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Fickle investors: An impediment to growth?

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Abstract

The aim of this paper is to construct theoretical models which help to shed light on the recent criticisms of volatile investment flows. We do not make any empirical attempt to establish the existence or gauge the importance of the adverse effects of volatile investment flows nor do we make any implicit claims regarding the role of such flows in recent exchange rate crises. Instead we simply assume the existence of fickle outside investors and examine the consequences for the economy in the context of two partial equilibrium endogenous growth models.

In our first model, the scale of fickle outside investment funds traces out a mean–variance trade-off for the growth rate of the economy. In particular, the volatility of these funds dissuades risk averse agents from risky entrepreneural activities. This result opens up the possibility that some regulation of outside investment may increase growth. Our second model involves increasing returns and multiple equilibria. In the context of this model fickle investor behavior can have very persistent and substantial effects on both output growth and volatility. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

The aim of this paper is to focus on the potential mechanisms through which volatile investment flows might influence long-run economic growth. In particular, we outline two endogenous growth models in which economic performance is adversely affected by the behavior of volatile investment flows or what we shall call 'fickle investors'. While our thoughts have been motivated by the recent volatility on international capital markets and the ensuing discussion about the value of international capital flows, see, e.g. Obstfeld (1998), Bhagwati (1998) and Rodrik (1998), we stress that our models are not inherently 'international' in nature. As long as their assumptions seem justifiable, their conclusions are relevant to any situation where outside funds are used to finance investment projects and the source of this finance can display volatility. In other words, our general insights may be as appropriate to international financial crises as they are to consideration of sectoral investment flows such as real estate speculators or investors in high technology industries in a closed economy.

Our goal is modest: To outline two reasonably simple dynamic models in which the volatility of exogenous investment flows is linked to the growth rate of the economy. Ours is a theoretical exercise. Whether or not volatile investment flows are empirically harmful for growth is clearly critical for the relevance of our analysis. As yet no clear empirical results have been established – Rodrik (1998) finds no relationship between capital controls/capital account liberalization measures and growth across countries and Razin and Rose (1994) do not find any strong links between capital market openness and business cycle volatility. Bekaert and Harvey (1997) show some evidence that stock market volatility increases after liberalization.[1] This suggests that one avenue through which fickle investors might lead to lower growth is via the negative relationship between growth and volatility documented by Ramey and Ramey (1995) and theoretically explored in this paper. Milesi-Ferretti and Razin (1998) find little correlation between currency crashes and subsequent output growth although their results reveal large differences across countries – clearly for some countries currency crashes have a severe impact on subsequent economic growth. These empirical ambiguities suggest that it may be useful to develop theoretical models which produce a negative relationship between fickle investors and economic growth in order to formulate more precise null hypotheses which may have more chance of leading to significant test results. It is along this dimension that the present paper can be seen as a useful contribution to the literature. Our own analysis suggests that it may be difficult to empirically isolate the adverse effects of fickle international investors even if these effects are present.

[1] These results are, however, sensitive to model specification.

The other issue which we do not attempt to address is the question of why are investment funds so volatile? We simply assume the existence of fickle investors and then examine their macroeconomic implications and make no attempt at modelling their behavior endogenously. As a result of assuming exogenous investor behavior our models are partial equilibrium in one very important dimension. There is an enormous literature which attempts to explain volatile investment market behavior as deviations from efficient market behavior which makes reference to, amongst others, herd behavior, irrationality, incomplete information and learning, speculative bubbles, multiple equilibria, etc. Likewise, investor behavior may be perfectly rational and its volatility the reaction to exogenous events elsewhere such as the resolution of policy uncertainties, of changes in alternative investment opportunities or the coordination of beliefs in a multiple-equilibrium situation. One example is the literature on speculative attacks, see, e.g. Krugman (1979), Flood and Garber (1984), Obstfeld (1994). Each of these explanations has the potential to produce a volatile supply of investment capital which is simply taken to be the starting point of our analysis. Our main reason for focusing on exogenous investor behavior is our desire to understand the macroeconomic implications of volatile investment flows rather than be diverted by having to account for the exact cause of this volatility. If the endogeneity of investor behavior is an important part of the *mechanism* whereby investment volatility adversely affects growth then our approach may be misleading. Aghion et al. (1998), Bacchetta and van Wincoop (1998), Boldrin and Levine (1998) all outline models where such a mechanism is important. However, the empirical work of Dumas (1994), Dumas and Solnik (1995), Eichengreen and Rose (1998) and Frankel and Rose (1996) all suggest that factors exogenous to the recipient country have a substantial role in driving investor flows (more particularly the level of interest rates in developed nations and changes to international portfolio evaluations of exchange rate risks) offering support for our assumption of the exogeneity of investment flows for the recipient country.

What is distinctive about our paper is its focus on how fickle investors or volatile investment flows can have an adverse impact on the economy. Further, much of the existing literature focuses on the conflict between policy authorities and private sector investment flows. Instead our paper is entirely about how the volatility of private sector investment flows can have adverse influences on the productive decisions of the private sector. Our analysis reveals theoretical mechanisms whereby fickle investment flows can permanently lower the growth rate of the economy as well as making fluctuations more volatile and persistent.

The plan of the paper is as follows. Section 2 introduces a partial equilibrium endogenous growth model where entrepreneurs seek funding from outside fickle investors. Scaling up outside funding generates a mean–variance trade-off for growth: an unlimited scale of outside funding is not desirable. This model then suggests that capital controls can be welfare improving. In Section 3 we turn to another partial equilibrium endogenous growth model which is characterized by increasing returns and multiple equilibria. Focusing on the stable equilibria permits analyzing the effect of volatile outside investors: we show how they lead to persistent responses and volatility in economic growth. A final section concludes and an appendix contains the detailed derivation of our results.

2. Fickle investors and reluctant entrepreneurs

This section focuses on how the interaction between fickle investors and occupational choice influences the long-term growth of an economy. A partial equilibrium model of an economy is presented, where entrepreneurial projects are financed both with internal savings as well as by outside investors. An increase in the scale of outside investment boosts the growth of the economy by increasing share prices and thereby the proportion of entrepreneurs in the economy. However, this scale increase also scales up the volatility in share prices and so exert an offsetting adverse effect on growth. Combining these two effects we demonstrate that maximizing the growth rate of the economy may involve some restrictions on fickle investors.

2.1. The model

We assume that time is discrete $t = 0, 1, 2, \ldots$ and that in each period a continuum of agents is born each of whom lives for two periods. In the first period, they supply one unit of labor. They then make a personal investment decision: Become an entrepreneur or an experienced worker. If they become an entrepreneur they start a project which comes on line in their second period of life. These new projects are tantamount to introducing new ideas or new technologies into the production process, improving overall productivity. For simplicity we assume the overall improvement in productivity is a pure externality which affects all projects in operation. That is suppose $0 \leq e_t \leq 1$ is the fraction of the population becoming entrepreneurs in period t and let γ_t be the productivity of all projects producing in period t. We assume

$$\gamma_{t+1} = \gamma_t(1 + \psi e_t) \tag{1}$$

where ψ is a parameter which determines the growth impact of new projects. This assumption regarding externalities is obviously important for any policy recommendations emanating from this model but not for the comparative static results we derive regarding how fickle investors affect growth. Let q_t denote the total number of projects in operation at date t. While knowledge never gets lost we assume that projects die with probability δ so that

$$q_t = (1 - \delta)q_{t-1} + e_{t-1}.$$

If individuals choose not to be an entrepreneur they remain as worker and supply v efficiency units of labor. The total amount of efficiency units of labor available at date t (that is the young unexperienced and the old experienced non-entrepreneurs) is therefore

$$n_t = 1 + v(1 - e_{t-1})$$

where $v < 1$ indicates that experience and old age means a loss in productivity, whereas $v > 1$ indicates a productivity gain: v plays no further role other than allowing for some parameter flexibility. We have assumed that inexperienced and experienced labor are perfect substitutes.

