financial market equilibrium under imperfect information and assumed naive expectations can be expressed as

$$\pi_A = rv. \qquad (16)$$

Such 'naïve' expectations can only be justified where financial markets are at a loss to explain likely future rates of innovation because of their inability to accurately forecast individual natural entrepreneurial ability *ex-ante* $\left(\varpi_i^e\right)$. In fact, an individual's entrepreneurial ability could be at any point along the distribution illustrated in figure 1. This rules out the possibility of learning behaviour on behalf of financial markets as described by Caplin and Leahy (1994). To compensate for the lack of information, financial markets adopt a conservative strategy of extrapolating the average of the current profit rates forward. In support of such a hypothesis, Cutler, Porterba and Summers (1990) have illustrated the tendency for speculative asset pricing to be highly serially correlated in the short-term. Such 'herd' type behaviour is consistent with the naive expectations assumption undertaken here.

It is next necessary to define a new minimum market valuation condition. Following the earlier procedure and referring to equation (8), an entrepreneur who devotes *l* units of labour to the pursuit of innovation acquires the ability to produce $dn = l\eta\varpi_i$ new varieties of product. However, capital markets do not know with certainty the true value of ϖ_i and place a valuation on the labour choice equivalent to $v\left[\varpi_i^e l\eta\right]$. Again, value maximisation by entrepreneurs requires that *l* will be set as large as possible whenever the market valuation is greater than the labour cost, (*wl*). If the minimum market valuation condition holds, the labour demand by entrepreneurs for innovation activities is unbounded. Stability requires

$$v = \frac{w}{\varpi_i^e \eta}. \tag{17}$$

f) The Labour Market

Wages are the crucial variable in ensuring stability for the financing of innovation under both expectations regimes. From equation (8) total labour demand in the R&D sector is given by

$$L_{R\&D} = \left[\frac{\dot{n}}{\eta\varpi_C}\right]. \tag{18}$$

The labour demand in the production sector of the economy is derived by dividing total expenditure by price to obtain the number of products sold. Since aggregate spending is set at the chosen numeriare *E=1* and given an input-output coefficient of one for labour input relative to output in the production sector, then the labour demand in this sector of the economy is

$$(19) \qquad L_P = \frac{1}{p}.$$

Using L_S to denote the fixed labour supply that the constant population in an economy supplies at every moment of time, the labour market clearing condition is

$$(20) \qquad \frac{\dot{n}}{\eta \varpi_C} + \frac{1}{p} = L_S .$$

A necessary condition placed upon this labour market condition is that employment in the production sector must be non-negative. Given this, the equilibrium price of an innovative product must satisfy $p \geq 1/L_S$.

EQUILIBRIA

a) General Equilibrium Under Conditions Where Financial Markets Have Perfect Information Regarding Natural Entrepreneurial Ability

Even when financial markets posses complete information regarding ϖ_i, innovation will only take place when the financial market valuation placed upon innovative activity, *v*, is greater than the valuation placed on the production of the existing range of products, $\bar{v}$. Combining equations (6), (14) and (19) gives this relative valuation boundary condition as

(21) $$\bar{v} = \frac{\alpha}{\varpi_C \eta L_S}.$$

Proof of this equation is contained in the Appendix.

Assuming that the relative valuation condition from equation (21) is met, entrepreneurial investment in the research sector will not continue unbounded; the labour market resource constraint and rising wages sets an upper limit on the amount of innovative activity undertaken in any one period of time. The rate of product development is determined by the pricing equation (6), the equilibrium market valuation condition in equation (14) and the labour market equilibrium condition in equation (20)

(22) $$\dot{n} = L_S \eta \varpi_C - \frac{\alpha}{v}.$$

Proof of this equation is contained in the Appendix.

To obtain the dynamic financial market valuation placed upon this amount of entrepreneurial activity, it is necessary to combine the formulae for the intertemporal consumption maximisation (4), the average profit return (12), and the no arbitrage condition (13)

(23) $$\dot{v} = \rho v - \frac{1-\alpha}{n}.$$

Proof of this equation is contained in the Appendix.

