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Irrational Exuberance, Entrepreneurial Finance and Public Policy*

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Abstract

Unrealistic optimism is a well documented phenomenon. This paper argues that it is important in many economic contexts. Focussing on start-up finance for businesses, optimism may be responsible for or consistent with features such as credit rationing or redlining that are normally taken as symptoms of under-provision of finance requiring intervention to expand lending. Optimism leads to the opposite conclusion, at least if it is legitimate to use fiscal policy to counteract systematic error. The paper reports on an experiment in which, due to optimism, the lower the prizes to entrepreneurial activity the higher the subjects income.

"The overweening conceit which the greater part of men have of their abilities is an ancient evil remarked by the philosophers and moralists of all ages......The chance of gain is by every man more or less overvalued and the chance of loss by most men undervalued and by scarce any man valued more than it is worth."

Adam Smith (1776)

"...there must come into play the diversity among men in degree of confidence in their judgement and powers and disposition to act upon their opinion to "venture"..."

Frank Knight (1921)

1. Introduction

There is considerable consensus among economists and policy makers that there is failure in the market for loans, especially those for new businesses. Even more remarkably, there is agreement about the direction of the failure: lending should be increased from the laissez-faire level. This paper challenges this view, invoking ideas from The Wealth of Nations. Adam Smith was convinced that entrepreneurs display the trait for which modern psychologists have coined the pleonasm 'unrealistic optimism'. Most entrepreneurs overestimate their chance of success. If unrealistic optimism is indeed pervasive, policies which encourage lending are called into question. Should governments really be luring people to ruin themselves?

Economists typically sidestep such issues by assuming that individuals are the best judges of their own interests. Burgeoning evidence of numerous cognitive biases make this a questionable foundation for welfare economics. Only recently has there been sustained discussion of the normative implications of self-harm and mechanisms to discourage it (see e.g. O'Donoghue & Rabin, 2003; Camerer et al., 2003; Sunstein & Thaler, 2003). This paper focuses on the public finance implications of a well documented bias with potentially important consequences.

Most economists have an instinctive distrust of "paternalistic" intervention. Demonstrating that systematically irrational private behavior prevails is certainly not enough to justify corrective policy. The danger lies in providing governments with a ready made excuse to adopt corrupt and destructive policies based on unsubstantiated hunch. Even if politicians are not self seeking they too may be prone to unrealistic optimism in believing that they can improve matters (Glaeser, 2003). A reasonably innocuous policy recommendation is that accurate information should be provided so as to allow "correct" choices to be made. Yet the reasons that lead to initial error may make people immune to education, as the experimental results reported here do indeed suggest.

The perspective of this paper is that identifiable cognitive biases create distortions which may be much the most important source of efficiency loss in the economic system. In remedying the efficiency problem the standard theory of tax/subsidy policy is in principle applicable. The implication is that start-up finance should be taxed. We go no further than advocating that subsidies are withdrawn, thereby avoiding slippery slope arguments.

Even to go this far represents a major change in government policy. In the US, the Small Business Administration (SBA), a government agency, has provided loan guarantees to small businesses since 1953. In 1997 Congress passed an SBA funding bill providing over $50 billion for the SBA's business loan programs.[1]

It is not just the US. Most governments think it meritorious that more people set up new businesses. The UK Government has announced "A new drive to boost the enterprise culture, encourage more people to set up their own business and reduce the barriers facing start-up firms ...particularly [amongst] under-represented groups, such as women, ethnic minorities and [in] disadvantaged parts of the country." (Department of Trade and Industry, 2002a). The European Commission has recently published a Green Paper on "Entrepreneurship in Europe" (2003). The aim is to encourage more people to become entrepreneurs. Entrepreneurship is seen as "first and foremost a mindset" (p.5) although the importance of unrealistic optimism is not mentioned. Psychology aside, it is reported that "Access to finance remains a major barrier for new entrepreneurs" (p. 11) and schemes to overcome this, such as the UK Governments Loan Guarantee Scheme to small businesses, are praised. The latter scheme is set to back some 5000 loans per year, targeted towards borrowers that banks would otherwise have rejected (Department of Trade and Industry, 2002b)

Policies of this sort reflect a view that "...lack of capital holds back millions of potentially entrepreneurial people in the industrial countries." (Blanchflower et al.,2001, p690). Economists' support for intervention is much influenced by theories of informational frictions in credit markets. Most notably, Stiglitz and Weiss (1981) explained credit rationing on the basis of asymmetric information. Their story is that if banks increase interest rates too much, bank lending may become less profitable. There are two reasons for this. As interest rates rise, entrepreneurs with safe projects tend to be the first to drop out. A safe project is solvent in most states, so the expected realised cost to the entrepreneur of the extra repayment is high. Risky projects with a small chance of yielding the entrepreneur a bonanza typically have higher chances of complete failure. The high default probability

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[1] In addition the Community Reinvestment Act provides banks with incentives for lending to small businesses in low-income areas.

means the expected cost to the entrepreneur of an interest rate rise is low. So, if entrepreneurs are approximately risk neutral, banks unable to judge whether an entrepreneur has a risky or safe project will find that beyond a certain point expected repayments fall as the interest rate increases. Reinforcing this selection effect is an incentive effect. Suppose all entrepreneurs are identical but once they are granted a loan, they have a choice whether to implement a safe or a risky project. The bank knows this option exists for the entrepreneur but can do little to effectively monitor the choice. It could be that very risky projects deliver lower expected gross revenue but that does not prevent rational entrepreneurs from picking them. As previously explained, the risky projects have lower expected repayments so may be more advantageous to the borrower even though they also have lower expected returns. Moreover, the difference in the expected repayment between a safe and a risky project is greater when interest rates are high. As a result, higher interest rates may induce borrowers to switch to riskier projects. This increases the banks' default rate, perhaps by so much that their expected repayment eventually falls as rates rise.

Consider now the interest rate that maximises the banks' expected revenue per loan. There will be an associated rate that if paid to depositors results in the banks just breaking even. Yet if the banking system faces an upward sloping supply of deposits there may not be enough funds forthcoming to make loans to all the entrepreneurs applying. In response to excess demand it is usually profitable for sellers to raise price. Not so here. The selection and incentive effects mean that an increase in the interest rate lowers bank profitability (so too would a reduction in the interest rate). Banks therefore make as many loans as they can, randomly selecting which entrepreneurs receive them. This is the famous credit-rationing result. Applicants denied credit are nearly all willing to pay higher than quoted interest rates and as a group are no different to those obtaining funding.

There has been little evidence of credit rationing in this sense (e.g. Berger and Udell, 1992 and Parker, 2002) but redlining, a related phenomenon, is widespread. Suppose that it is possible to observe that an individual belongs to a group, say those living in a particular area. The bank cannot tell much about the characteristics of individual loan applicants but does know the distribution of characteristics of those in the area. It is therefore possible to draw up a group-specific relationship between the interest rate charged by the banks and the expected revenue per loan. As before, selection and incentive effects may mean that the relationship is not monotonic and at its turning point the expected return per loan may not be enough to allow the banks to attract depositors. If so, no one applying from this area may be granted a loan. They are "redlined". Those living in an adjacent area may have a slightly more profitable distribution of characteristics,

good enough to bring the maximum revenue per loan above the cost of granting it. So, in the first area it is impossible to get a loan at any interest rate but in the second, only minimally different in the composition of borrowers, loans may be available at quite low rates. Moreover, in the redlined zone, the expected surplus per applicant at the maximising interest rate may be large. So if the group is only just redlined, a negligible financial subsidy can generate considerable welfare gain. This redlining analysis does not depend on the supply of deposits being upward sloping.