Each project i hires $n_{t,i}$ units of labor to produce output

$$y_{t,i} = \gamma_t n_{t,i}^{\alpha}.$$

Each project maximizes instantaneous profits or dividends,

$$d_{t,i} = \max_{n_{t,i}} \ \gamma_t n_{t,i}^{\alpha} - w_t n_{t,i}$$

where w_t is the wage per efficiency unit of labor at t. Total output is given by

$$y_t = \int_0^{q_t} y_{t,i}\, \mathrm{d}i.$$

By symmetry and profit maximization we have

$$y_t = \gamma_t q_t^{1-\alpha} n_t^{\alpha}, \quad w_t n_t = \alpha y_t, \quad d_t q_t = (1-\alpha) y_t.$$

For simplicity we assume agents only consume in the second period so that when young they save their entire wage earnings. Further we assume they invest these resources entirely by purchasing projects. However a proportion of projects is also purchased by outside investors although this proportion is time varying and is the source of fickleness in our model. Entrepreneurs and workers are prevented from buying other assets by assumption.

It is at this point that our model is most appropriate in an international context as this assumption of incomplete markets may be most appealing there. The home bias in portfolio selection is a well documented fact at the international level, see Baxter and Jermann (1997) for a recent restatement. No similar bias exists at the national or regional level. We therefore have in mind for our model a small developing country with few overseas investments but which receives large capital inflows from more developed nations. While these capital inflows are large relative to the host nation they form only a small part of the portfolio of developed countries. We stress that there is nothing 'international' about our model otherwise: it can equally well be understood as a partial equilibrium growth model of some sector with the fickle investors coming from outside that sector, where one might want to appeal to moral hazard issues as a reason for the nondiversifiability of entrepreneurial risk. We also stress that our assumption about the absence of other asset markets for our entrepreneurs and workers is anything but trivial. If entrepreneurs held well diversified portfolios, they would be able to self-insure against fickle investment flows. Presumably then, resources by fickle investors flowing into the economy would be offset by corresponding flows out of the economy by the entrepreneurs and workers. Again, calling into memory recent events such as the financial crisis in Russia and the political price to be paid by local entrepreneurs for capital outflows may make this assumption more appealing in the international rather than the sectoral context. Certainly the prevalence of restrictions on capital movements both in and out of a country are far more numerous than within the national economy.

As a result of these assumptions labor income is used to purchase a proportion of projects such that

$$z_t w_t = p_t q_t$$

where p_t is the (ex-dividend) price per project and $(z_t - 1)w_t$ are the funds provided by outside investors. We assume $z_t \in (0, \infty)$ is random but stationary. This is not very restrictive. For example, one may want to think of z_t and its innovation variance σ_t^2 as being drawn from a stationary Markov process, allowing for homoskedastic fluctuations in z_t as well as GARCH-processes or stochastic volatility. More specifically, one may want to think of z_t as a process with small increases most of the time, interrupted by occasional sharp drops as a simple way to capture financial crises. The fluctuations in z_t and its variance reflect the impact of fickle outside investors. In the case of no outside investors $z_t \equiv 1$ and labor income is used to purchase the entire stock of projects. If $z_t = 2$, then the funds provided by outside investors are as large as the funds saved by workers and entrepreneurs. If $z_t < 1$, investors as a group are selling the projects short.[2]

The return earned in period $t+1$ per unit invested in period t is given by

$$R_{t+1} = (1-\delta)\frac{d_{t+1} + p_{t+1}}{p_t}$$

where the factor reflects the fraction of dying or unsuccessful projects in the diversified portfolio of investors.

[2] This case creates no mathematical problems, but is admittedly hard to reconcile logically with our portfolio restriction for entrepreneurs and workers.

To make the choice of whether to become an entrepreneur or an experienced worker at date t, the agent needs to reason as follows. As an entrepreneur, they will collect dividends d_{t+1} when old and sell the project at a price p_{t+1}. Thus, the consumption of an entrepreneur is given by

$$c^{(e)}_{t+1} = R_{t+1}w_t + d_{t+1} + p_{t+1}$$
$$= R_{t+1}\left(w_t + \frac{p_t}{1-\delta}\right).$$

In comparison the total consumption of experienced workers is the sum of wage earnings times any returns earned:

$$c^{(w)}_{t+1} = R_{t+1}w_t + vw_{t+1}.$$

Let $u(c)$ be the utility function for consuming when old then the fraction of agents becoming entrepreneurs will be tied down by the condition

$$\mathrm{E}_t[u(c^{(e)}_{t+1})] = \mathrm{E}_t[u(c^{(w)}_{t+1})]. \tag{2}$$

We define the entrepreneurial risk premium, π_t (which we shall show later is positive) by the relationship

$$\mathrm{E}_t[c^{(e)}_{t+1}] \equiv \mathrm{E}_t[c^{(w)}_{t+1}] + \pi_t w_{t+1} \tag{3}$$

(note that w_{t+1} is already known at date t).

This risk premium denotes the additional consumption required to compensate the entrepreneur for the additional riskiness of their occupational choice compared to the worker. Note that we have written the risk premium to be proportional to a measure of wealth, namely the second-period wage w_{t+1}, which is plausible for utility functions which approximate constant relative risk aversion. In order to examine the steady state of the model we also need to make the following assumption (which for a very wide range of plausible parameter values is likely to hold):

Assumption 1.

$$\frac{1}{\alpha} + \frac{1}{\delta} + \frac{\pi_t}{\delta v} > 1.$$

The model is analyzed in detail in Appendix A, here we only report some of the results. To analyze the model, we shall first take π_t as given and we shall later show how to calculate it.