The entire system of equations is now formalised into the dual differential equations (22) and (23). This is consistent with the standard Grossman and Helpman (1991) result with the exception that there is now a formal recognition made of natural entrepreneurial ability and the role it plays in determining the rate of innovation. In particular, differences in socio/institutional arrangements have the potential to alter ϖ_C and through this to have a significant influence upon the evolution of $\dot{v}$ and $\dot{n}$ between countries through time. To establish this effect in terms of growth rates, it is necessary to forge a link between innovative activity and GDP. Real GDP is defined as the sum of value-added manufacturing plus R&D

$$(24) \qquad G \equiv p_D D + v\dot{N}.$$

Growth in real GDP in response to innovation is therefore equivalent to the weighted average growth rates in the index of manufactured output and research output

$$(25) \qquad g_G = g\left[\frac{A(1-\alpha)}{\alpha} + (1-A)\right]$$

where A is the weighting applied to the respective indices.

Proof of this equation is contained in the Appendix.

b) General Equilibrium When Financial Markets Posses Imperfect Information Regarding Natural Entrepreneurial Ability: The Appearance of a Speculative Bubble

Following a similar procedure as to what was presented in the case of fully informed financial markets, a minimum market valuation condition must be met before innovation will take place. To establish this, it is necessary to combine equations (6), (17) and (19) to get

(26) $$\bar{v} = \frac{\alpha}{\varpi_C^e \eta L_S}.$$

Proof of this equation is contained in the Appendix.

Assuming that this minimum valuation condition is met, the rate of product development is obtained by combining the pricing equation (6), the equilibrium market valuation condition in equation (17) and the labour market equilibrium condition in equation (20) to give

(27) $$\dot{n} = L_S \eta \varpi_C - \frac{\alpha \varpi_C}{v \varpi_C^e}.$$

Proof of this equation is contained in the Appendix.

The next step is to consider the financial market valuation placed upon entrepreneurial activity. Consistent with the assumption of naive behaviour on behalf of financial markets, the market valuation of entrepreneurial activity under imperfect information is constant at the discounted value of the average profit level. This is obtained by combining the formulae for the intertemporal consumption maximisation (4), the average profit return (12), and the no arbitrage condition (16)

(28) $$v^e(t) = \frac{1-\alpha}{n\rho}.$$

Proof of this equation is contained in the Appendix.

The system of equations is now formalised into just one differential equation and two side conditions. In particular, the constant market valuation expressed in equation (28) contrasts the evolving market valuation under conditions of perfect information expressed in equation (23). Comparing equations (27) with (22) identifies that the difference in the rate of innovation under the two expectational regimes depends crucially upon the aggregate accuracy of assessment of natural entrepreneurial ability *ex-ante* $\left(\varpi_C^e\right)$ in comparison with the true natural entrepreneurial ability *ex-post* $\left(\varpi_C\right)$. In particular, if $\varpi_C^e = \varpi_C$, then equation (27) and (22) are exactly the same. However, if $\varpi_C^e > \varpi_C$ or $\varpi_C^e < \varpi_C$ then the rate of innovation implied by equation (27) is either above or below (respectively) the rate of innovation implied by equation (22). One consequence of the assumed naive behaviour of financial markets is that the rate of innovation under imperfect information exceeds that under perfect information, since $\varpi_C^e > \varpi_C$. Thus the divergence between fundamental and market values not only causes the emergence of a speculative bubble but also a higher growth outcome.[7]

Proposition 3. The traditional argument of the presence of bubbles violating the transversality condition of an optimal savings time path does not apply in this case because the difference between the fundamental value and the expectations driven market price is not explosive.

Proof: see Appendix.