The observable characteristic could be wealth rather than geographical area. There is an incentive for entrepreneurs to provide maximum self-finance or post all available assets as collateral. Doing so limits moral hazard which brings down interest rates more than proportionately. In addition, entrepreneurs with safe projects are willing to accept a smaller cut in the interest rate for a given increase in self-finance. So self-finance is a signalling device and not investing own wealth in the project is a poor message to send to the bank. The redlining analysis can therefore be applied to groups identified by wealth (which is posted as collateral). It is not that low-wealth borrowers are charged more for finance it is simply unavailable to them.[2]

There is a host of evidence consistent with redlining on the basis of wealth. Holtz-Eakin et al. (1994a, 1994b), Evans and Leighton (1989), Blanchflower and Oswald (1998) and Evans and Jovanovic (1989) among many others, find that wealth increases the propensity to become self-employed, even after controlling for the possible correlation between entrepreneurial ability and wealth. Bond and Townsend (1996) report that in a low-income, primarily Mexican neighborhood in Chicago, only 11.5 percent of business owners financed their start-up with a bank loan, while 50 percent of the respondents financed their start-up entirely out of their own funds.

The widespread practice of credit scoring is direct evidence of redlining with respect to other factors. Banks attach weights to individual characteristics and only grant loans if the overall mix is sufficiently good. In most places it is illegal to use characteristics such as race or gender but it remains controversial whether this occurs in practice (e.g. Munnell, et. al. 1996, Blanchflower et. al. 2003; Ross and Tootell, 2004).

The now standard theory thus accounts for some of the key facts of credit markets and provides a justification for intervention on efficiency grounds.[3] Part of the appeal

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[2]Of course lower wealth requires larger loans, but raising the repayment in proportion does not bring in compensating revenue. First, moral hazard is greater. Second, with less of their own wealth at stake, lower-quality entrepreneurs apply. So a high-wealth group that it is just viable to lend to is no longer so if its members experience a fall in wealth.

[3]It is not always true that asymmetric information leads to under-lending. De Meza and Webb (1987)

of the model is that remedial policies designed to bring excluded groups into the market are likely to yield distributional as well as efficiency gains. Yet if optimism replaces rational expectations, all the policy conclusions change. The observational properties of the model are unchanged; credit rationing, redlining and related phenomena still arise. The difference is that entrepreneurs wanting loans but failing to obtain them may be better off than those receiving loans. Policies directed towards increasing lending, in particular those focussed on excluded borrowers, such as loan guarantee schemes may be particularly harmful.

The next section of the paper reviews psychological evidence for unrealistic optimism and findings which suggest that it is important in entrepreneurial settings. Then a model is built which justifies our claims concerning the positive and normative implications of optimism. This shows that taxing lending may directly raise welfare and that a statutory exemption on the assets that can be claimed by the creditor in the event of default may be beneficial. Section 4 contains a summary of an experimental credit market in which the extent and implications of optimism can be precisely determined. The gains from discouraging lending are large and selection effects are inconsistent with standard models. Subjects act on their beliefs but their beliefs are unrelated to the truth. This may also help to explain recent difficulties in finding evidence of asymmetric information in insurance markets. Finally, conclusions are drawn.

2. The Psychology of Optimism

2.1. The Meaning and Measurement of Unrealistic Optimism

"According to popular belief, people tend to think that they are invulnerable. They expect others to be victims of misfortune, not themselves" (Weinstein 1980, p. 806). This hopeful outlook on life implies "an error in judgement" which Weinstein called unrealistic optimism or optimistic bias. The terms unique invulnerability (Perloff, 1983) and positive illusions (Taylor and Brown, 1988) are also applied to describe similar phenomena. What is referred to is an underestimation of the likelihood of experiencing negative events and an overestimation of the probability of experiencing positive events. Put alternatively, expectations are irrational so the mean forecast error is significantly different from zero.

show that if entrepreneurs differ in ability rather than intrinsic risk there is too much lending. In a pooling equilibrium the able types cross-subsidise the less able who are consequently induced to enter though they would not do so under full information. When moral hazard is added this overlending result is consistent with credit rationing and wealth dependency of lending (de Meza and Webb 1999, 2000).

The evidence is that optimistic biases are robust and widespread whilst pessimistic biases are relatively rare.

Unrealistic optimism is then distinct from risk preference, the willingness to take gambles at given odds. Furthermore, being unrealistic optimistic, is not the same as being overconfident. The latter is also a positive illusion, but it refers to an excessive precision in forecasting, i.e. confidence intervals are too narrow.

The direct measure of unrealistic optimism is (minus) the difference between an individual's subjective estimate of the probability of a (bad) good event occurring and the true value of the probability. Few psychological studies attempt to measure unrealistic optimism, firstly, because of the difficulty in determining the accurate probability for a particular individual and secondly, because of the difficulty individuals have in understanding and providing probabilities (Gigerenzer, 2002; Weinstein & Klein, 1996). Instead, the usual approach is to investigate whether people think an event is more or less likely to happen to them than to their peers; a comparative rather than absolute measure.

A vast amount of evidence supports the existence of optimistic biases. Among many other positive events, most students think they have a better chance than their peers of liking a job, owning their own home, and having a high starting salary. Drinking problems, suffering a heart attack before age 40, divorce a few years after marriage, being fired from a job and not finding another within 6 months are all rated as more likely to occur to others in their peer group (Weinstein, 1980). Typical is the finding of Guthree, Rachlinski and Wistrich, 2001, that in a gathering of US judges 90% thought their decisions less likely to be reversed than the median reversal probability of those present. The optimistic biases are not limited to questionnaire responses concerning remote events, but are also present in real, immediate and visually vivid risky situations, such as novice bungee jumpers who perceive their own risk of injury to be less than the risk of the typical bungee jumper (Harris et al., 1996). Evidence also exists on men who have tested seropositive for the HIV virus who are actually more optimistic about not developing AIDS than men who have tested seronegative for the virus (Taylor et al., 1992). Similarly, studies aimed at analyzing the progress of the degree of optimism after an experience with a stressful event (such as earthquakes or exposure to intense radiation) show that the positive illusion that the stressful negative event is more likely to happen to others than to oneself tends to return after a relatively short period of time (Burger and Palmer, 1992).

Despite its potential importance for policy, there is much less research on absolute optimism. Fischoff Slovic and Lichenstein (1977) and Lichtenstein, Fischhoff and Phillips, (1982) find people considerably over-estimate the probability their answers are correct by some 50%. Weinstein et al. (1996) examined the accuracy of personal risk estimates

of college students for hazards such as pneumonia, suicide, motor vehicle accident, divorce, obesity, and pregnancy. Optimism was the norm. Strecher et al. (1995) report on 2,785 patients completing a questionnaire including a health risk appraisal and questions regarding smoking behaviour and perceived health risks of heart attack, cancer, and stroke. While most smokers accurately perceived their health risks to be greater than non-smokers, smokers were also more likely to underestimate their health risks.

2.2. Determinants of optimism

Weinstein's (1980) pioneer study examined a range of positive and negative real life events that might occur sometime in the future to determine the extent of optimistic biases and the conditions under which they occur. It seems that two conditions must be fulfilled for the optimistic bias to arise: (1) the event is perceived as controllable (i.e. there are things one can do or contemplate doing to influence the event) and (2) people have some degree of commitment or emotional investment in the outcome. In both cases the desire to protect self-esteem may be at work.