The dynamics of the model are characterized by the dynamics of the number of projects q_t,

$$q_{t+1} = \frac{1}{v + \pi_t \alpha}((1 + v)(1 - \alpha) + v(1 - \alpha)(1 - \delta)q_t + \alpha \mathrm{E}_t[z_{t+1}]). \tag{4}$$

With this all other variables can now be computed. For example, the number of entrepreneurs is given by

$$e_t = \frac{1}{v + \pi_t \alpha}((1 + v)(1 - \alpha) - (v + \pi_t)\alpha(1 - \delta)q_t + \alpha \mathrm{E}_t[z_{t+1}]). \tag{5}$$

A few remarks are in order. First, the dynamics of the model are very simple and take the form of a first-order difference equation, given a process for π_t. Second, the autoregressive coefficient for q_t is the product of the fraction of surviving projects $(1 - \delta)$ and the profitability of projects $(1 - \alpha)$ at $\pi_t = 0$: If there are already lots of projects in operation in the economy the relative return to being an entrepreneur rather than an experienced worker declines. Third, the entrepreneurial decision is forward looking; e_t depending on financing conditions next period when the entepreneur needs to sell the project $(\mathrm{E}_t[z_{t+1}])$. Fourth, surprises in outside financing $(z_{t+1} - \mathrm{E}_t z_{t+1})$ have no effect on the growth path of the economy but simply result in a redistribution between existing entrepreneurs, workers and outside investors. Finally, predictable changes in external financing have lasting effects. For instance suppose $z_t \equiv \bar{z}$, except that $\mathrm{E}_{t_0 - 1} z_{t_0} > \bar{z}$, i.e. a larger fraction of assets is expected to be held by overseas investors at t_0. In this case, the fraction of agents becoming entrepreneurs rises in period $t_0 - 1$, creating additional projects for the date t_0, with convergence back to the $\bar{z}$-situation at the rate of $(1 - \alpha)(1 - \delta)$ in the periods $t > t_0$. Our model thus offers in a simple way the persistent effects of changes in financial conditions that are the focus of Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Suarez and Sussman (1997) or Ortalo-Magné and Rady (1998).

2.2. Capital inflows and the mean effect

In order to solve for the steady-state growth path, we make the simplifying approximation that the entrepreneurial risk premium, π_t, is a constant, $\bar{\pi}$, which is independent of the state of the economy or its parameters. On the steady-state growth path the fraction of agents becoming entrepreneurs is given by

$$\bar{e} = \frac{1 + v}{v} \frac{\frac{1}{\alpha} + \frac{1}{1 + v}\mathrm{E}[z] - 1}{\frac{1}{\alpha} + \frac{1}{\delta} + \frac{\bar{\pi}}{\delta v} - 1} \tag{6}$$

and steady-state growth is

$$\bar{g} = \frac{\gamma_t}{\gamma_{t-1}} = 1 + \psi \bar{e}$$

which is obviously increasing in $\bar{e}$. To get a ballpark idea of the quantitative implications: if there are no outside investors, $\bar{z} \equiv 1$, if there is no experience premium for older workers $v = 1$, if the labor share is $\alpha = 2/3$ and if the depreciation rate δ is 10% then $\bar{e} = 4/21$, i.e. approximately 19% of all agents become entrepreneurs. With $\psi = 0.2$, this results in 4% annual growth.

Under Assumption 1 applied to $\pi_t \equiv \bar{\pi}$, Eq. (6) yields the following comparative static results. Across economies with different parameters in steady state, the fraction of agents $\bar{e}$ choosing to become entrepreneurs and thus the growth factor $\bar{g}$ is

1. increasing in the fraction E[z] of assets held by outside investors,
2. for $\pi \approx 0$, decreasing in the experience premium v,
3. for $\bar{\pi} > -v$, increasing in the depreciation rate δ,
4. decreasing in the labor factor share α as well as the entrepreneurial risk premium $\bar{\pi}$, if

$$\mathrm{E}[z] < \frac{1+v}{\delta}\left(1 + \frac{\bar{\pi}}{v}\right),$$

   else increasing,
5. constant with respect to everything else.

These results are not surprising. With higher outside financing each project will be sold at a higher price, making it more attractive to become an entrepreneur. With a higher experience premium, the opportunity costs of becoming an entrepreneur rise, explaining the second result. With a higher depreciation rate, there will be fewer projects around in total, if the fraction of entrepreneurs were to remain constant, thus raising the marginal product of a new project, and making it more attractive to become an entrepreneur, explaining the third result. For the fourth result, an increased labor share makes the choice to become an entrepreneur relatively less attractive in the absence of outside funds, and thus depresses growth. When outside funds are present, an increase in the parameter α also implicitly increases these funds, as we have assumed them to be proportional to wage earnings for simplicity of algebra: When the scale of outside funds is large enough, this effect will dominate and increase growth.

2.3. Capital inflows and the variance effect

To investigate the impact of fickle investors on entrepreneurial decision making, we need to study the relationship between the variance of z_t and the entrepreneurial risk premium π_t off the steady state. To do so, we shall also assume a constant relative risk aversion utility function

$$u(c) = \frac{c^{1-\eta} - 1}{1 - \eta}$$

and assume all random variables to be both bounded and small. Rather than numerical simulation, we prefer to use analytical approximations in order to stress as clearly as possible the intuition behind our model. The key device is to rely on a second-order approximation to marginal utility for deriving a first order approximation for the risk premium.[3]

Let $\sigma_{t,z}$ be the variance of z_{t+1}, conditional on information up to and including date t. Likewise, let $\sigma_{t,c^{(e)}}$ be the conditional variance of $c^{(e)}_{t+1}$ and $\sigma_{t,c^{(w)}}$ the conditional variance of $c^{(w)}_{t+1}$. In Appendix A, we show that the entrepreneurial risk premium π_t satisfies

$$\pi_t = \eta \frac{\sigma^2_{t,c^{(e)}} - \sigma^2_{t,c^{(w)}}}{2w_{t+1}\mathrm{E}_t[c^{(w)}_{t+1}]} > 0. \tag{7}$$

to a first-order approximation. This can be rewritten as

$$\pi_t = \eta \frac{(1-\delta)\dfrac{q_t}{z_t} + 0.5}{(1-\delta)^2 q_{t+1}\left(\dfrac{q_t}{z_t}\left(\dfrac{1-\alpha}{\alpha}(1 + v(1-e_t)) + \mathrm{E}_t[z_{t+1}]\right) + vq_{t+1}\right)} \sigma^2_{t,z} . \tag{8}$$

Eq. (7) confirms our earlier statement that the entrepreneurial risk premium is positive. Note that q_t and e_t are bounded. If, furthermore, q_{t+1} is strictly bounded from below, $q_{t+1} > \underline{q}$, and $\sigma^2_{t,z}$ is bounded above, Eq. (8) shows that π_t is bounded[4] as well.

Eq. (8) equates π_t to an expression involving the exogenous random variables z_t, $\mathrm{E}_t[z_{t+1}]$ and $\sigma_{t,z}$, as well as the endogenous state variables q_t and q_{t+1}, noting that e_t follows from Eq. (5). However, Eq. (8) is only an implicit equation in π_t as

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[3] Canton (1997) applies a similar device to compare steady states in a different context.

[4] Note, that $z_t \to 0$ yields

$$\pi_t \to \eta \frac{\alpha}{(1-\delta)(1-\alpha)q_{t+1}(1 + v(1-e_t))} \sigma^2_{t,z} ,$$

and that $z_t \to \infty$ yields

$$\pi_t = \eta \frac{1}{2(1-\delta)^2 v q^2_{t+1}} \sigma^2_{t,z} .$$

both e_t and q_{t+1} depend in turn on π_t. Combining Eq. (8) with Eqs. (4) and (5), one can derive an explicit quadratic equation in π_t which has exactly one economically meaningful solution, as long as $\sigma_{t,z}$ is not too large. This solution can be shown to be increasing in the relative risk aversion η as well as the conditional fickleness variance $\sigma^2_{t,z}$. Further, it can be shown that Eqs. (4), (5) and (8) imply a cubic equation for the steady-state value of $\bar{q}$. Details can be found in Appendix A.