Satisfaction of the transversality condition is possible because the decrease in firm profits from overestimation of ϖ_C, is exactly offset by the rise in consumer utility from more

[7] Note, this 'higher growth' outcome is conditioned on the consumer desire for greater product variety. This intertemporally insatiable appetite for a greater range of products is a particular attribute of the specification of the consumer's utility function in this type of endogenous growth model. The net result? An interesting contradiction to the traditional precepts that speculative bubbles are necessarily all bad – see Yanagawa and Grossman (1993) for instance.

products entering the market. This leaves the spillover effect (and the subsequent rise in η) as a net gain to society, hence the higher growth outcome. Furthermore, since the overestimation of ϖ_C is constant, the speculative bubble never bursts which ensures the down turn in growth projected by real business cycle models such as Kyland and Prescott (1982) never materialises.

III CONCLUSION

It was the purpose of this paper to explore the implications of heterogenous entrepreneurial ability upon economic growth. It was established that psychological/genetic factors may be an important generator of interpersonal differences in entrepreneurial ability, largely in response to the nuances of birth. To explain between economy differences, it is necessary to explore socio/institutional disparities between countries. In this respect, the model contributes to the growing field of study which focuses on the implications of societal/institutional arrangements on the pace of growth. Further extensions of the heterogeneity concept could be made regarding the potential for different socio/institutional regimes to contribute to 'rent-seeking' versus productive entrepreneurialism as consistent with Murphy, Shleifer and Vishny (1991). This is an area of possible fruitful research.

The paper described how the sum total of societal/psychological/genetic effects will compose the basis of each individual's 'natural' entrepreneurial resource constraint. Determination of individual natural entrepreneurial ability was identified to be a major problem for financial markets. Assuming that financial markets have no knowledge of an individual's natural entrepreneurial ability and they cannot accurately make projections of future rates of innovation (and thus the future rates of return on entrepreneurial equity), the paper therefore argued that financial markets adopt a heuristic rule-of-thumb approach of extrapolating current rates of average profit return on entrepreneurial equity into the future. This resulted in the emergence of a speculative bubble but, because of spillover effects from a higher rate of innovation, there was a net gain to society from naive financial market behaviour. It was established that since the speculative bubble was perpetuated to infinity, there was no subsequent downturn in the higher growth outcome. This result was reliant upon the simple expectations behaviour attributed to the financial sector. Future extensions of the model presented in this paper could examine the introduction of more complex financial market assessments of natural entrepreneurial ability including the introduction of search costs and ability signalling game theoretic frameworks.

APPENDIX

Proof of equation (4): Solution for the Maximisation Condition of the Representative Agent

Part (i): Solution for the Instantaneous Aggregate Demand Function

Using a similar approach to Helpman and Krugman (1985), the representative consumer's utility maximisation problem is identified below.

(A.1) $$Max D = \int_0^n x(j)^{\alpha} dj \qquad 0 < \alpha < 1$$

subject to

(A.2) $$E = \int_0^n p(j)x(j)dj \, .$$

This maximisation problem is solved in two stages. Firstly, the First Order Condition (FOC) for solving the representative consumer's maximisation problem for the individual product *(j)* is

(A.3) $$x(j)^{\alpha-1} - \lambda p(j) = 0.$$

Rearranging gives

(A.4) $$x(j)^{\alpha-1} = \lambda p(j).$$

Secondly, it is necessary to consider instantaneous maximisation in terms of the *entire* range of products, *n*. Assuming each firm's output is independent of total expenditure *(E)*, the individual product FOC identified in equation (A.4) can be respecified using the elasticity of substitution relationship $\varepsilon = 1/(1-\alpha)$ and the sum of the efficient rates of production for each atomistic producer of individual quantities, $Dx(j)$. This gives

(A.5) $$D^{-1/\varepsilon} x(j) = \lambda p(j).$$

Solving for *D* gives

(A.6) $$D = \left(\frac{\lambda}{x(j)}\right)^{-\varepsilon} p(j)^{-\varepsilon}.$$

Now the budget constraint needs to be respecified to reflect the *marginal* benefit for each *additional* product relative to its cost. This is identified as

(A.7) $$E = \int_0^n p(j')dj'D.$$

Using the FOC identified in equation (A.6) and substituting this result into equation (A.7) gives