In addition to these self-serving biases, there are other systematic errors that give rise to optimism in identifiable circumstances. There is evidence (Weinstein et al., 1996) supporting Kahneman and Slovic's theories on people's tendencies to overestimate small probabilities and to underestimate large ones. When the events in question are respectively good and bad, optimism is the result. Furthermore, Weinstein (1980) finds that unfamiliarity with a contingency breeds optimism with the correlation stronger for negative hazards.

Straightforward cognitive error is a further source of optimism. Most people taking psychometric tests know they are noisy. Even with no prior view of how they differ from the population they take their actual score as the best point estimate despite scores above the mean being more likely to be biased upwards and those below downwards. Such base rate neglect leads people with above average experience to be optimists (de Meza and Southey,1996 Landier and Thesmar, 2003).

2.3. Entrepreneurial optimism

The factors just discussed suggest that business start-ups are incubators of optimism. Firstly, entrepreneurs typically have most of their personal wealth tied up in the business so that their degree of commitment or emotional investment in the outcome is extremely high and hence they tend to be especially optimistic about the result. Secondly, individuals are more optimistic about outcomes they believe are under their control and setting

up a business is certainly an activity in which an illusion of control is likely to be felt. Thirdly, there is evidence that people tend to overweight unlikely events and underweight likely ones (e.g. Gonzalez and Wu, 1999). As only some 30% of new businesses make it through 5 years, failure is a high-risk event and so one would expect positive illusions to be widespread. Finally, since starting a new business is inevitably uncharted territory there is scope for unchecked fantasizing and optimism is more likely.

Positive illusions do indeed seem to impact on economic decision making in general[4], and in the entrepreneurial setting in particular. Here we summarize some relevant findings on start-ups.

There is striking evidence on the discrepancy between financial returns to self-employment and to paid employment, yet entrepreneurs are not dissuaded. The U.S. Small Business Administration (1997) found that one-sixth of self-employed individuals earn less than the minimum wage. On the face of it this might reflect people being forced into self-employment due to low skills. Hamilton (2000) shows though that even controlling for a wide variety of characteristics, entrepreneurs enter and persist in business despite the fact that they have both lower initial earnings and lower earnings growth than they could have achieved in paid employment. It is unlikely this is due to selection effects since the prior wage distribution of those becoming self-employed does not appear to be significantly different from that of paid employment stayers. Nonpecuniary benefits could be part of the explanation but entrepreneurs are sacrificing substantial earnings lending plausibility to the notion that misperceptions are implicated.

The evidence of Moskowitz and Vissing-Jorgensen (2002) is similar. They find that the return on family businesses is no better than on public equity but the risk is far greater. Unrealistic optimism is one of five possible explanations given by Moskowitz and Vissing-Jorgensen to explain the seemingly perverse exposure to greater risk uncompensated by higher returns.

Looking at innovation by independent inventors, Åstebro (2003) reports even more striking commitment to loss making ventures. The chance of innovations reaching the market is approximately 7%. Of the "lucky" 7%, some 60% realise negative returns and the average realised return among those that commercialise their inventions is minus 7%, even ignoring the cost of the inventor's often enormous effort. Many inventors persist in

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[4]One of the earliest applications of optimism to economics was to corporate takeovers. Roll (1986) argues that hubris on the part of executives of acquiring firms explains why M&As typically destroy value. Malmendier and Tate (2002) test this idea showing that directors in acquiring companies increase their equity stake during M&As despite such stock under-performing the market.

trying to bring their ideas to market despite receiving good advice that the prospect of making money is negligible, calling into question the rationality of entry decisions.

An ingenious experiment by Camerer and Lovallo (1999) sheds light on the implications of optimistic illusions for entry decisions when all that matters is relative performance. Their subjects must choose whether to enter a tournament or take a fixed payment. Fewer participate in the tournament when winners are determined randomly from amongst the entrants than when determined by relative performance on a quiz. Rationality suggests the opposite should occur if people have any information about their relative ability at the quiz. Most subjects who enter think the total profit earned by all entrants will be negative, but their own profit will be positive. When subjects are told that quiz performance will be important excess entry further increases. These self-selected subjects seem to neglect the fact that they are competing with a reference group of subjects who all think they are skilled too ("reference group neglect").[5]

Consistently with these results, in a sample of some 3,000 entrepreneurs, Cooper, Woo,and Dunkelberg (1988) report that 81% believed their chance of success to be at least 70% and 33% believed their chance to be a certain 100%. Only 39% think that any business like theirs is likely to succeed.

Pinfold (2001) reports on the returns actual business founders in New Zealand expect and the level of risk they believe they are taking. His survey shows that in the eyes of New Zealand's entrepreneurs, starting a new business is an attractive proposition: considerable financial rewards coupled with many additional advantages (nonpecuniary benefits such as independence, personal development, and employment). Furthermore, while realizing that there are risks involved, these entrepreneurs tend to underrate the risk and have faith in their personal ability to overcome the odds. They prefer to lay the blame for failure on the incompetence of the participants rather than regarding failure as a likely consequence of inescapable risk. The sampled New Zealand business founders consistently believed the probability of their venture failing to be less than half the historical rate[6] and they estimated rewards that were considerably higher than those obtained by business in general. The survey results show then that the high degree of unrealistic optimism about returns and about the ability to beat the odds provides an explanation for the oversupply of new ventures, which will result in very high rates of failure.

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[5]Larwood and Whittaker (1977) report on students and executives playing a marketing game. Most subjects think their chance of winning exceeds the average but it is not directly shown that these beliefs drive entry.

[6]Entrepreneurs rated the chances of their business surviving its first five years at 75.7%, which was 23.5% higher than they rated the chances of other similar start-ups.

Further evidence on self-employed expectations is supplied by Arabsheibani et al. (2000). They surveyed the answers to the following two questions from the British Household Panel Study:

1. "Would you say that you yourself are better off, worse off or about the same financially than a year ago?"

2. "Looking ahead, how do you think you yourself will be financially a year from now, better than you are now, worse off than now or about the same?"

The authors find that the self-employed expect better financial outcomes than employees but experience worse realizations. For the self-employed the ratio of those making optimistic errors (realization below forecast) to pessimistic errors (realization above forecast) is 2.13 whereas for employees the corresponding figure is 1.55. Somewhat similar results are found by Landier and Thasmar (2003) for a sample of French entrepreneurs.

2.4. The survival value of optimism

Use of systematically wrong probabilities impairs decisions so must optimists eventually be driven out by realists? There are reasons why optimism benefits the individual, at least at some point in evolutionary history. Even in equilibrium, evolution does not necessarily lead to a population of rational agents who revise their beliefs according to Bayes' rule. There may be better uses of limited brain capacity, or there may be a stable equilibrium in which offsetting dysfunctional adaptations survive.

Waldman (1994) shows that the potential stability of second-best adaptations in a world of sexual inheritance provides a possible explanation for why a propensity to systematic error may persist. According to Waldman, the unique first-best adaptation is for males to accurately estimate their own abilities and receive no disutility from effort, nevertheless a second-best adaptation (i.e., an adaptation such that a trait is optimal taking as fixed the value of the other trait) may arise. Consider a male who receives disutility from effort. If this individual estimates his abilities accurately, he would choose an effort level that is smaller than the one that maximizes his accumulation of wealth. Overestimating abilities offsets this "distortion" since, with appropriate functional forms the individual's incentive to apply effort increases. The individual is pushed away from utility maximization and towards wealth maximization.

