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Efficiency, Depth and Growth: Quantitative Implications of Finance and Growth Theory*

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ABSTRACT

We develop a parsimonious finance and endogenous growth model with microeconomic frictions in entrepreneurship and a role for credit constraints. We demonstrate that though an efficiency-growth relation will always exist, the efficiency-depth-growth relation may not. This has implications for the connection between the theory and empirics of finance and growth. We go on to ask whether the model can account for some historical trends in growth, financial depth and financial efficiency for the UK over the period 1850--1913. The best model of finance and growth is one that departs from the standard depth-growth link.

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1 Introduction

The connection between finance and economic growth has been the subject of increasing attention over recent years. The majority of this attention has been on its empirical aspect, however. Though the implications of the empirical results cannot be taken without qualification, the core messages emanating from this research have been consistent and forceful. It has been shown that the extent of financial development in an economy is related to the level of sustained economic growth.

Work such as King and Levine (1993a) has gone so far as to suggest that we can draw predictions about the rate of economic growth over ten to thirty years based on the extent of financial depth. Those sorts of implications, and those of succeeding papers,¹ are open to further validation: In short, are they realistic? Driffill (2003), among others, suggests that they are not, partly because of the strength of outliers (specifically, the Asian ‘tiger’ economies) in driving the results, and partly because of the simple implausibility of the predictions. There has been some further dissent,² but on the whole, as suggested by Beck and de la Torre (2006, p.1), the “causal link running from financial depth to growth has been rather convincingly established.”

At the same time as finding positive relationships between financial development and economic growth, work such as King and Levine (1993b) seeks to bolster empirical findings with the development of theory relating financial matters to the determinants of growth. The tacit implication is that the empirical findings are supported by, and support, the theoretical results. But while the empirics typically consider cross-section regressions on aggregate financial depth, the theories relate measures of financial efficiency to economic growth. In these theories, there is assumed to be some wedge between savings and investments which acts to reduce the rate of technological progress or human capital accumulation by dampening entrepreneurial or educational activities. In order to consider results from each approach as a single body of research, the connection between these frictions and the level of aggregate depth then needs to

¹See, *inter alia*, Levine and Zervos (1998), Beck et al. (2000) and Demirgüç-Kunt and Levine (2001).

²Such as Manning (2003) and Trew (2006).

be made explicit.

In this paper we begin to address the absence in the theoretical literature of any quantitative, and therefore testable, implications. By developing a model that does have quantitative implications, we can look at the connection between theoretical and empirical findings. We calibrate the model to historical data and draw conclusions on the quantitative performance of the theory.

It will be argued that balanced growth actually implies that the economy needs to obtain a constant level of financial depth. We will see that greater financial efficiency, as normally understood, must be associated with *lower* financial depth. But the theory tells us that growth is increasing in efficiency; the data tells us that growth is increasing in depth. That apparent contradiction can only be resolved if we look at the connection between efficiency and depth. Work such as Rousseau (1998) has established, theoretically and empirically, a channel through which changes in financial efficiency can have a permanent effect on depth. In the context of growth empirics, Jayaratne and Strahan (1996) have also looked at efficiency and depth in isolation, using a specific natural experiment. That paper argues that, empirically, growth improvements arose from increases in efficiency, not financial deepening. More recently, Rousseau and Wachtel (2006) consider changes in the relationship between depth and growth, and show that it does not always exist over time. In general, then, the theory linking efficiency to growth cannot without qualification be held to support the numerical implications of empirical work based on depth. Growth, efficiency and depth interact in ways not yet fully accounted for in extant finance and growth theory.

The empirical literature has moved toward increasingly rich analyses. Demirgüç-Kunt and Levine (2001) considers the finance-growth nexus using firm-level and economy-wide panel data, while work such as Beck et al. (2005) has looked at the differing impact of financial development on firm size and growth. A number of papers have also begun to consider factors which determine the efficacy of finance in influencing growth. Beck and Levine (2005) and Bordo and Rousseau (2006) are examples in the context

of legal origin. Theoretical work³, on the other hand, has continued to focus on the juxtaposition of cross-sectional econometrics and theory without explicitly assessing the quantitative connection between them. There is, in this approach, no calibration of theoretical results to empirical facts, and no attempted simulation of time paths or cross sections found in the data.