(A.8) $$E = \int_0^n p(j')^{1-\varepsilon} dj' \left(\frac{\lambda}{x(j)}\right)^{-\varepsilon}.$$

Solving for $\left(\frac{\lambda}{x(j)}\right)^{-\varepsilon}$ gives

(A.9) $$\left(\frac{\lambda}{x(j)}\right)^{-\varepsilon} = \frac{E}{\int_0^n p(j')^{1-\varepsilon} dj'}.$$

Substituting this result into the aggregate demand curve represented in equation (A.6) gives the instantaneous consumption maximisation solution in terms of both the individual product and maximisation over the entire range of products. This is represented as

(A.10) $$x(j) = \frac{Ep(j)^{-\varepsilon}}{\int_0^n p(j')^{1-\varepsilon} dj''}.$$

Part (ii): Solution for Intertemporal Consumption Maximisation

Assuming consumers can borrow or lend freely at the instantaneous interest rate $r(\tau)$, the representative consumer endowed with one unit of labour maximises the intertemporal consumption maximand

(A.11) $$U_t = \int_t^{\infty} e^{-\rho(\tau - t)} \log D(\tau) d\tau$$

subject to an intertemporal budget constraint of the form

(A.12) $$\int_t^{\infty} e^{-[R(\tau)-R(t)]} p_D(\tau) D(\tau) d\tau \leq \int_t^{\infty} e^{-[R(\tau)-R(t)]} w(\tau) d\tau + W(t) .$$

where p_D represents an 'ideal' price index of equilibrium prices for the basket of goods consumed in instantaneous equilibrium at each point in time and is approximated by $p_D = \left[\int_0^n p(j)^{1-\varepsilon} dj \right]^{1/(1-\varepsilon)}$. This assumes that indirect utility is weakly separable in the level of spending and the ideal price index.

In equation (A.12) $R(\tau) \equiv \int_0^{\tau} r(s) ds$ represents the discount factor from time *0* to time τ, $p_D(\tau)$ denotes the ideal price index at time τ, *w* is the weighted average wage rate between educated and non-educated individuals, while *W* is asset wealth. This budget constraint may be simplified by remembering that labour is the only input into the production process and identifying that the wealth variable drops out with aggregation because loans (equities and bonds) are effectively only between households; there is no saving by firms. This gives the revised budget constraint of

(A.13) $$\int_t^{\infty} e^{-[R(\tau)-R(t)]} p_D(\tau) D(\tau) d\tau .$$

Solving for intertemporal consumption maximisation gives

(A.14) $$e^{-\rho(\tau-t)} \frac{1}{D(\tau)} - \zeta e^{-[R(\tau)-R(t)]} p_D(\tau) = 0$$

where ζ is the lagrangean multiplier. Rearranging gives a FOC for intertemporal consumption maximisation of

(A.15) $$\frac{e^{-\rho(\tau-t)}}{D(\tau)} = \zeta(t)e^{-[R(\tau)-R(t)]}p_D(\tau) \qquad \text{for all } \tau \geq t.$$

This equates the marginal utility of consumption at time τ (perceived at time *t*) with the discounted value of the cost of this unit of the consumer goods at time τ. The determining variables on the LHS and the RHS of the FOC are ρ and r (respectively). Subsequently, a necessary condition for intertemporal equilibrium in consumption is that spending must grow at an instantaneous rate equal to the difference between the interest rate and the subjective discount rate

(A.16) $$\frac{\dot{E}}{E} = r - \rho.$$

One problem with this solution to the intertemporal utility maximisation problem is that it is dependent upon nominal prices equating to real prices at every unit of time. The subjective discount rate is assessed in real terms but the interest rate is measured in nominal terms. Nothing pins the price down at any point in time so it is necessary to set the time path for one nominal variable and measure prices at every moment against the chosen numeraire. For simplicity, the evolution of nominal spending with respect to time is normalised so that at every moment nominal spending remains constant, thus