Bernardo and Welch (2001) invoke group selection.[7] They argue that entrepreneurs buck trends and this is socially valuable. They then show that since groups with some op-

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[7] Sinn and Weichenrieder (1993) discuss biological foundations for risk preferences from this perspective.

timistic individuals have an evolutionary advantage over groups without such individuals this may be enough for the trait to survive.

Optimism may confer private strategic advantages. As we show in Section 3, optimists may apply more effort than realists. This is no bad thing as debt or equity contracts create a moral-hazard problem leading to the undersupply of effort. So if optimism is observable, competitive markets will reward it with higher payoffs. A similar story applies if team production is important. With the contribution of individuals difficult to measure there is a tendency towards free-riding. Optimists, overestimating the effectiveness of their effort, will offset this effect and will thus be more sought after as team members. Again if optimism is identifiable, it need not be a liability. It may be that in hunter-gatherer society, where social groups are small, aspects of character such as optimism become known though optimism is not so well adapted to the larger societies of today. A further evolutionary possibility is that in attracting mates it is important (especially for males) to offer prospects of future material success. Really believing in the truth of claims is the best way to persuade others. Hence, optimism may be a good reproductive strategy even if it actually impairs future material success. If so women's best response is to excel in the psychology necessary to detect false claims.

Somewhat similarly, in competitive situations observable optimism may amount to a precommitment to higher output, an aggressive strategy. As long as rivals are producing strategic substitutes this boosts payoffs. Heifetz & Spiegel (2001) develop an explanation for unrealistic optimism along these lines.

3. Modelling Credit-Market Optimism

This section builds a simple model showing that optimism helps explain the major empirical regularities of business-loan markets whilst turning the usual policy prescriptions on their head.[8] Not only does optimism affect the entry decision, it may also impact on the subsequent running of the business through its influence on strategic decisions and the choice of effort. Overrating the effectiveness of their input creates a substitution effect inducing entrepreneurs' to raise their effort. In addition, there is an analogue of an income effect whereby the entrepreneur believes that their talent is such that only a little input is needed to achieve all that can reasonably be done. The specification chosen here implies

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[8]de Meza and Southey (1996), Niehans (1997), Manove and Padilla (1999) all follow Smith in suggesting that entrepreneurs will be drawn disproportionately from the "super optimists" but address different questions and do not integrate the moral hazard and optimism.

that effort increases (for some evidence that this is the sign of the effect see Landier and Thesmar, 2003). Optimism may also result in the choice of high risk strategies that lower expected returns though this will not be modelled.[9]

It is initially assumed that entrepreneurs are identical in their objective capacities but differ in their optimism. This leads to variations in entry decisions and in effort choices. The case of heterogeneous ability is then discussed.

The structure of the model is that there are many risk-neutral banks and many risk-neutral potential borrowers. Each potential entrepreneur has a project which yields H if successful, zero otherwise. For simplicity, H is independent of the number of successful entrepreneurs, as might be the case when output is sold on the world market or when each entrepreneur serves his own market niche.

The objective success probability, $P(e)$, depends on non-verifiable effort e:

$$P(e) = ae \tag{3.1}$$

where a is a constant representing "ability". Entrepreneurs differ in their opinion on the effectiveness of their effort and perceive their (subjective) probability of success as

$$p(e) = a\lambda e \tag{3.2}$$

where λ is uniformly distributed on $[1, 2]$. So all potential entrepreneurs are optimists but believe themselves to be realists. This formulation implies that effort and optimism are complements i.e. an entrepreneur perceives a higher marginal effect of his effort on his success probability the higher his degree of optimism.

The cost of effort is given by $C(e) = e^2/2$. Each project requires capital input K. Entrepreneurs have initial wealth W ($< K$). External finance is in the form of a standard bank loan. One explanation for debt as the equilibrium form of finance follows from optimism. Suppose project realisation is verifiable. Since every entrepreneur perceives the probability of the H outcome to be greater than does the bank, the equilibrium contract minimises repayment in the H state, a debt contract (see de Meza and Southey,1996, Manove and Padilla,1999, Heaton, 2002, Hackbarth, 2002, and Landier and Thesmar, 2003). Alternatively, if project outcome is not verifiable then equity finance is not possible and the only feasible contract involves a fixed payment D with the bank seizing the entrepreneur's assets if the payment is not made. Despite the publicity attracted by

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[9]Gibson and Sanbonmatsu (2004) find evidence that optimists (as measured by a personality test) persist longer than pessimists in the face of gambling losses and eventually lose more money. This suggests that optimists may wait too long before closing failing businesses.

venture capitalists, empirically, the role of equity in startups is very limited (Bank of England, 2001).

Entrepreneurs post their wealth W $(< K)$ as collateral.[10] If the project fails, the entrepreneur forfeits W minus x, the statutorily protected assets.[11] Banks do not observe individuals' types but do know the frequency distribution of types. If the bank offers a loan, it demands a repayment D if the project succeeds and seizes $W - x(< D)$ if the entrepreneur defaults.

The model is solved explicitly in the Appendix. Here the key properties of the model and their implications are summarised and discussed.

(i) Given D, the substitution effect implies that effort is increasing in optimism. So more optimistic individuals are more likely to succeed, but not to the extent that they believe they will.

(ii) Borrowers' effort is decreasing in the level of protected assets since the stick for failure is then less severe.

(iii) The higher is D the lower is effort since the carrot for success is then smaller. This is the familiar moral hazard effect. Note though that optimism offsets the effort damping of a positive D. It is possible that the more optimistic types supply more than the efficient level of effort.

(iv) The decision to apply for a loan depends on whether the borrowers expected utility evaluated at the subjective probabilities, SU, exceeds non-entry utility,W. Hence, there is a threshold level of optimism above which a loan is applied for.

(v) Beyond some level, further increases in D reduce the expected bank revenue per loan, R. This is due to the moral-hazard effect. Offsetting this is the advantageous selection resulting from the least optimistic and hence lowest effort types dropping out as D increases. Given the functional forms chosen here, R reaches a maximum which is increasing in W and a.

(vi) There is a critical value of W below which, whatever D is chosen, banks cannot earn enough revenue to cover the competitive return on deposits. These borrowers are redlined. If a varies across individuals and is observable then the redlined groups will be those with wealth/ability combinations below some threshold.

(vii) Although there is a threshold wealth below which a group is redlined, above this level it is ambiguous whether entry increases in wealth. When wealth is high there is less

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[10]Equivalently, the entrepreneur invests W directly in the project and borrows $K - W$. Were it costly to liquidate assets the collateral route is strictly preferred.

[11]Optimists would want to escape statutory asset protection by liquidating their resources to provide maximum self finance. Sufficient liquidation costs make this strategy unattractive.

moral hazard. In a competitive capital market these costs are borne by the borrower so reduction of deadweight cost encourages entry. In addition, higher wealth means lower at-risk lending, and as there is pooling across types, the cross-subsidy from the more optimistic to the less optimistic is lessened. As the less optimistic types are the marginal entrants, this discourages entry. The Appendix shows that entry first increases with wealth and then decreases. So in a cross section of individuals, the entry rate of those with high wealth may exceed those with lower wealth. An increase in the mandatory protection of assets from seizure is equivalent in its positive effects to a fall in wealth. Such a change affects all borrowers, so the increase in the numbers entering in the relatively high wealth groups may exceed those exiting from lower wealth groups.