This paper reduces some of the key mechanisms at work in a number of prominent theories of finance and growth to a single model that can be calibrated to data. The simplicity of the resulting model reflects the stripped-down nature of our approach. The intention is to develop quantitative implications which are transparent enough to allow an interpretation in terms of historical growth paths.

We first provide in Section 2 a brief survey of a number of key theoretical contributions, and argue that they can be considered in the context of a small number of core mechanisms. We develop in Section 3 a simple finance and endogenous growth model in the manner of King and Levine (1993b). Section 4 then uses this representative model to conduct a number of quantitative tests using historical series for growth, depth, efficiency and TFP. Section 5 concludes with our main findings.

2 The Prevailing Mechanics of Finance and Growth Theory

Our intention is to reduce the most commonly cited finance and growth theories down to their core, laying bare the central mechanisms through which finance is said to influence the rate of economic growth. We do not derive an empirically motivated theory; we intend only to reflect the prevailing state of thought in finance and growth theory. In doing this, we will then be in a position to test our representative theory in the light of its implications for time-series growth paths.

The emergence of the new growth literature has placed the accumulation of technology or human capital at the heart of the growth process. It has become straightforward

³With the clear exception of Townsend and Ueda (2006).

to introduce this or that friction into the intermediate, quality-enhancing sector and so demonstrate that there can be real consequences for the long-run growth of an economy. For financial matters to have an impact on growth, we need to introduce frictions between those who save and those who wish to invest. Such frictions motivate the existence of specialised financial structures, the efficacy of which enters into the rate of human capital or technology accumulation and so has an indirect impact on the level of sustained growth.

Capasso (2004) and Levine (2005) go through in some detail the nature of a good deal of the theoretical literature. Microeconomic frictions arise out of the imposition of at least incomplete but also, more typically, asymmetrical information. Wright (2002) has also placed asymmetric information at the heart of the historical finance and growth narrative.

King and Levine (1993b) is the original finance and growth model with adverse selection, in which entrepreneurs are screened by a financial intermediary to determine their quality. The screening is costly, and the chosen entrepreneurs develop better quality intermediate goods with some known probability. In Bose and Cothren (1996), banks can choose potential creditors with either a costly screening technology or by designing a separating contract, or by a mix of the two. Models that motivate financial structures by the presence of moral hazard include Blackburn and Hung (1998) and Morales (2003). In each there is a post-contract incentive for agents to either deceive or shirk.

In addition to asymmetric information, the imposition of a simple credit constraint has been shown to play an important role, though this aspect is only rarely emphasised. Aghion et al. (2005) demonstrate that imperfect creditor protection can determine the availability of capital to potential entrepreneurs. This can have a knock-on effect on growth and, in that model, convergence to the technological frontier. Acemoglu and Zilibotti (1997) develop a model in which minimum investment requirements mean that agents cannot always insure against the risk involved in investing in high-return projects. A series of positive shocks can cause financial development and economic

development to take-off. The importance of ‘access to finance’ has formed the backbone of recent World Bank research in finance and development. This policy emphasis has not yet been reflected in an analytical synthesis, though Beck and de la Torre (2007) do suggest some potential directions for future research.

We can draw together some key aspects of the mechanisms underlying predominant finance and growth theories. Something akin to entrepreneurship drives the accumulation of either human capital or greater technologies. The efficiency with which the motive to innovate or accumulate translates into actual growth is determined by the ease with which entrepreneurs can obtain finance for their risky projects. With asymmetric information in the financial sector, this efficiency is dependent upon the sophistication of the financial technologies such as screening and monitoring. Further, credit constraints can inhibit the ability of agents to access the financial market. As the economy becomes richer, so it can afford those financial structures that better facilitate higher economic growth.