2.4. The mean–variance trade-off

Our results imply that there is a *mean–variance trade-off* with respect to the presence of fickle investors. More outside investment has two opposing effects: It increases the growth rate of the economy by providing entrepreneurs with a higher average sale price for their project, and at the same time *decreases* the growth rate by scaring risk-averse agents away from entrepreneurship into the relatively safer haven of employment due the increased variance of the sale price.

Illustrating the nature of the trade-off requires numerical calculations. Table 1 provides numerical results for a 'baseline' parameterization, using $v = 1, \alpha = 2/3, \delta = 0.1, \psi = 0.2$ and $\eta = 5$. We have varied $\bar{z}$ as well as σ_z. The calculations are based on solving for the entrepreneurial risk premium at the steady state, using the analytical approximations above. One can easily see the increase in the growth rate due to an increase in $\bar{z}$ as well as the decrease in the growth rate due to an increase in σ_z. To see the trade-off even more clearly assume that outside financing $z - 1$ is a scaled version of a random variable[5] X,

$$z - 1 = \lambda X, \quad \mathrm{E}[X] = 1, \quad \mathrm{Var}[X] = \xi^2.$$

Thus each extra unit of outside financing comes with ξ extra units of fickleness. If $\xi = 1$, so that $\sigma_z = 0.1$ for $z = 1.1$ and $\sigma_z = 0.2$ for $\bar{z} = 1.2$, increases in outside financing always have a positive effect on the growth rate in this table. If, however, $\xi = 2$, so that $\sigma_z = 0.2$ for $\bar{z} = 1.1$ and $\sigma_z = 0.4$ for $z = 1.2$, then some outside financing $\bar{z} = 1.1$ increases the growth rate, but more outside financing $\bar{z} = 1.2$ is detrimental to the growth rate. These results hold more generally for our model: The benefit to the growth rate of the economy due to the mean effect of additional outside investment increases approximately linearly in λ, while the costs due to the variance effect increase approximately quadratically in λ. Hence, the growth rate of the economy is a hump-shaped function of the scale of outside investment.

The trade-off is visualized in Fig. 1. The insight can clearly be seen with the help of Eqs. (6) and (8). Suppose first, that $\xi = 0$ (so only the mean effect is

[5] One may want to assume $X > 0$ to rule out net short sales by fickle investors.

Table 1
Model 1

	$\bar{z} = 1.0$		$\bar{z} = 1.10$		$\bar{z} = 1.20$	
	$\bar{\gamma}$ π	$\bar{e}$ σ_R	$\bar{\gamma}$ π	$\bar{e}$ σ_R	$\bar{\gamma}$ π	$\bar{e}$ σ_R
$\sigma_z = 0$	3.81	19.05	4.00	20.00	4.19	20.95
	0.00	0.00	0.00	0.00	0.00	0.00
$\sigma_z = 0.1$	3.76	18.81	3.96	19.78	4.15	20.74
	1.31	10.38	1.18	9.45	1.07	8.68
$\sigma_z = 0.2$	3.62	18.10	3.82	19.11	4.02	20.10
	5.48	20.72	4.92	18.88	4.44	17.34
$\sigma_z = 0.3$	3.38	16.91	3.59	17.97	3.81	19.03
	13.29	31.01	11.83	28.25	10.61	25.95
$\sigma_z = 0.4$	3.04	15.19	3.27	16.36	3.50	17.50
	26.64	41.22	23.38	37.55	20.72	34.50

Note: This table provides numerical results for a 'baseline' parameterization, using $v = 1$, $\alpha = 2/3$, $\delta = 0.1$, $\psi = 0.2$ and $\eta = 5$. We have varied $\bar{z}$ as well as σ_z. The calculations are based on solving for the entrepreneurial risk premium at the steady state. All numbers are in percent.

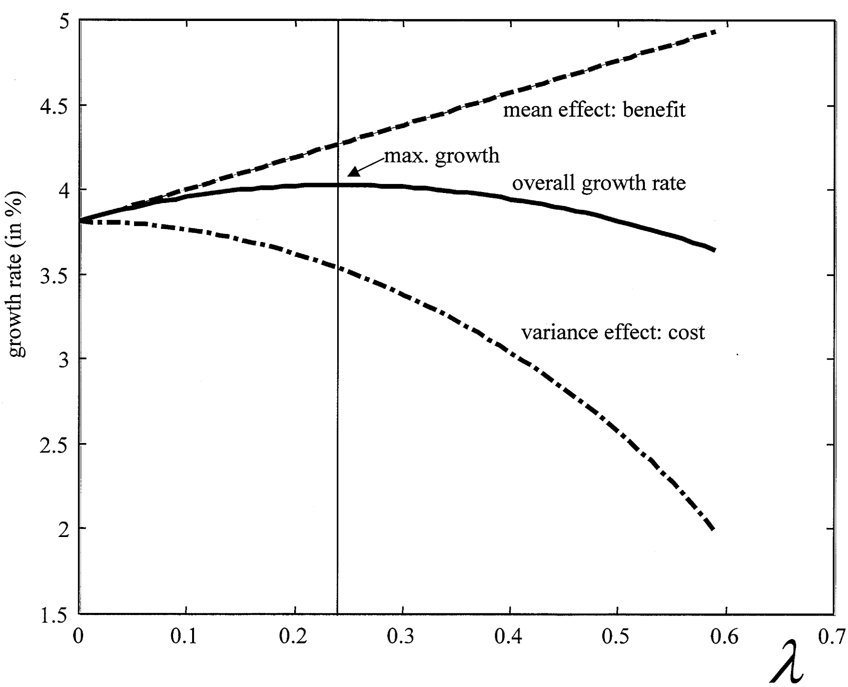

Fig. 1. Model 1: Mean–variance trade-off.

Table 2
Model 1

	$\eta = 1$		$\eta = 2$		$\eta = 3$	
	$\bar{z}$	σ_z	$\bar{z}$	σ_z	$\bar{z}$	σ_z
	$\bar{\gamma}$	$\bar{e}$	$\bar{\gamma}$	$\bar{e}$	$\bar{\gamma}$	$\bar{e}$
	π	σ_R	π	σ_R	π	σ_R
$\xi = 1$	4.22	3.22	1.83	0.83	1.46	0.46
	6.02	30.10	4.48	22.41	4.20	21.02
	68.26	80.87	21.35	47.42	12.02	32.83
$\xi = 2$	1.32	0.63	1.14	0.28	1.09	0.18
	4.09	20.45	3.94	19.69	3.89	19.47
	8.32	50.11	3.71	25.69	2.35	17.16
$\xi = 5$	1.04	0.21	1.02	0.11	1.01	0.07
	3.85	19.24	3.83	19.15	3.82	19.11
	1.11	20.93	0.56	10.68	0.38	7.17

Note: Optimal amount of outside financing, given that $\bar{z} - 1$ outside financing creates fickleness shocks with standard deviation $\sigma_z = \xi(\bar{z} - 1)$. The relative risk aversion η as well as the volatility-to-mean ratio ξ have been varied.

present, $\pi = 0$). In that case, the steady-state fraction $\bar{e}$ of agents who decide to become entrepreneurs (and thus the growth rate of the economy) linearly increases with λ. Suppose next, that $\mathrm{E}[X] = 0$ rather than $\mathrm{E}[X] = 1$, so that only the variance effect is present. Holding q_t, q_{t+1} and e_t constant, Eq. (8) shows π to be a linear function of σ_z^2 and thus a quadratic function of λ. Using this in Eq. (6) and taking a Taylor expansion there with respect to π shows $\bar{e}$ to be approximately quadratic in λ as well.[6]

How large is the optimal scale of outside investment? We investigate this issue in Table 2, considering our model under different values for η and ξ. These simulations show that the variance effect has the potential to be large and quantitatively significant even when considering modest amounts of risk aversion and standard-deviation-to-mean ratios ξ. It cannot therefore be dismissed as being of 'second order' a priori.