A non-monotonic relationship between start-ups and the assets the state protects from seizure by creditors, is shown empirically by Berkowitz and White (2003), Fan and White (2004). They investigate the impact of variations in homesteading laws between US states. Greater asset protection increases redlining and there is an initial tendency for start-ups to be encouraged. The latter effect is attributed to the benefit of the implicit insurance provided. This explanation fails to account for why, if utility is raised by greater asset protection, a competitive market would not supply the optimal asset protection, at least if, as they assume, agents are rational and well informed.

(viii) Unlike in Stiglitz and Weiss (1981) groups that are redlined are better off out of the market and welfare would be increased further were some further exclusion to occur.[12] Consider a group on the verge of being redlined. The marginal entrepreneur, has SU equal to W but, being optimistic, their objective utility is below W. The intramarginal entrepreneurs are even worse off. This is because expected utility measured at objective probabilities, OU, declines in λ.[13] So, if a group is close to being redlined, every member of it would be better off were they denied loans. Policies can be devised that target redlined groups, such as loan guarantee schemes, but they are invariably designed to bring them into the market rather than exclude them. In this model it would be unambiguously harmful to introduce such a policy.

(ix) Policies that affect all borrowers, not just those close to being redlined, are harder to assess. Consider a non-prohibitive tax on all lending. This increases redlining and the rise in the interest rate causes the least optimistic types from the non-redlined groups to exit. This is all to the good, at least as long as objective utility is the criterion. The

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[12] The criterion is the aggregate realised welfare of the group (equivalently, expected utility evaluated at true success probabilities).

[13] Only realists ($\lambda = 1$) choose effort to maximise OU and as optimists choose higher effort levels, their OU must be lower.

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higher D also discourages effort. Normally this would aggravate moral hazard, but here optimism may result in an excessive level of effort on the part of some entrepreneurs. Thus the tax may also improve matters on this score. As is confirmed in the Appendix, a tax may increase the expected utility of entrepreneurs even if they receive none of the proceeds. Perhaps of more relevance, a subsidy is not only costly for tax payers but lowers the welfare of borrowers.

(x) Varying the level of protected assets also has mixed effects on welfare. Some groups previously eligible for loans will now be redlined by the banks. As already shown, in this model exit is unambiguosly a gain. For groups still able to borrow, an increase in protected assets (equivalent to a fall in wealth) increases repayments and so effort declines offsetting the possibly excess level created optimism. In addition, the increase in protected assets may either raise or lower entry, these effects being respectively good or bad. Even when entry occurs, the overall impact of an increase in protected assets may be to benefit the entrepreneurs, as the Appendix shows.

(xi) Extending the model to encompass heterogeneous ability (unobservable by banks) adds new insights. Start from the case of realistic entrepreneurs. Suppose that at the equilibrium D the threshold ability level above which entry occurs is a^*. Now suppose that some or all of the potential entrants are optimistic. Everyone that entered under realism will still enter, but there will be some extra applicants who wrongly think that their ability is above a^*. If optimism does not affect or lowers effort[14] then the effect of optimism is certainly to lower the quality of lending and depress bank revenue for a given D. Thus optimism may create redlining where it would not be present under realism. Even if optimism raises effort and does not worsen other operating decisions, the fact that it draws in lower-ability types may create redlining.

(xii) Other things equal, an entrepreneur's SU is decreasing in their ability. So with heterogeneous but unobservable ability, there is a tendency for the marginal borrowers in the pooling equilibrium to be of lower ability and hence are less profitable than the intramarginal types. This was shown for rational agents by de Meza and Webb (1987) who conclude that restricting lending, say through a tax, would increase aggregate surplus. Optimism reinforces this tendency in so far as marginal types enter when it is not even in their private interest to do so.[15]

Finally it no longer necessarily follows that redlined groups are better off out of the

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[14]A function with this property is $p = 1 - (\lambda e)^{\eta+1} \ \ \eta < -1$

[15]If ability and optimism are inversely correlated then the marginal borrowers may be the least likely to default. It then follows that the tax on lending should be prohibitive or else there should be a marginal subsidy to raise quality. This is discussed further in the policy section.

market. With heterogeneous types and realism every loan applicant correctly anticipates non-negative expected gains, so it is strictly better that a just redlined group is funded. Adding optimism means that many applicants have negative expected utility measured at objective probabilities. Whether it is efficient to bring in excluded groups depends on the strength of optimism and the diversity of abilities.

To summarise the main results of the model, by inducing the relatively incompetent to apply for funds, optimism may create or increase redlining. Granted that welfare should be measured by expected utility evaluated at objective probabilities (or by realised utility) the implication of optimism is that, even in the presence of redlining, taxing lending will be beneficial and subsidising it harmful. Moreover, increased statutory protection of assets may induce additional entry, a finding that is otherwise difficult to explain, and this may raise welfare.

4. Experimental Evidence of Entrepreneurial Optimism

Though individuals may provide questionnaire answers indicating unrealistic optimism, their motives may be to impress the interviewer or even themselves. When it comes to decisions with financial consequences, cooler judgements may apply. It is difficult though to draw definite conclusions from field data. Observing low average returns to start-ups may be due to misperceptions, mismeasurement, the psychic benefit of being one's own boss, or risk aversion. Experimental methods overcome some of the problems. We now summarise findings from the experiment of Coelho (2003) which allows the effect of optimism to be clearly identified.

The experiment replicates the theoretical model of Section 3 for the case of heterogeneous abilities except there is no explicit moral-hazard dimension.[16] This is also the set up of de Meza and Webb (1987) except their theoretical analysis assumes entrepreneurs are unbiased in estimating their own success probabilities. Combined with the assumption that outside financiers only know the population distribution of abilities the result is over-investment. The experiment tests for the presence of unrealistic optimism and for whether beliefs are even correlated with performance. It turns out that the most important source of welfare loss is not the familiar hidden-types problem but the irrational expectations of the agents normally assumed to have superior private information. These beliefs are so

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[16]Subjects do not know the size of the prize for success till they have played, effectively eliminating moral hazard. Nevertheless optimism and its relation to performance can be detected although credit rationing of the form in the model cannot arise.

off beam as to undermine the selection effects analysed in de Meza and Webb.

4.1. The experimental design

The experiment involves three main parts: (1) subjects play one or two practice rounds of a skill-based task (the "game") (2) they make two sets of payoff relevant choices (3) they play the game for real. Each stage is now described in more detail followed by an italicised commentary on the reasons for the chosen format.

• Subjects first played practice round(s) of a skill-based task for which success and failure are clearly defined. One "project" was counting down 2 minutes within an accuracy of 10 seconds and another was directing a hoop round a wire course without triggering an alarm.

Setting up a business involves the entrepreneur backing themselves to succeed in a challenge involving skill and luck. The experimental tasks embody (in a convenient form) related uncertainties. We considered but rejected using more intellectual tasks. The fact that business success does not appear to be strongly correlated with IQ was not the most important reason for doing so. IQ is often entangled with ego and choices may be driven by a desire to impress the experimenter or avoid embarrassment. Moreover, many subjects may have a good idea of their IQ whereas at the outset people typically have a much less precise idea of their business acumen. The trial rounds provided the subjects with partial information and we were interested to see whether base rate neglect resulted in the pattern of success and failure increasing distortions in the real choices.

In the next part of the experiment, participants had to make two sets of nine choices each. At the end of the experiment, one of the 18 questions was selected at random and the subject's winnings were calculated according to their choices on that question.