A recent analysis is that of Townsend and Ueda (2006), which builds on the theory of Greenwood and Jovanovic (1990) to include transitional behaviour. They develop a dynamic general equilibrium model of an economy with evolving levels of financial depth and economic inequality. Financial structures exist because of the imposition of fixed and marginal costs to exchange; i.e., the information problem is not explicit. They compare the quantitative implications of the model to data from Thailand for the period 1976-1997.

To reiterate, the purpose of this paper is to demonstrate the dangers of drawing conclusions from arguments which omit the sort of direct connection between data and theory propounded by Townsend and Ueda (*op. cit.*). A theory of economic growth and financial efficiency, however it is motivated, cannot be held to support, and nor can it be supported by, empirical relationships between measures of aggregate financial depth and economic growth unless connections between depth and efficiency are spelled out.

In Section 3 we develop a model in the spirit of King and Levine (1993b) which links

financial matters to economic growth. The model includes: A role for entrepreneurship in the accumulation of human capital, as facilitated by the existence of an intermediating sector; asymmetric information between intermediaries and entrepreneurs in the form of adverse selection; and constraints on an able agent's access to finance. We invoke a model in which entrepreneurs wish to obtain finance for investment in their own human capital, rather than for an addition to technology. It will be clear that for our purposes the difference of each approach is minimal. Using this model, we embark upon some quantitative tests. We draw out the numerical implications of our representative model using historical series for financial depth, TFP, economic growth and a proxy for efficiency.

3 A Representative Model of Finance and Growth

The purpose of this section is to outline a simple version of an endogenous growth model that can capture the principle mechanics of significant theoretical models. We calibrate the model to historical data for the UK and so trace out the implied 'transition path' for financial efficiency over the period of the industrial revolution.

The mechanism by which finance affects long-run growth follows the trend suggested by the theories discussed in Section 2: Ever since King and Levine (1993b), the majority of theories linking finance to growth revolve around entrepreneurship and either human capital accumulation or technological progress. We adopt that perspective also. In addition, we assume that there can be arbitrary credit constraints. By appropriately calibrating this model, we will be able, in Section 4, to consider the theoretical relationship between depth, efficiency and growth in the light of predominant econometric results.

3.1 Financial Intermediation and Growth

In the model of King and Levine (1993b) intermediaries are effectively venture capitalists that have the technology necessary to screen potential entrepreneurs who are

then employed and given funds to run a research project. The fruit of such labour is an addition to the stock of knowledge (specifically, via a quality-ladders setup *à la* Grossman and Helpman, 1991). Post-screening, the intermediary knows with certainty the ability of the applicant. There is no costly effort (so no moral hazard), and the intermediary market is perfectly competitive.⁴ Reductions in the cost of screening or in the tax on intermediary profits thus increase the efficiency of the financial sector, increase the rate of technological progress and so increase the rate of long-run growth. On top of this cost, we allow for the existence of simple credit constraints: An agent is not necessarily *able* to enter the financial market.

3.1.1 Outline

In this model firms demand physical capital and human capital. We have a continuum of agents in each household of total mass one, and a random distribution of type within each. If we assume a large number of households then in the aggregate we can work with the average distribution of type within a given household. So, on average, a proportion φ_1 has no ability to acquire human capital whatsoever, a proportion φ_2 has low ability Λ' and the remainder, proportion $\varphi_3 = 1 - \varphi_1 - \varphi_2$, has high ability $\Lambda > \Lambda'$. It is important that able agents do not know their own level of ability, only that they have some.⁵ Agents with no ability take household responsibility for selling physical capital to firms. Only agents with high ability have the potential to develop human capital; intermediaries wish to screen potential entrepreneurs before funding them. We will assume that intermediaries always prefer screening to blind selection.