3. Fickle investors and increasing returns

The previous section outlined a model where fickle investors can be bad for growth if the variance effect dominates. In this section we outline a very different

[6] To do the full analysis, one would need to take into account the endogeneity of $q_t = q_{t+1} = e_t/\delta = \bar{q}$ in Eq. (8) to find the exact relationship between $\bar{e}$ and λ in this case, but the argument should be clear enough.

model: An endogenous growth model with increasing returns and multiple equilibria. We show how the volatility of outside investors selects the stable among the two equilibria, and leads to persistent responses in economic growth. In this model and in contrast to the model of Section 2, the returns to investing are tied down by an arbitrage condition.

3.1. The model

The model is as follows. Time is discrete, $t = 0, 1, 2, \ldots$. In each period, there is a stock of operational projects q_t: Think of projects as blueprints or firm-specific knowledge, enabling its owner to earn rents. For each project $i \in [0, q_t]$, labor $n_{t,i}$ is hired to produce an intermediate good

$$x_{t,i} = n_{t,i}^{\alpha}.$$

Intermediate goods are used in final goods production according to the production function

$$Y_t = \left(\int_0^{q_t} x_{t,i}^{\mu} \, \mathrm{d}i \right)^{1/\mu}.$$

Final goods production is organized by a sector of competitive firms, giving rise to the usual project-specific demand function for the intermediate good. The intermediate good producers are in monopolistic competition and maximize profits period by period by choosing $n_{t,i}$, taking into account the demand function for their good as well as the wage bill $w_t n_{t,i}$.

We assume one unit of labor (and a competitive labor market) so that market clearing requires

$$\int_0^{q_t} n_{t,i} \, \mathrm{d}i = 1.$$

Before completing the model by describing how new projects get introduced, we can already perform a partial equilibrium analysis of the production decisions each period. As all projects enter these decisions symmetrically we have

$$n_{t,i} \equiv n_t = 1/q_t, \quad x_{t,i} \equiv x_t = q_t^{-\alpha}, \quad Y_t = q_t^{1/\mu - \alpha}.$$

Let d_t be the profits generated per project. Since production of the final good is characterized by constant returns to scale it is used in paying for the intermediate production goods $x_{t,i}$. The share $\alpha\mu$ of the revenue for each project is used for paying wages, the rest is distributed as dividends to the project owners:

$$w_t = Y_t, \quad d_t q_t = (1 - \alpha\mu) Y_t.$$

Note that the latter equation can also be written as

$$d_t = (1 - \alpha\mu) q_t^{\omega}$$

where

$$\omega = \frac{1}{\mu} - \alpha - 1.$$

We can already see one feature of the model: If $\omega > 0$ (i.e. aggregate increasing returns), then a more quickly growing economy will lead to larger dividends per project.

The stock of projects changes via the introduction of new projects as well as the deterioration of existing ones. Let e_t denote the new projects and let δ be the depreciation rate. We postulate

$$q_t = (1 - \delta) q_{t-1} + e_t.$$

We assume there is an outside capital market with a fixed real interest factor $R = 1 + r$. We furthermore assume that the country under consideration is small and its risk uncorrelated with world market portfolio risk so that no risk premium is charged for the uncertain dividend streams. With this, we can already compute an equation for the share price s_t of each new project:

$$s_t = d_t + \frac{1}{R} \mathrm{E}_t[(1 - \delta) s_{t+1}].$$

Potential new projects are owned by the entrepreneurs of the country under consideration but need funds z_t to become operational. The relationship between new project and start-up funds is subject to decreasing returns to scale,

$$e_t = A z_t^{\theta}$$

where $0 < \theta < 1$. To get balanced growth in this model we need to impose the condition

$$1 = \theta(\omega + 1) \tag{9}$$

and we assume this equality from here onwards. This is obviously a necessary but strong assumption, typical of endogenous growth models with increasing returns. It allows us to concentrate on the comparatively simple analysis of balanced growth paths.

The choice of z_t is restricted by the opportunity costs of investing these funds elsewhere: We assume that a unit of z_t can return one unit of output forever, so that costs are

$$\sum_{s=0}^{\infty} \frac{1}{R^s} = \frac{R}{R-1} = \frac{R}{r}.$$

The marginal cost of a unit of funding must equal its marginal benefit, yielding the arbitrage condition

$$R/r = \theta A z_t^{\theta-1} s_t. \tag{10}$$

This closes the model. Among the many differences to the model in Section 2, this arbitrage condition is perhaps the most important one. Investment behavior here is no longer completely exogenous, but needs to satisfy a forward-looking constraint. The arbitrage condition needs to stay satisfied even when we consider random fluctuations in investor behavior.

The model is analyzed further in Appendix B. Let $\gamma_t = d_t/d_{t-1}$ be the growth rate of dividends. The dynamics of the economy is then completely characterized by the dynamics of γ_t,

$$\gamma_t = \left(\frac{1 - \left(\frac{(1-\alpha\mu)A^{1+\omega}\theta r}{R} + \frac{1-\delta}{R} \mathrm{E}_t[(\gamma_{t+1}^{1/\omega} - (1-\delta))^{\omega}] \right)^{1/\omega}}{1-\delta} \right)^{-\omega}. \tag{11}$$

If there is no uncertainty and $\omega > 0$, then the right-hand side of Eq. (10) is an increasing function of γ_{t+1}. A plot of this relationship can be seen in Fig. 2, using the base parameterization of Section 3.2. In this figure, there are two steady states $\bar{\gamma}_{\mathrm{L}}$ and $\bar{\gamma}_{\mathrm{H}}$.

In fact, this is a typical situation. It turns out that for interesting parameter values, there will be two steady states $\bar{\gamma}$: These two steady states are the solutions to the equation

$$\frac{(1-\alpha\mu)A^{\omega+1}\theta r}{R} = \left(1 - \frac{1-\delta}{R}\bar{\gamma}\right)(1-(1-\delta)\,\bar{\gamma}^{(-1/\omega)})^{\omega}. \tag{12}$$