•In the first set of nine questions (the first set of questions or FSQs) subjects were asked to choose between receiving a prize of £8 if they succeed in the skill-based task, or £8 with a specified probability P increases across nine options from 10% to 90%.

These questions are designed to measure optimism rather than to directly represent business choices.[17] Since the prizes are the same for the both alternatives choices should be independent of risk preference with the skill-based option selected if the subject considers think their chance of success is at least P. So, the P at which an individual switches from backing their skill to preferring a random payoff measures their (motivated or "implicit") forecast of success in the skill-based task. If subjects are optimists the average success rate of the subjects would be below the average switching P. Even if there is optimism, as long

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[17]Though once a business is underway choices of this sort might arise.

as forecasts to some degree reflect ability, success rates should be increasing in the switch P.

• The second set of choices (the SSQs) required subjects to choose between £4 for sure or a prize of £z (£z varied from £5 to £13 in a set of 9 questions) for succeeding in the skill-based task but with no payment for failure.

The £4 option can be regarded as paid employment, a safe option, and the £z the reward from succeeding in a business venture. In this interpretation the business venture requires external finance and £z is the return after repayment of the loan. Decreasing the interest rate is represented by increasing £z. Assuming that lenders have no information about individuals characteristics (or are not allowed to use their information), everyone is charged the same interest rate. Given a particular equilibrium interest rate, the subjects divide between the two options according to their switch z.

If individuals are rational there will be a threshold value of z above which the skill based option is chosen. Those switching at higher zs are either more risk averse or consider they are less likely to succeed in the task. Risk preferences can be estimated by using the subjective probability of success elicited from the FSQs to evaluate individuals' expected winnings at the switch £z. Under risk aversion, the average winnings of those preferring the skill-based task at a given interest rate will not be less than the safe payment. If risk aversion does not vary with the SSQ switch point then, if beliefs even if biased, are at least positively correlated with performance are, the proportion of those succeeding would fall as the interest rate decreases. The difference between the average winnings of those opting for the skill-based option and the safe alternative of £4 is a conservative estimate of the losses from faulty decisions in the SSQs.

•Finally, subjects played the game for real. Before the FSQs were answered, a randomly selected 50% of the subjects were told the overall success rate and asked to make an explicit forecast of the chance they would succeed at the skill-based task.[18] The remaining subjects were told the overall sucess rate after answering the SSQs and then asked to asked to forecast their own success probability.

4.2. Results

The subjects were 85 LSE students. Table 1 compares the average success rate on the skill-based task with the forecast implicit in the FSQ switch points and with the explicit forecast. There is considerable optimism with forecast of success well in excess of the

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[18]Participants choose from ten options ranging from "between zero and one in a ten chance" to "more than nine in a ten chance".

actual success rate. Although implicit and explicit forecasts averaged across all tasks were close to 50%, this does not seem to reflect an equal ignorance principle. The means were significantly different according to task and there was considerable dispersion within tasks. Moreover, the beliefs revealed in the FSQs were important determinants of the SSQs choices.[19]

Average success rate	27%
Average mid FSQ switch probability	50%
Average lowest FSQ switch probability	45%
Average mid explicit forecast	47%
Average lowest explicit forecast	42%

Table 1

The timing of the explicit forecast question made no significant difference to the relation between the explicit and implicit forecasts.

To check whether subjects acted on their beliefs, the switching zs in the SSQs were regressed on the switching Ps from the FSQs. It can be seen from (4.1) that there is a significant relationship between subjects' perception of their ability to succeed in the skill based task and the minimum prize for which they were prepared to choose this activity (with t-statistics in parenthesis).

$$SSQ = 11.7 - 5.9FSQ \qquad (4.1)$$
$$(26.64)\ (-7.32)$$

$$Adjusted\ R^2 = 0.41$$

To see whether those selecting into the skill based activity are those with a comparative advantage at it, a probit was run of success in the skill activity on the FSQs switch point (standard errors in parenthesis).

$$Success = -0.79 + 0.35FSQ \qquad (4.2)$$
$$(-0.39)\ (0.71)$$

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[19]As the subjects select a probability interval we report results on the basis that point switches were uniformly distributed within the interval (the 'mid' point of the interval) and also if they were clustered at the end point least favourable to optimism.

$$PsuedoR^2 = 0.0024$$

As FSQ is not significant, the implication is that people are not at all self aware. A similar exercise using explicit forecasts rather than implicit forecast yielded the same conclusion. Knowing only that one individual is much more confident that they will succeed than is another is no help in predicting which of them is most likely to succeed.

The results reported to this point suggest that there will be no relationship between the magnitude of the prize required to tempt a subject to back their own ability and their actual performance. Neither adverse nor advantageous selection is present. Those choosing the entrepreneurial activity at high interest rates are just as likely to succeed as those opting for it at low interest rates. It could be the case, though, that the extreme observations have predictive value, but that this gets lost in the full pooling because of uninformed people in the middle of the SSQ switch points distribution. So, a comparison of success rates of the groups with highest and lowest switch £zs was under taken, choosing cut offs to reasonably balance the numbers, was carried out. Results in Table 2 show that the success rates for the two groups in the table are not significantly different and so they confirm the lack of relation between the magnitude of the prize to back own skills and actual performance.

SSQ switch point	% of subjects in each group	Success rate in each group
Below or equal to £7.5	35.1%	29.6%
Above or equal to £10.5	20.8%	25%

Table 2

Subjects requiring the highest prizes to enter the skill activity were slightly less successful on average than those requiring smaller prizes, but the difference is not statistically significant. Thus interest rates do not have a selection effect. As neither advantageous nor adverse selection effects are present, there is no need for policy to offset these sources of market failure. This does not mean that there is no welfare issue. The general tendency to overestimate the chance of success means there is considerable scope for improvements.

Consider the 58% of subjects choosing to back their skill when the prize for succeeding is £8. Their average winnings were some £2.40 whereas they could have had £4 for sure. So eliminating the option to back their skill would have made them financially better off. Before concluding that removing the option would be welfare enhancing at least two objections should be considered.

i) It could be argued the subjects are risk loving and deliberately sacrifice expected income for thrills. However, using the procedure outlined above if anything subjects were risk averse.

ii) Perhaps the subjects enjoy playing the skill game. Of itself that would not give rise to the observed pattern of FSQs and SSQs choices since the game is played irrespective of the answers. There is though the possibility that subjects anticipate that they will feel better if they win through a skill-based option rather than a random device. This would generate FSQs switch points above explicit forecasts of success. The fact that there was no significant difference between mean forecasts and FSQs switch points (whichever of the two was asked first) is evidence against this interpretation. Moreover, even if the lower of FSQs switch point and forecast is used to proxy expectations, substantial optimism remains.

In summary, there is clear evidence that people have exaggerated views of their own ability and act on these beliefs. Moreover, perceptions are uncorrelated with performance, so interest rates have neither an adverse nor advantageous selection effect.

5. Policy

Given that subjects make systematic errors in evaluating the expected returns to the skill-based activity, the least intrusive intervention would be to issue a warning explaining the error and reporting the true mean success rate. The cognitive biases that lead to the error would though quite likely lead to such warnings being ignored. In fact information on overall success rates was provided to half the participants prior to the choices being made and it made no difference to the distribution of the switch points.

Discouraging the skill-based activity through taxation is more drastic. The motive is not to curtail an externality, but because people act on false information.[20] There are at least two obvious dangers. There may be private benefits to the choices that the researcher has missed. Even if this is not so, once the principle of paternalism is accepted the floodgates may be released for all sorts of inappropriate intervention.