We suppose that only a proportion, λ , of the agents with some ability can access the financial market; this proportion is independent of agent type. All agents with nonzero

⁴A related model in Trew (2007) extends that presented here to include moral hazard considerations. That work also shows that we can model related connections between depth, efficiency and growth within a quality-ladders framework with imperfect competition in intermediate sectors. The usefulness of such a model for quantitative testing is limited by the additional complexity, however (simply put, there are too many free parameters). We therefore restrict our attention to the model in which quantitative mechanisms are most transparent.

⁵If agents knew their level of ability, given that the screening technology of the intermediary identifies ability with precision, and given also that agents know this, there would be no reason for those with less than high-ability to apply.

ability who also have access to the credit market apply to a financial intermediary to be screened. Those that are rejected do not contribute to household income. Those that are accepted are consequently funded by the intermediary to acquire education or conduct research, becoming human capital with fixed probability β . In the case of education this might reflect the likelihood of not dropping-out; in the case of research this might reflect the probability of useful innovation. Either way, we obtain the same result. Those that fail to develop human capital contribute nothing to household income, those that do develop human capital are consequently employed by firms and enter the production function as human capital. In the event that the agent succeeds in acquiring human capital it is the researcher that owns the human capital, paying a proportion t of income from human capital to intermediaries. The intermediary thus sets t^* to maximise expected profits.

3.1.2 Firms

Firms use human capital, H , and physical capital, K , as inputs to the production process, $Y_t = AK_t^\alpha H_t^{1-\alpha}$.⁶ Each firm maximises profits, $\pi_t = Y_t - rK_t - hH_t$, where each takes the rates of return on physical capital, r , and human capital, h as given: $r = \alpha(Y_t/K_t)$ and $h = (1 - \alpha)(Y_t/H_t)$. We can use the equation for h to obtain the firm's demand for human capital, $H_t = [(1 - \alpha)Y_t]/h$, which, upon substitution into the production function, obtains a form of the familiar Ak endogenous growth setup,

$$Y_t = \left[A \left(\frac{(1 - \alpha)}{h} \right)^{1-\alpha} \right]^{\frac{1}{\alpha}} K_t. \quad (1)$$

Once we have found a relationship between the rates of return on human and physical capital, we can treat this model as one in which externalities to production are just enough to generate constant returns and 'Ak' growth. Following Barro and Sala-i-Martin (2004), we can then think of K as something like a proxy for a composite

⁶In order to more faithfully reflect King and Levine (1993b), we might have thought of entrepreneurs adding to the stock of knowledge via a compound coefficient of technological progress of the form $Y_t = A\tilde{A}_t^{1-\alpha}K_t^\alpha$. This difference would not matter for the purposes of our simple numerical simulation.

capital variable. In doing so, we assume that the $H : K$ ratio is constant. As in most of the extant theory, transitional dynamics will not exist here.

3.1.3 Intermediaries

The intermediary incurs the cost $f(H) > 0$ to screen agents for ability and funds successful applicants to acquire human capital at cost $x(H) > 0$. Note that these costs are not necessarily invariant to the level of human capital. We make the initial assumption that $f' > 0$ and $x' > 0$, i.e., that the costs of intermediation are increasing in the size of the demand for human capital. So both the outlay required to fund the acquisition of human capital, x , and the cost of screening candidate acquirers of human capital, f , is increasing in the level of human capital – a reasonable assumption if we imagine that the higher the level of human capital aspired to, the more costly it is to both fund and identify suitably able agents. We will consider departures from this in Section 3.2.1.