The local dynamics around each steady state can be studied more easily when examining a linearized form of Eq. (11),

$$\hat{\gamma}_t = \varphi \mathrm{E}_t[\hat{\gamma}_{t+1}] \tag{13}$$

where

$$\varphi = \frac{\bar{\gamma}^{1/(1-\theta)}}{R}.$$

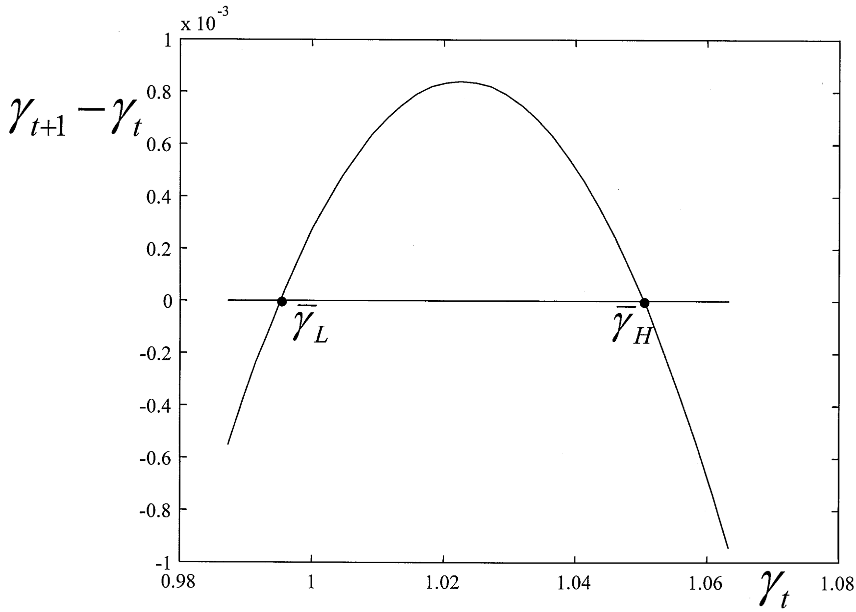

Fig. 2. Model 2: Steady states in base parameterization.

The general solution to this equation is

$$\hat{\gamma}_{t+1} = (1/\varphi)\,\hat{\gamma}_t + u_{t+1} \tag{14}$$

where $E_t[u_{t+1}] = 0$. For the two steady states, we typically have the following:

Low growth, dynamically unstable steady state: Here, steady-state growth is low, $\bar{\gamma}_L < R^{1-\theta}$ and hence $\varphi < 1$. In this case, the dynamics in Eq. (14) are locally unstable – any shock will lead to divergent dynamics.

High growth dynamically stable steady state: Here steady-state growth is high, $\bar{\gamma}_H > R^{1-\theta}$, and hence $\varphi > 1$. In that case, the dynamics in Eq. (14) are locally stable in the face of shocks. Shocks will lead to fluctuations in the growth rate.

The mechanism at work in producing these features is somewhat similar to the mechanism in, e.g. Benhabib and Farmer (1994) and Boldrin and Rustichini (1994).

We are interested in studying the impact of shocks to investment behavior. Given the instability of the low growth steady state we therefore need to focus our attention on the high growth stable steady state. Since we are interested in the effect of shocks to the funding z_t by investors we introduce $\hat{\zeta}_t$ as the log-deviation of z_t/d_t from its value along the balanced growth path. Let

$$\phi_t = \hat{\zeta}_t - E_t[\hat{\zeta}_t]$$

be the surprise movement in $\hat{\zeta}_t$ where we interpret ϕ_t as *fickleness shocks* which we assume are distributed $N(0, \sigma_2)$. In Appendix B we show that

$$u_t = \frac{\chi}{(1-\theta)(1-\chi)}\,\phi_t, \tag{15}$$

where $\chi = (1-\delta)\bar{\gamma}^{(-1/\omega)}$. To calculate the implied volatility of the log growth factor, we find

$$\frac{\sigma_{\hat{\gamma}}}{\sigma} = \frac{\varphi}{\sqrt{\varphi^2 - 1}}\,\frac{\chi}{(1-\theta)(1-\chi)}\,. \tag{16}$$

Likewise, the implied volatility of the log price–dividend ratio is given by

$$\frac{\sigma_{\hat{\rho}}}{\sigma} = \frac{\varphi}{\sqrt{\varphi^2 - 1}}\,\frac{1}{1-\theta}$$

see Appendix B. These equations show how much volatility in growth and stock market prices will be caused by random fluctuations in the supply of outside investment funds in the context of this model.

3.2. A numerical example

To study these issues in further detail we use specific numerical examples. As our base case we use the parameterizations $\mu = 0.4$, $\alpha = 0.7$, $\delta = 0.09$, $R = 1.05$ and $A = 1$. These numbers are meant to be suggestive rather than represent the end product of a serious calibration exercise. That said the numbers are not randomly chosen but intended to represent plausible values for an economy measured at an annual frequency. This base parameterization leads to the solution $\omega = 0.8$, $\theta = 0.56$, $\bar{\gamma}_L = 1.00$ and $\bar{\gamma}_H = 1.05$, $\rho_H = 11.15$, $1/\varphi_H = 0.94$ and $\sigma_\gamma/\sigma = 1.11$ and $\sigma_\rho/\sigma = 6.6$, see also Fig. 2. The model serves to amplify the volatility of fickle investment flows for both growth and the price–dividend ratio, especially for the latter. This base parameterization also leads to very persistent responses in the growth rate, with the effect of a shock dying out at the rate $1/\varphi_H$. Table 3 shows how our results vary when we alter μ and α. We vary μ in such a way that ω takes evenly stepped values. For low levels of increasing returns ω, growth rates display a less persistent response but a rather large volatility. Conversely, as increasing returns become more substantial the auto-correlation in growth rates rises but volatility declines.

4. Conclusions

Our aim in this paper has been to examine theoretically whether the fickle behavior of investors can adversely affect growth. We have made no attempt to

Table 3
Model 2

	$\alpha = 0.55$			$\alpha = 0.7$		
	ω θ $1/\varphi_{\mathrm{H}}$	$\bar{\gamma}_L$ $\bar{\gamma}_H$ σ_γ/σ	$\bar{\rho}_L$ $\bar{\rho}_H$ σ_ρ/σ	ω θ $1/\varphi_{\mathrm{H}}$	$\bar{\gamma}_L$ $\bar{\gamma}_H$ σ_γ/σ	$\bar{\rho}_L$ $\bar{\rho}_H$ σ_ρ/σ
$\mu = 0.556$	0.25	0.98	6.52	0.10	0.99	7.07
	0.80	1.12	30.30	0.91	1.12	36.54
	0.61	4.42	6.29	0.30	28.59	11.51
$\mu = 0.513$	0.40	0.97	6.15	0.25	0.98	6.52
	0.71	1.11	25.16	0.80	1.12	32.95
	0.73	2.16	5.15	0.60	4.51	6.24
$\mu = 0.476$	0.55	0.96	6.08	0.40	0.97	6.14
	0.65	1.09	19.57	0.71	1.11	27.30
	0.81	1.43	4.84	0.73	2.19	5.08
$\mu = 0.444$	0.70	0.98	6.52	0.55	0.96	6.01
	0.59	1.07	13.96	0.65	1.10	21.27
	0.89	1.12	5.29	0.80	1.45	4.73

Note: Variations in the parameterization and corresponding results.

model this investor fickleness but take it as exogenously given although motivated by reference to the many strands in the macroeconomic and finance literature which justify volatile investment flows. We also stress that we make no statement regarding the empirical importance of fickle investors or their role in provoking any particular financial crisis. Instead we articulate two partial equilibrium endogenous growth models in which fickle investors have an important and potentially adverse influence on the economy. In our first model there exists a mean–variance trade-off which implies that increases in the scale of fickle investment beyond some point are not good for economic growth. The trade-off result at the heart of this model also suggests that empirically documenting either beneficial or adverse influences of fickle (international) investment on growth may be difficult. In our second model we introduced fickle investors as a source of uncertainty in a model with increasing returns and an arbitrage condition for outside investors. We show how fickleness shocks trigger persistent responses in the growth rate and volatility in growth in general.