As for the first objection, it certainly only makes sense to act when evidence of error is strong. Moreover, the existence of unmeasured benefits from entry leaves the case for intervention unaffected when there is misperception of the chance of success. What is certainly unjustified is to intervene in the "wrong" direction as appears to be the case

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[20]In reality there are often positive externalities to start up success and negative ones to failure. It is not clear where the balance lies.

with present encouragements to set up new businesses. Subsidies make the recipients worse off even before the financial cost is counted. The second objection should of course be taken seriously but already there are many paternalistic policies around, such as the licensing of medicines and doctors, tobacco taxes and seat belt legislation.

Given that fiscal policy is to be used to improve decisions, how in this instance should it be implemented? Irrespective of the SSQs switch point, the subjects have a success rate of around 30%. As private information is no help in predicting success, if any subjects should be excluded from the skill-based activity then all should. Given the numbers in the experiment, only if the value of succeeding in the skill activity is at least £13 are objectively expected earnings a match for the safe alternative. Assuming that there is no externality associated with success, if the market determined prize is below £13, to maximise aggregate surplus it would be best to impose a prohibitive tax. For market determined prizes above this level, even realists would enter, so the displayed level of optimism does not yield any misallocation of activity.

Two features give rise to the all or nothing policy. It has been implicitly assumed that tax revenue is a pure transfer. In fact raising tax revenue from other sources may be distortionary so a rational government will choose the level of public spending so that at the margin it is more valuable than private spending. This premium on tax revenue means that even if entrepreneurs are objectively worse off choosing the skill based activity, it should not be taxed out of existence. Moreover, if there is a positive correlation between beliefs and performance, even with optimism an interior solution for the optimal tax is on the cards. Such a tax drives out the lowest-quality types only drawn in by optimism but higher-quality types that would enter even under realism remain active.

To see the issues, define $F(x)$ as the cumulative distribution function of SSQs switch payoffs. There is a tax of t on the actual success income z. Granted risky debt, this could equally well be a tax per loan or on bank deposits.[21] The true average probability of success of the entrants is $\Pi(z-t)$. A conventional selection effect implies $\Pi' < 0$. The safe payoff is S and α measures the private value of an additional dollar of government spending. Assuming potential entrepreneurs are risk neutral (risk aversion strengthens the tax case), the policy objective is to choose t to maximise

$$W = F(z-t)((z-t)\Pi(z-t) - S) + \alpha t F(z-t)\Pi(z-t) \tag{5.1}$$

$$\frac{dW}{dt} = -F'(z\Pi - S) - F\Pi'z + (\alpha - 1)[F\Pi - t\Pi F' - tF\Pi'] \tag{5.2}$$

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[21] We are assuming the subjects would behave the same when z=10 as when z=12 and t=2.

According to the experimental results, $\Pi z < S$, $\Pi' = 0, F' > 0$, so if $\alpha = 1$ it is optimal to increase the tax till no subjects participate in the skill based activity. If these conditions do not apply, interior solutions are possible. When $\alpha > 0$ the benefit from a tax is initially greater but now the premium on tax revenue means that it may be best to stop short of a prohibitive tax.

6. Conclusions

According to psychologists, optimism is all around. It would be surprising were economic decisions immune to these biases and this paper has surveyed field and experimental evidence suggesting they are not. The vast bulk of public economics analyses the welfare consequences of fiscal policy and other interventions assuming that people take decisions in their own best interests. Hence the justification for policy is distributional or to counteract externalities. To suggest that policy should combat self-delusion is a good deal more controversial. The evidence reported here suggests the problem cannot be sidestepped by supposing that misperceptions are minor or random.

Current policy towards business start-ups is to encourage them. Entrepreneurs' unrealistic optimism is a reason for neutrality. A few good apples may attract all the publicity but this should not divert attention from most of the barrel being bad. Just as Adam Smith observed that the focus on the few high profile successes attracted too many aspiring opera singers, so the same may be true of entrepreneurs. The issue is especially poignant in the case of minority and disadvantaged groups. Policy makers are generally particularly keen that finance should be channelled to people in such categories. The analytical model of this paper indicates that doing so may create a royal road to ruin. In the experiment reducing the prizes for the entrepreneurial activity actually increases the subjects income.

This paper has not tried to judge whether start-ups do confer positive externalities. To the extent that this is the case, there is an argument for subsidies even if optimism is also present. In evaluating the case that new businesses are a good thing in themselves, at least two notes of caution should be taken on board. A common argument, made for example in the EC Green Paper, is that most new jobs are created in start-ups. True, but because start-ups so often fail, a year or two down the line they are also responsible for destroying more jobs than established firms. Moreover the failure of a business is generally bad news for customers and suppliers, negative externalities that are often ignored.

In some respects our modelling of optimism has underemphasised its costs. First, it was supposed that though optimists were excessively keen to set up businesses, the effect

of optimism was to increase effort and so offset the distortions created by the presence of outside financiers. In fact effort may rise by so much due to optimism that, despite the disincentive of debt repayment, it ends up inefficiently high. There is though another dimension by which optimism may have a negative influence (suggested by Kahneman and Lovallo (1993)). Once in business choices must be made between alternative strategies. Optimists will tend to overestimate chances of success so will mistakenly often opt for business strategies involving mean-reducing spreads of payoffs. They will also back options that depend on their own overestimated skill as opposed to relying on the expertise of outsiders. These are forces making the performance of optimists inferior to that of realists.

A second issue is risk aversion. The model assumed risk neutrality and the experiment found this to be a good approximation when the payoffs were reasonably small. With larger payoffs risk aversion may be a more appropriate assumption. Optimists think failure less likely than do the financiers so will continue to prefer contracts that concentrate returns in the success states (de Meza and Southey, 1996) but with risk aversion the cost is that optimists are, objectively, underinsured. Policy should try to offset this. Statutory homestead laws that protect assets in the event of failure and more lenient bankruptcy provisions in general amount to compulsory insurance. This would be an added merit of such legislation. When optimism is taken seriously the rules of public finance must be rethought.

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A. Appendix: Solving the model

An entrepreneur's utility evaluated at subjective probabilities is

$$
\begin{aligned}
SU &= p\left(H - D + W\right) + \left(1 - p\right)x - C(e) = x + p\left(H - D + W - x\right) - C(e) \quad \text{(A.1)}\\
&= x + a\lambda e\left(H - D + W - x\right) - e^2/2.
\end{aligned}
$$

Maximising SU yields effort

$$
e^* = a\lambda\left(H - D + W - x\right) \tag{A.2}
$$

with maximum SU

$$
SU^* = x + \left(\frac{1}{2}\right)a^2\lambda^2\left(H - D + W - x\right)^2. \tag{A.3}
$$

Borrowers' effort is decreasing in the level of protected assets.

The socially optimal effort level, maximising $PH - C(e)$, equals

$$
e^s = aH. \tag{A.4}
$$

Comparing e^* and e^s, notice that optimism offsets moral hazard: the interest payment D ($> W - x$) dampens effort, but this effect may be more than counteracted by optimism, λ.

A potential entrepreneur applies for a loan if $SU^* \geq W$ or

$$
\lambda \geq \lambda_m \equiv \frac{\sqrt{2A}}{a\left(H - D + A\right)} \tag{A.5}
$$

where $A \equiv W - x$. Hence, only the most optimistic individuals, those with λ above the marginal value λ_m, want to enter. Notice that there is an advantageous rather than adverse selection effect of an increase in D. A higher interest rate deters the least optimistic borrowers who have the highest default risks. Nevertheless an increase in D decreases the effort of all entrepreneurs that remain active and this moral hazard effect eventually causes bank revenue to decline in D.