It is assumed to be better for intermediaries to screen agents than to accept the average. We also require that it is not feasible for households to fund the amount $x(H)$ from their own resources. For a given agent, expected intermediary profits will be the probability-weighted incomes and expenditures. The probability that an agent who applies will be of low ability is $\varphi_2/(1 - \varphi_1)$, in which case only the screening cost is expended. The probability of successfully developing human capital from high-ability agents and thus obtaining a rent from him is $\beta(1 - \varphi_1 - \varphi_2)/(1 - \varphi_2)$. If we assume competition then the expected intermediary profit is zero,

$$\begin{aligned} E(\pi) = & \lambda\beta \left(\frac{1 - \varphi_1 - \varphi_2}{1 - \varphi_1} \right) [thH - x(H) - f(H)] + \\ & + \lambda(1 - \beta) \left(\frac{1 - \varphi_1 - \varphi_2}{1 - \varphi_1} \right) [-x(H) - f(H)] + \\ & + \lambda \left(\frac{\varphi_2}{1 - \varphi_1} \right) [-f(H)] = 0. \end{aligned} \tag{2}$$

If we specify $x(H) = \eta_x hH$ and $f(H) = \eta_f hH$,⁷ where $\eta_x > 0$ and $\eta_f > 0$ are the cost parameters of intermediation, then we obtain the following expression for the fee charged by the intermediary,

$$t^* = \frac{1}{\beta} \left\{ \eta_x + \left[\frac{1 - \varphi_1}{1 - \varphi_1 - \varphi_2} \right] \eta_f \right\}. \quad (3)$$

Equation (3) is increasing in the costs of financial intermediation, η_f and η_x , and in the share of low ability agents, φ_2 , and decreasing in both the probability of human capital creation, β and the share of high ability agents, φ_3 . So t^* reflects the size of the wedge between those who wish to save and those who wish to borrow finance.

3.1.4 Households

The cost $\lambda t^* hH$ is borne by consuming households. The household receives income from physical and human capital, however, at the rates r and h respectively. Using equation (3), the household budget constraint will thus be the familiar $\dot{c}_t + \dot{k}_t = rk_t + \lambda\tau(1 - t^*)hH$. We mirror King and Levine here by incorporating a tax on income from innovation, where $1 - \tau$ is the tax rate applied to household income from human capital. Households maximise the discounted present value of future consumption,

$$\max_{c_t} U = \int_0^\infty e^{-\rho t} u(c_t) dt, \quad (4)$$

where $u(c_t)$ is the instantaneous utility function. If we assume CES preferences of the form $u(c_t) = (c_t^{1-\theta} - 1)/(1 - \theta)$, then we obtain the standard Euler equation governing the growth rate of consumption, $\dot{c}_t/c_t = \theta^{-1}(r - \rho)$.

⁷This means that, simply, we require $(\varphi_2 + \varphi_3)\eta_f < \varphi_2\eta_x$ for the case in which intermediaries always choose to screen. We will consider potential generalisation of these functions in Section 3.2.1.

3.1.5 Equilibrium Growth

In equilibrium we require that the net return on capital is equal to the net return on human capital, i.e., that $r = \lambda\tau(1 - t^*)h$.⁸ From the production function, equation (1) we have the following expression for r ,

$$r = \left[A \left(\frac{(1 - \alpha)}{h} \right)^{1 - \alpha} \right]^{\frac{1}{\alpha}}. \quad (5)$$

By the equilibrium financial intermediation condition, $h = r/[\lambda\tau(1 - t^*)]$, we may solve for the interest rate,

$$r = A[\lambda\tau(1 - \alpha)(1 - t^*)]^{1 - \alpha}. \quad (6)$$

Hence, we have a simple closed-form solution for the equilibrium growth rate,

$$\gamma = \frac{1}{\theta} \{ A[\lambda\tau(1 - \alpha)(1 - t^*)]^{1 - \alpha} - \rho \}. \quad (7)$$

An increase in the efficiency of financial intermediation, by reducing η_f or η_x *ceteris paribus* results in an increase in the equilibrium growth rate by reducing the cost of intermediation, t^* . So there is simply a wedge in between what firms pay for human capital and what agents receive, where the significance of this wedge reflects the efficiency of financial intermediation. This is the main theoretical result of King and Levine (1993b).

3.2 Financial Depth and Efficiency

We can use this simple model to draw-out a preliminary analysis of finance and growth relationships. As noted above, in empirical estimations, measures of financial depth are typically used. By depth is meant some ratio of financial throughput to final output.