Clearly much remains to be done and two particular issues need to be addressed. First, we need a detailed empirical assessment of whether increasing the scale of outside investment benefits or hinders growth and the conditions under which either effect works, taking into account the possible nonlinearities presented here. Second, progress on the theory side will depend on endogenizing the fickle behavior of the investors. We believe that the investigation at hand shows that such future work is desirable. Our theoretical analysis raises the possibility that the most important adverse effects of volatile investment flows may not be due to their disruptive effect on current macroeconomic policy but their impact on long-term growth.

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Appendix A. Solving the model of Section 2

The arbitrage equation for the decision as to whether to become an entrepreneur or an experienced worker boils down to $\mathrm{E}_t[c^{(e)}_{t+1}] = \mathrm{E}_t[c^{(w)}_{t+1} + \pi_t w_{t+1}]$ or

$$d_{t+1} + \mathrm{E}_t[p_{t+1}] = (v + \pi_t)w_{t+1}.$$

Note that d_{t+1}, w_{t+1} and, for the next step, n_{t+1} are known at date t. Multiply with n_{t+1}/d_{t+1} to rewrite this equation as

$$n_{t+1} + \frac{n_{t+1}\mathrm{E}_t[p_{t+1}]}{d_{t+1}} = (v + \pi_t)\frac{w_{t+1}n_{t+1}}{d_{t+1}}. \tag{A.1}$$

After some calculation, Eq. (A.1) can be rewritten as

$$\mathrm{E}_t\left[n_{t+1} + \frac{\alpha}{1-\alpha} z_{t+1}\right] = \frac{(v + \pi_t)\alpha}{1-\alpha}\mathrm{E}_t[q_{t+1}]$$

or

$$1 + v(1 - e_t) + \frac{\alpha}{1-\alpha}\mathrm{E}_t\,[z_{t+1}] = \frac{(v + \pi_t)\alpha}{1-\alpha}((1-\delta)q_t + e_t).$$

Solving this for e_t delivers Eq. (5) and thus also Eq. (4) with $e_t = q_{t+1} - (1-\delta)q_t$. To calculate the steady state in Eq. (6), use $\delta\bar{q} = \bar{e}$ and solve. The comparative static results of Section 2.2 follow immediately.

To derive our expression (7) for the risk premium, write

$$c^{(e)}_{t+1} = \mathrm{E}_t[c^{(w)}_{t+1}] + \pi_t w_{t+1} + \varepsilon_{t+1,c^{(e)}},$$

$$c^{(w)}_{t+1} = \mathrm{E}_t[c^{(w)}_{t+1}] + \varepsilon_{t+1,c^{(w)}},$$

where $\varepsilon_{t+1,c^{(e)}}$ and $\varepsilon_{t+1,c^{(w)}}$ have mean zero, conditional on information up to and including date t. To a second-order approximation,

$$\mathrm{E}_t\left[\frac{(c^{(e)}_{t+1})^{1-\eta} - 1}{1-\eta}\right] = \frac{(\mathrm{E}_t[c^{(w)}_{t+1}])^{1-\eta} - 1}{1-\eta} + \pi_t w_{t+1}(\mathrm{E}_t[c^{(w)}_{t+1}])^{-\eta} - (\eta/2)(\mathrm{E}_t[c^{(w)}_{t+1}])^{-\eta-1}\sigma^2_{t,c^{(e)}},$$

where

$$\sigma^2_{t,c^{(e)}} = \mathrm{E}_t[\varepsilon^2_{t+1,c^{(e)}}].$$

A similar expression can be obtained for $c^{(w)}_{t+1}$. Comparing these two expressions and solving for π_t yields Eq. (7). To show $\pi_t > 0$, we need to show that $\sigma_{t,c^{(e)}} > \sigma_{t,c^{(w)}}$. To that end, rewrite $\varepsilon_{t+1,c^{(e)}}$ and $\varepsilon_{t+1,c^{(w)}}$ as

$$\varepsilon_{t+1,c^{(e)}} = \left(w_t + \frac{p_t}{1-\delta}\right)\varepsilon_{t+1,R},$$

$$\varepsilon_{t+1,c^{(e)}} = w_t \varepsilon_{t+1,R},$$

where

$$\varepsilon_{t+1,R} = R_{t+1} - \mathrm{E}_t[R_{t+1}].$$

Positivity of π_t now follows immediately, since $p_t/(1-\delta) > 0$. Using the latter expressions as well as

$$\varepsilon_{t+1,R} = \frac{w_{t+1}}{p_t q_{t+1}}\varepsilon_{t+1,z}$$

where

$$\varepsilon_{t+1,z} = z_{t+1} - \mathrm{E}_t[z_{t+1}],$$

rewrite Eq. (7) as

$$\pi_t = \eta\frac{w_{t+1}}{\mathrm{E}_t[c^{(w)}_{t+1}]}\frac{(1-\delta)(q_t/z_t) + 0.5}{(1-\delta)^2 q^2_{t+1}}\sigma^2_{t,z}.$$

Crunching a bit further yields Eq. (8).

To establish the mean–variance trade-off result we proceed as follows. To turn Eq. (8) into an explicit expression for π_t, one needs to take into account the dependence of q_{t+1} and e_t on π_t as given in Eqs. (4) and (5). Note that $(v + \pi_t \alpha) q_{t+1}$ and $(v + \pi_t \alpha) e_t$ are linear functions in π_t. Thus, Eq. (8) with the denominator of the right-hand side, and multiplying the result with $(v + \pi_t \alpha)^2$ yields a quadratic equation in π_t, which can be solved, using the usual formulas. Explicitly, one gets

$$A_t \pi_t^2 + B_t \pi_t + C_t = 0 \tag{A.2}$$

where

$$\mathrm{A}_t = (1-\delta)^2 (1-\alpha) D_t \frac{q_t}{z_t} \left(v(1-\delta) q_t + 1 + v + \frac{\mathrm{E}_t[z_{t+1}])}{1-\alpha} \right) - \alpha^2 F_t\,,$$

$$B_t = (1-\delta)^2 D_t \Bigg(v \frac{1-\alpha}{\alpha} \frac{q_t}{z_t} \Bigg(\alpha v (1-\delta) q_t - (1+v)(1-\alpha) - \alpha \mathrm{E}_t[z_t + 1]$$

$$+ 1 + v + \frac{\alpha}{1-\alpha} \mathrm{E}_t[z_{t+1}] \Bigg) + v D_t \Bigg) - 2\alpha v F_t\,,$$

$$C_t = -v^2 F_t,$$

with the abbreviations

$$D_t = (1+v)(1-\alpha) + v(1-\alpha)(1-\delta) q_t + \alpha \mathrm{E}_t[z_t + 1],$$

$$F_t = \eta((1-\delta)(q_t/z_t) + 0.5)\sigma_{t,z}^2.$$

The solutions to Eq. (A.2) are, as usual,

$$\pi_t^{(1,2)} = \frac{-1}{2A_t} (B_t \pm \sqrt{B_t - 4 A_t C_t}).$$

Even though there are two solutions, only one of them is economically meaningful. First note, that for $\sigma_{t,z} = 0$, one of the solution is $\pi_t = 0$, whereas the other solution is $\pi_t < 0$, which is not meaningful. Generally, as long as $\sigma_{t,z}$ is not too large, we have $A_t > 0$, $B_t > 0$ (because there must be a solution at $\sigma_{t,z} = 0$) and $C_t \leq 0$. Hence, we find that exactly one of the two solutions is nonnegative. This is the economically meaningful one due to the positivity of π_t, see Eq. (7).