Expected bank revenue from a loan is

$$
r = PD + \left(1 - P\right)A = P\left(D - A\right) + A. \tag{A.6}
$$

Taking into account the applicant self selection, revenue per loan is

$$R = A + (D - A) a^2 (H - D + A) \int_{\lambda_m}^{2} \frac{\lambda}{2 - \lambda_m} d\lambda \tag{A.7}$$

$$= A + a (D - A) \left(a (H - D + A) + \sqrt{\frac{A}{2}} \right)$$

which is concave in D, with turning point at

$$D^* = A + \frac{H}{2} + \frac{1}{2a} \sqrt{\frac{A}{2}} \tag{A.8}$$

and corresponding maximum revenue

$$R^* = A + \frac{1}{4} \left(aH + \sqrt{\frac{A}{2}} \right)^2. \tag{A.9}$$

Increasing the interest rate beyond a certain point, lowers bank revenue. This is not due to adverse selection; as D rises, less optimistic types drop out of the market which increases bank revenue. There is however a moral hazard problem. D acts as a tax on returns so as it increases, the incentive to apply effort is reduced so that the default rate rises.

At the competitive equilibrium, ignoring discounting, $R = K + t$ where t is a lending tax. Solving this zero-profit condition for D gives the equilibrium interest rate

$$D(A) = \frac{1}{2} \left(H + 2A + \frac{1}{a} \left(\sqrt{\frac{A}{2}} - \sqrt{d(A)} \right) \right) \tag{A.10}$$

where

$$d(A) = \left(a (H + 2A) + \sqrt{\frac{A}{2}} \right)^2 + 4ac(A) \tag{A.11}$$

and

$$c(A) = -aA (H + A) - A\sqrt{\frac{A}{2}} + \frac{A - (K + t)}{a}. \tag{A.12}$$

Note that if $d(A) < 0$ there is no lending as all possible interest rates lead to a loss. Groups with As for which $d(A) < 0$ are therefore redlined. It is easy to see that an increase in x (decrease in A) or an increase in t will lead to more redlining. Specifically, redlining occurs when

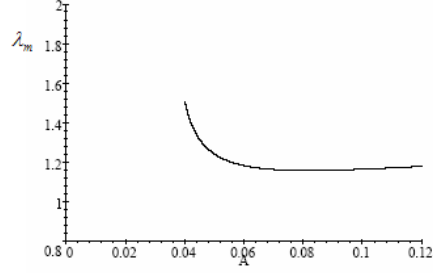$$A < A_r \equiv \frac{2}{81} \left(2\sqrt{9(K + t) - 2a^2 H^2} - aH \right)^2. \tag{A.13}$$

Figure A.1:

Although there is a threshold wealth below which a group is redlined, above this level it is ambiguous whether entry increases in wealth. To illustrate, suppose $H = 0.8, a = 0.5, K = 0.1, t = 0.01$. For these parameter values $d(A) < 0$ for $A < 0.0378$. Potential entrepreneurs with low initial wealth or a high level of protected assets, such that A is below this threshold are redlined.

In this example $\lambda_m(A) = \frac{\sqrt{2A}}{a(H-D(A)+A)}$ is non-monotonic in A as Figure 1 shows. At low wealth levels, close to the redlining threshold, there is very little entry. Even for optimists, the deadweight cost of moral hazard raises interest rates too high for entry to be worthwhile. The number of entrepreneurs is initially increasing in wealth but drops at high wealth levels due to the shrinkage in cross subsidy. Entry is maximised (λ_m minimised) for $A = 0.0815$ with the corresponding equilibrium $\lambda_m = 1.16$. This demonstrates that an increase in the mandatory protection of assets from seizure in the event of default may increase lending.

Now turn to welfare effects. The objective utility of an entrepreneur is given by

$$OU = a^2 (H - D + A)^2 (\lambda - \lambda^2/2) + x \tag{A.14}$$

so that the expected utility per borrower equals

$$x + \frac{a^2 (H - D + A)^2}{2 - \lambda_m} \int_{\lambda_m}^2 (\lambda - \lambda^2/2) \, d\lambda \tag{A.15}$$

$$= x + \frac{a^2}{6} (H - D + A)^2 (2 + \lambda_m) (1 - \lambda_m).$$

The expected net gain per loan, g, is the difference between this expected objective utility and the payoff from staying out of the market, W:
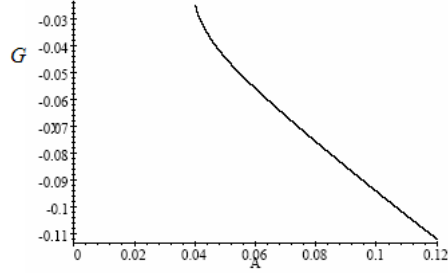
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Figure 2: Gain from lending

Figure A.2:

$$g = \frac{a^2}{6} \left(H - D + A \right)^2 \left(2 + \lambda_m \right) \left(1 - \lambda_m \right) - A \tag{A.16}$$

The aggregate gain from lending is thus

$$G(A) = \left(\frac{a^2}{6} \left(H - D\left(A\right) + A \right)^2 \left(2 + \lambda_m\left(A\right) \right) \left(1 - \lambda_m\left(A\right) \right) - A \right) \left(2 - \lambda_m\left(A\right) \right) \tag{A.17}$$

An increase in protected assets (decrease in A) makes banks less willing to lend. The equilibrium interest rate increases, which reduces excessive effort. Although the effect of an increase in protected assets on entry is ambiguous, as shown in Figure 2, in this numerical example welfare is greater at higher levels of protected assets.

Turning to a lending tax, the equilibrium interest rate Δ as a function of the tax τ is

$$\Delta(\tau) = \frac{1}{2} \left(H + 2A + \frac{1}{a} \left(\sqrt{\frac{A}{2}} - \sqrt{\delta(\tau)} \right) \right) \tag{A.18}$$

where

$$\delta(\tau) = \left(a\left(H + 2A\right) + \sqrt{\frac{0.08}{2}} \right)^2 + 4a\psi(\tau) \tag{A.19}$$

and

$$\psi(\tau) = -a(A)\left(H + A\right) - A\sqrt{\frac{A}{2}} + \frac{A - \left(K + \tau\right)}{a} \tag{A.20}$$

Increasing the tax raises Δ and lowers borrowing. The aggregate net gain (for $A = 0.08$) as a function of the tax is

$$G(\tau) = \left(\frac{a^2}{6} \left(H - \Delta(\tau) + 0.08 \right)^2 \left(2 + L_m\left(\tau\right) \right) \left(1 - L_m\left(\tau\right) \right) - 0.08 \right) \left(2 - L_m\left(\tau\right) \right) \tag{A.21}$$
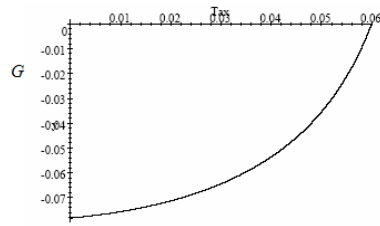
33

Figure A.3:

where

$$L_m(\tau) = \frac{\sqrt{2(0.08)}}{a\left(H - \Delta(\tau) + 0.08\right)}. \tag{A.22}$$

A lending subsidy costs money and destroys utility, but a tax yields direct benefits, as can be seen in Figure 3, and raises revenue.