We can think, for example, of receipts to the financial intermediary as a proportion of

⁸This is akin to the argument in Tsiddon (1992): “I assume that each financial intermediary can provide a risk-free return to lenders that is equal to or greater than the risk-free rate of return individuals can earn in the market for physical capital. Competition guarantees that each financial intermediary has zero profit.” p. 305

output, and define depth, \mathcal{D}^t , as,

$$\mathcal{D}^t = \frac{\lambda \phi^t t h H}{A K_t^\alpha H_t^{1-\alpha}}, \quad (8)$$

where $\phi^t = \beta \left(\frac{1-\varphi_1-\varphi_2}{1-\varphi_1} \right)$. Using the expression for the return on human capital, this reduces to simply,

$$\mathcal{D}^t = \lambda^{1-\alpha} \phi^t A^2 \left\{ \frac{t^*}{[\tau(1-t^*)]^\alpha} \right\} (1-\alpha)^{1-\alpha} \psi^\alpha, \quad (9)$$

where $\psi = \frac{H_t}{K_t}$. Since we know that H_t and K_t will always grow at the same rate, γ , their ratio will be constant. Plainly, with this measure financial depth is increasing in both η_f and η_x since both serve to increase the perfectly competitive level of t^* , the cost of financial intermediation to agents. In other words, depth is here decreasing in the level of financial efficiency. Before going on to consider this further let us look at another measure of depth: The outgoings of intermediation as a proportion of output, $\mathcal{D}^{f,x}$,

$$\mathcal{D}^{f,x} = \lambda^{1-\alpha} \phi^{x,f} A^2 \left\{ \frac{1}{[\tau(1-t^*)]^\alpha} \right\} (1-\alpha)^{1-\alpha} \psi^\alpha, \quad (10)$$

where now $\phi^{x,f} = \left[\left(\frac{1-\varphi_1-\varphi_2}{1-\varphi_1} \right) \eta_x + \eta_f \right]$. Of course, using the expression for t^* we have that $\phi^{x,f} = \beta \left(\frac{1-\varphi_1-\varphi_2}{1-\varphi_1} \right) t^* = \phi^t t^*$, so $\mathcal{D}^t = \mathcal{D}^{f,x}$. Since the intermediary sector is perfectly competitive, the two measures of depth are identical: Outgoings as a proportion of final output is the same as incomings as a proportion of final output. It is clear that whichever measure we use (or even a sum of debits and credits to intermediaries as a proportion of output), we will arrive at the same efficiency-depth connection.⁹

Let us consider the first measure of depth, \mathcal{D}^t . Equation (9) clarifies a tension between the empirical and theoretical findings of finance and growth. In the extant theory, increases in financial efficiency, however defined, imply greater economic growth.

⁹As mentioned above, we could extend this model to one that incorporates moral hazard and work with measures of monitoring costs, etc., as proxies for financial efficiency. We wish to obtain relatively clear quantitative implications of this representative model, however, so we focus on only a minimum of variables for financial efficiency.

But those increases in efficiency, taken alone, also imply a reduction in financial depth along a balanced growth path. Yet empirically, the level of financial depth is typically taken as a proxy for financial development, and regressed against estimates of economic growth. A positive contemporaneous (and sometime leading) coefficient on financial depth is typically found. The theory and empirics of finance and growth are, from this standpoint, apparently incongruous.

Although we typically assume that estimations using depth are meant as proxies for estimations of financial efficiency, these findings are not necessarily contradictory. Increased depth might result from other factors that also cause growth. The problem arises where we place theories of efficiency alongside the empirics of depth. Furthermore, there is a theoretical literature (which we will come onto below) linking increases in efficiency to increases in the size of the financial sector (though not in the confines of balanced-growth theories). So we should suspect that there is something missing from this representative model.