(A.17) $$E(t) = 1 \quad \textit{for all } t.$$

Given this, the intertemporal consumption equilibrium condition which was identified in equation (A.16) can now be interpreted as

$$\text{(A.18)} \qquad r(t) = \rho \quad for \;\; all \;\; t.$$

Proof of equation (12): Derivation of Rate Operating Profit for Each Brand

Since *x(j)p(j)* is total expenditure, then from equation (11) gives

$$\text{(A.19)} \qquad \pi_T = E - wx(j).$$

Rearranging equation (6) gives

$$\text{(A.20)} \qquad w = \alpha p(j).$$

Multiplying both sides of equation (A.20) by $x(j)$ gives

$$\text{(A.21)} \qquad x(j)w = \alpha p(j)x(j).$$

Using the normalisation condition *E=p(j)x(j)=1* gives

$$\text{(A.22)} \qquad wx(j) = \alpha.$$

Substituting this result into (A.19) and remembering n is the total number of innovations that have taken place, gives an average profit per innovation of

(A.23) $$\pi_A = \frac{1-\alpha}{n}.$$

Proof of equation (21): Derivation of Minimum Market Valuation Boundary Condition for Innovation Under Perfect Information

Assuming all labour is engaged in production and rearranging the labour demand function for the production sector identified in equation (19) gives

(A.24) $$p(j) = 1/L_S$$

Combining this result with the equilibrium price condition identified in equation (6) gives the wage function for producers of existing products as

(A.25) $$w = \frac{\alpha}{L_S}.$$

Substituting this result into the market valuation stability condition identified in equation (14) and converting to the aggregate level gives the market valuation for maintaining production of only existing products as

(A.26) $$\bar{v} = \frac{\alpha}{\varpi_C \eta L_S}.$$

Proof of equation (22): Derivation of the Rate of Innovation Per Unit of Time Under Perfect Information

Rearranging the labour market equilibrium condition identified in equation (20) to a form consistent with the rate of product innovation gives

$$\dot{n} = L_S \eta \varpi_C - \frac{\eta \varpi_C}{p}. \tag{A.27}$$

Substituting the equilibrium price condition identified in equation (6) into (A.27) gives

$$\dot{n} = L_S \eta \varpi_C - \frac{\alpha \eta \varpi_C}{w}. \tag{A.28}$$

Rearranging the equilibrium market valuation condition identified in equation (14) so that it is expressed in terms of *w*, and substituting into (A.28) gives

$$\dot{n} = L_S \eta \varpi_C - \frac{\alpha \eta \varpi_C}{v \eta \varpi_C}. \tag{A.29}$$

Removing common elements in the numerator and denominator of (A.29) gives

$$\dot{n} = L_S \eta \varpi_C - \frac{\alpha}{v}. \tag{A.30}$$

Proof of equation (23): Deriving the Market Valuation Placed upon Innovation Activity Under Perfect Information

Rearranging the equilibrium capital market condition identified in equation (13) gives

$$\dot{v} = rv - \pi_A. \tag{A.31}$$

Substituting the average profit return identified in equation (12) into (A.31) gives

(A.32) $$\dot{v} = rv - \frac{1-\alpha}{n}.$$

Substituting the intertemporal consumption maximisation condition identified in equation (4) into (A.32) gives

(A.33) $$\dot{v} = \rho v - \frac{1-\alpha}{n}.$$

Proof of equation 25: Derivation of GDP Growth Rate

From equation (3), product innovation of the magnitude g results in an improvement in the consumer utility index of the magnitude

(A.34) $$g_D = \frac{g(1-\alpha)}{\alpha}.$$

The rate of growth of research output is simply g. Combining g_D with g gives the changes in each respective index, but to obtain the overall impact on real GDP, both g_D and g must be weighted by their respective contributions to the real GDP outcome. Using the definition for real GDP identified in equation (24), this weighting mechanism for the index of manufactured output is

(A.35) $$A = \frac{p_D D}{\left(p_D D + v\dot{N}\right)}.$$

Applying this weighting mechanism to g_D and g gives

(A.36) $$g_G = Ag_D + (1-A)g \, .$$

Substituting (A.34) into (A.36) and rearranging gives

(A.37) $$g_G = g\left[\frac{A(1-\alpha)}{\alpha} + (1-A)\right].$$

Proof of equation (26): Derivation of Minimum Market Valuation Boundary Condition for Innovation Under Imperfect Information