To show that π_t is increasing in the relative risk aversion η as well the conditional fickleness variance $\sigma_{t,z}^2$, note that $\partial q_{t+1}/\partial \pi_{t+1} < 0$ and that $\partial e_t / \partial \pi_{t+1} < 0$. Thus, implicit differentiation of Eq. (8) delivers the result.

Finally, to calculate the steady state from Eqs. (4) and (5) or Eqs. (6) and (8), exploit $\bar{e} = \delta\bar{q}$ and rewrite Eqs. (6) and (8) as

$$\mathrm{q} = \frac{\chi_1}{\chi_2 + \bar{\pi}},$$

$$\bar{\pi} = \frac{\chi_3 + \chi_4\bar{q}}{\bar{q}(\chi_5 + \chi_6\bar{q} + \chi_7\bar{q}^2)},$$

for some coefficients χ_i, $i = 1, \dots, 7$. Multiplying both equations with their respective denominators leads to the two equations

$$\bar{\pi}\bar{q} = \chi_1 - \chi_2\bar{q},$$

$$\bar{\pi}\bar{q}(\chi_5 + \chi_6\bar{q} + \chi_7\bar{q}^2) = \chi_4 + \chi_5\bar{q}.$$

Use the first equation to replace $\bar{\pi}\bar{q}$ in the second to obtain a third-order polynomial in $\bar{q}$.

Appendix B. Solving the model of Section 3

The behavior of the economy can be summarized by the following four equations:

$$d_t = (1 - \alpha\mu)q_t^{\omega}, \tag{B.1}$$

$$s_t = d_t + \frac{1-\delta}{R}\,\mathrm{E}_t[s_t + 1], \tag{B.2}$$

$$q_t = Az_t^{\theta} + (1-\delta)q_{t-1}, \tag{B.3}$$

$$R/r = \theta A z_t^{\theta - 1} s_t. \tag{B.4}$$

Since this is a growing economy, these equations are not yet in a form suitable for dynamic analysis. It turns out to be convenient to consider transformations of the variables instead. We will use the first Eq. (B.1) to replace q_t with a function of d_t everywhere,

$$q_t = \left(\frac{d_t}{1 - \alpha\mu}\right)^{1/\omega}.$$

Let

$$\gamma_t = d_t/d_{t-1}$$

be the *growth rates of dividends*, let

$$\rho_t = s_t/d_t$$

be the *price–dividend ratio* and let

$$\xi_t = z_t^{\theta\omega}/d_t = z_t^{1-\theta}/d_t,$$

keeping in mind Eq. (9). We shall call this variable the *funding ratio* as it is the ratio of a (transformation) of the funding z_t to the dividends d_t paid per project. With these new definitions, the second Eq. (B.1) can be written as

$$\rho_t = 1 + \frac{1-\delta}{R}\,\mathrm{E}_t[\rho_{t+1}\gamma_{t+1}] \tag{B.5}$$

while Eq. (B.3) becomes

$$1 = A(1-\alpha\mu)^{1/\omega}\xi_t^{1/\omega} + (1-\delta)\gamma_t^{(-1/\omega)} \tag{B.6}$$

and Eq. (B.4) yields

$$R/A\theta r = \rho_t/\xi_t. \tag{B.7}$$

The dynamics can be collapsed into a single equation in γ_t. To do so, solve Eq. (B.6) for ξ_t and use it as well as Eq. (B.5) to express both ξ_t and ρ_t as functions of γ_t. Replacing ξ_t and ρ_t in Eq. (B.5) and multiplying with common terms yields

$$(1-(1-\delta)\gamma_t^{(-1/\omega)})^{\omega} = \frac{(1-\alpha\mu)A^{1+\omega}\theta r}{R} + \frac{1-\delta}{R}\,\mathrm{E}_t[(1-(1-\delta)\gamma_{t+1}^{(-1/\omega)})^{\omega}\,\gamma_{t+1}]. \tag{B.8}$$

Solving this equation for γ_t yields

$$\gamma_t = \left(\frac{1-\left(\dfrac{(1-\alpha\mu)A^{1+\omega}\theta r}{R} + \dfrac{1-\delta}{R}\,\mathrm{E}_t\,[(\gamma_{t+1}^{1/\omega}-(1-\delta))^{\omega}]\right)^{1/\omega}}{1-\delta}\right)^{-\omega} \tag{B.9}$$

and thus Eq. (11).

To find the steady state, drop the time subscripts in Eq. (B.8). Sorting terms yields

$$\frac{(1-\alpha\mu)A^{\omega+1}\theta r}{R} = \left(1-\frac{1-\delta}{R}\,\bar{\gamma}\right)(1-(1-\delta)\,\bar{\gamma}^{(-1/\omega)})^{\omega}$$

as claimed in the text. This equation needs to be solved for $\bar{\gamma}$: We will use graphical and numerical solution methods.

Given some steady state $\bar{\gamma}$, define for abbreviation purposes

$$\chi = (1-\delta)\bar{\gamma}^{(-1/\omega)}.$$

The other steady-state values can now be obtained from Eqs. (B.5) and (B.6). One gets

$$\bar{\rho} = \frac{1}{1 - \frac{1-\delta}{R}\bar{\gamma}}, \tag{B.10}$$

$$\bar{\xi} = \frac{(1-\chi)^{\omega}}{A^{\omega}(1-\alpha\mu)}. \tag{B.11}$$

To analyze the dynamics, loglinearize Eq. (B.8) around a steady state. After some calculations, one obtains

$$\hat{\gamma}_t = \varphi \mathrm{E}_t[\hat{\gamma}_{t+1}] \tag{B.12}$$

where

$$\varphi = \frac{1-\delta}{\chi R}\bar{\gamma} = \frac{\bar{\gamma}^{1/(1-\theta)}}{R}.$$

To solve for $\hat{\xi}_t$ and $\hat{\rho}_t$, one can use loglinearized versions of Eqs. (B.5) and (B.6). One obtains

$$\hat{\xi}_t = \frac{\chi}{1-\chi}\hat{\gamma}_t, \tag{B.13}$$

$$\hat{\rho}_t = \frac{\chi}{1-\chi}\hat{\gamma}_t. \tag{B.14}$$

Thus, let $\hat{\zeta}_t$ be the log-deviation of z_t/d_t from its value along the balanced growth path[7] and let $\phi_t = \hat{\zeta}_t - \mathrm{E}_t[\hat{\zeta}_t]$ be the fickleness shock. Since $\hat{\xi}_t = (1-\theta)\hat{\zeta}_t$, it follows from Eq. (B.13), that

$$u_t = \frac{\chi}{(1-\theta)(1-\chi)}\phi_t$$

and thus Eqs. (15) and (16).

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