There is another possibility that has been closed off in this model which might help us to reconcile these issues: The severity of credit constraints might be a function of financial efficiency. Increases in efficiency, if they serve to sufficiently increase access to credit, might then yield a combination of higher growth *and* higher depth. We will come on to this possibility in Section 3.2.2.

It might seem like we could also relate measures of financial efficiency with technological progress, via the coefficient A . As it stands, we have human capital-based endogenous growth; the rate of accumulation reflects the costs of financial intermediation. Alternatively, we could have more explicitly considered technological progress within this set-up (see footnote 6); but this would not serve to modify the requirements for balanced growth. Within this framework, the parameter A captures exogenous TFP; endogenous growth, reflecting the financial efficiency conditions, is captured in the accumulation of human capital.

Before coming to consider the link between efficiency and depth, we must consider how robust this finding is to alternative functional forms for financial costs.

3.2.1 Robustness to Alternative Functional Forms

We have developed what is, in essence, a very stripped-down model of endogenous growth. We could have been more general, however, in specifying the nature of the financial costs incurred by the intermediary. Suppose that we specify $f(H) = h\tilde{\eta}_f(H)$ and $x(H) = h\tilde{\eta}_x(H)$; so now f and x can be any function of H . We might consider that financial costs rise or fall as a proportion of hH as the economy grows. Using equation (2), competitive intermediaries set t^* to maximise expected profits,

$$t^* = \frac{1}{\beta H} \left\{ \tilde{\eta}_x(H) + \left[\frac{1 - \varphi_1}{1 - \varphi_1 - \varphi_2} \right] \tilde{\eta}_f(H) \right\}. \quad (11)$$

Quite clearly, by equation (7), balanced growth is not necessarily obtained in this set-up. For balanced growth, we require t^* to be constant in H , i.e.,

$$\tilde{\eta}'_x(H) - (H)^{-1}\tilde{\eta}_x(H) + \left(\frac{1 - \varphi_1}{1 - \varphi_1 - \varphi_2} \right) [\tilde{\eta}'_f(H) - (H)^{-1}\tilde{\eta}_f(H)] = 0, \quad (12)$$

which, of course, is satisfied when we let $\tilde{\eta}_f(H) = \eta_f H$ and $\tilde{\eta}_x(H) = \eta_x H$. If this is not the case, to recover balanced growth we could relate the size of the economy to endogenously changing levels of access to finance, so $\lambda = \tilde{\lambda}(H)$. We would require $\frac{\partial \tilde{\lambda}}{\partial H} = \frac{\tilde{\lambda}}{(1-t^*)} \frac{\partial t^*}{\partial H}$; in other words, increases in financial efficiency (reductions in t^*) over time must, for balanced growth, be matched by *reductions* in access to finance. This is the opposite to what we would expect, and moves us further away from reconciling the efficiency-depth connection.

An alternative would be to specify $\tilde{\eta}_f(H)$ and $\tilde{\eta}_x(H)$ to offset one another in their impact on t^* , such that, for all H , $(H)^{-1}\tilde{\eta}_x(H) - \tilde{\eta}'_x(H) = \left(\frac{1 - \varphi_1}{1 - \varphi_1 - \varphi_2} \right) [\tilde{\eta}'_f(H) - (H)^{-1}\tilde{\eta}_f(H)]$. The impact on depth is then also neutral, since t^* is simply invariant to H in whichever measure of depth we use. There seems no good empirical justification for doing this, so we concentrate on the simpler set-up with $\tilde{\eta}_f(H) = \eta_f H$ and $\tilde{\eta}_x(H) = \eta_x H$.