Assuming all labour is engaged in production and rearranging the labour demand function for the production sector identified in equation (19) gives

(A.38) $$p(j) = {}^{1}\!/\!_{L_S}$$

Combining this result with the equilibrium price condition identified in equation (6) gives the wage function for producers of existing products as

(A.39) $$w = \frac{\alpha}{L_S}.$$

Substituting this result into the market valuation stability condition identified in equation (17) and converting to the aggregate level gives the market valuation for maintaining production of only existing products as

(A.40) $$\bar{v} = \frac{\alpha}{\varpi_C^e \eta L_S}\, .$$

Proof of equation (27): Derivation of the Rate of Innovation Per Unit of Time Under Imperfect Information

Rearranging the labour market equilibrium condition identified in equation (20) to a form consistent with the rate of product innovation gives

(A.41) $$\dot{n} = L_S \eta \varpi_C - \frac{\eta \varpi_C}{p}.$$

Substituting the equilibrium price condition identified in equation (6) into (A.41) gives

(A.42) $$\dot{n} = L_S \eta \varpi_C - \frac{\alpha \eta \varpi_C}{w}.$$

Rearranging the equilibrium market valuation condition identified in equation (17) so that it is expressed in terms of *w*, converting to the aggregate level and substituting into (A.42) gives

(A.43) $$\dot{n} = L_S \eta \varpi_C - \frac{\alpha \eta \varpi_C}{v \eta \varpi_C^e}.$$

Removing common elements in the numerator and denominator of (A.43) gives

(A.44) $$\dot{n} = L_S \eta \varpi_C - \frac{\alpha \varpi_C}{v \varpi_C^e}.$$

Proof of equation (28): Deriving the Market Valuation Placed upon Innovation Activity Under Imperfect Information

Rearranging the equilibrium capital market condition identified in equation (13) gives

(A.45) $$v^e(t) = \frac{\pi_A}{r}.$$

Substituting the operating profit condition identified in equation (12) into (A.45) gives

(A.46) $$v^e(t) = \frac{1-\alpha}{nr}.$$

Substituting the intertemporal consumption maximisation condition identified in equation (4) into (A.46) gives

(A.47) $$v^e(t) = \frac{1-\alpha}{n\rho}.$$

Proof of Proposition 3: Satisfaction of the Transversality Condition

To illustrate that the presence of a speculative bubble in this model does not violate the transversality conditions, the Hamiltonian condition under the assumption of imperfect information on behalf of financial markets is

(A.48) $$H(t) = \ln E(t) - \ln p_D(t) + \lambda\left[r(t)W^e(t,\tau) + w(t) - E(t)\right].$$

The first order conditions are

(A.49) $$\frac{\partial H(t)}{\partial E(t)} = 0$$

and

(A.50) $$\frac{\partial\lambda(t)}{\partial t} = \lambda(t) - \frac{\partial H(t)}{\partial W^e(t,\tau)}.$$

The corresponding transversality condition is

(A.51) $$\lim_{t\to\infty} e^{-\rho t}\lambda(t) \geq 0 \quad \text{and} \quad \lim_{t\to\infty} e^{-\rho t}\lambda(t)W^e(t,\tau) = 0.$$

Since *E(t)=1* in the model $\forall t$, then $\lambda(t)=1$, $\forall t$. Furthermore, since $W^e(t,\tau) = v^e(t,\tau)n(t) = (1-\alpha)/\rho$ is constant, then the verification of the transversality condition is straightforward with

(A.52) $$e^{-\rho t}\lambda(t) = e^{-\rho t} \geq 0, \qquad \forall t$$

and

(A.53) $$e^{-\rho t}\lambda(t)W^e(t,\tau) = e^{-\rho t}\frac{1-\alpha}{\rho} \to 0 \qquad \text{when } t \to \infty.$$

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