In short, balanced growth, *ceteris paribus*, requires a *total* financial cost of proportionate form; balanced growth implies constant financial depth.¹⁰

3.2.2 Efficiency, Depth and Access

Let us return to the case with $\tilde{\eta}_f(H) = \eta_f H$ and $\tilde{\eta}_x(H) = \eta_x H$. Suppose that the proportion of agents that can access credit is a function of a measure of financial efficiency, say $\lambda = \lambda_f(\eta_f)$ with $\lambda'_f < 0$. Rousseau (1998) establishes a theoretical link between the degree of adverse selection in financial intermediation and financial depth by showing that it can determine the size of the pool of applicants. This channel is similarly developed in Aghion et al. (2005), where the degree of creditor protection (taken to be a proxy of financial efficiency) is related to credit constraints, and so also to the size of the financial sector. In the context of growth theory, Greenwood and Jovanovic (1990) and Aghion and Bolton (1997) demonstrate channels through which greater financial sophistication eventually yields greater use of financial services. Rousseau (1998) also supports this relationship empirically, using measures of interest rate spreads to proxy financial efficiency. Using unobservable components models, it is found that a 1% reduction in the loan-deposit spread is associated with increases of between 1.7 and 3.8% in long-run measures of financial depth.

For the purposes of this paper, let us simply posit a relationship between financial efficiency and access to finance. We can then consider, in quantitative terms, the importance of this linkage in reconciling efficiency-depth considerations of finance and growth. Using (9) with $\lambda = \lambda_f(\eta_f)$ we have,

$$\frac{\partial \mathcal{D}^t}{\partial \eta_f} = \Phi[(1 - t^*)\lambda_f]^{-\alpha} \left\{ t^*(1 - \alpha) \frac{\partial \lambda_f}{\partial \eta_f} + [1 + \alpha(1 - t^*)^{-1}] \lambda_f \frac{\partial t^*}{\partial \eta_f} \right\}, \quad (13)$$

where $\Phi = \tau^{-\alpha} \phi A^2 (1 - \alpha)(\psi)^\alpha$. For depth to be increasing in efficiency, we wish to satisfy $\frac{\partial \mathcal{D}^t}{\partial \eta_f} < 0$,

$$t^*(1 - \alpha) \frac{\partial \lambda_f}{\partial \eta_f} < - [1 + \alpha(1 - t^*)^{-1}] \lambda_f \frac{\partial t^*}{\partial \eta_f}. \quad (14)$$

¹⁰There is an analogous requirement for balanced growth in a quality-ladders setup (see Trew, 2007).

The effect of η_f on λ has to be sufficiently negative to outweigh the upward pressure of η_f on t^* . By evaluating $\partial t^*/\partial \eta_f$, and expressing the condition in terms of an elasticity, we obtain,

$$\frac{\eta_f}{\lambda_f} \frac{\partial \lambda_f}{\partial \eta_f} < -\frac{\eta_f}{\phi^t t^* (1 - \alpha)} [1 + \alpha(1 - t^*)^{-1}]. \quad (15)$$

Of course, this does not yield a direct comparison to the empirical relationship found in papers such as Rousseau (1998). We can think of changing η_f as changes in the interest rate spread, because t^* is essentially a wedge between what savers receive and what borrowers pay. But λ_f is not depth; inequality (15) is the condition under which increases in efficiency also increase depth via the credit channel. The elasticity of depth with respect to efficiency is, however,

$$\frac{\eta_f}{\mathcal{D}^t} \frac{\partial \mathcal{D}^t}{\partial \eta_f} = \frac{\eta_f}{\lambda_f} \frac{\partial \lambda_f}{\partial \eta_f} (1 - \alpha) + \frac{\eta_f}{t^*} \frac{\partial t^*}{\partial \eta_f} [1 + \alpha(1 - t^*)^{-1}]. \quad (16)$$

This equation makes clear the conflicting tendencies of greater efficiency to both reduce the costs of intermediation and increase the pool of credit applicants. The overall effect of changes in efficiency on growth are monotonic; the effect on depth is ambiguous. If increases in efficiency cause large increases in the applicant pool relative to decreases in intermediary costs then efficiency and depth will both be positively associated with growth. If the effect on intermediary costs dominates, however, this relation will not hold. Though an efficiency-growth relation will always exist, the standard efficiency-depth-growth relation may not.

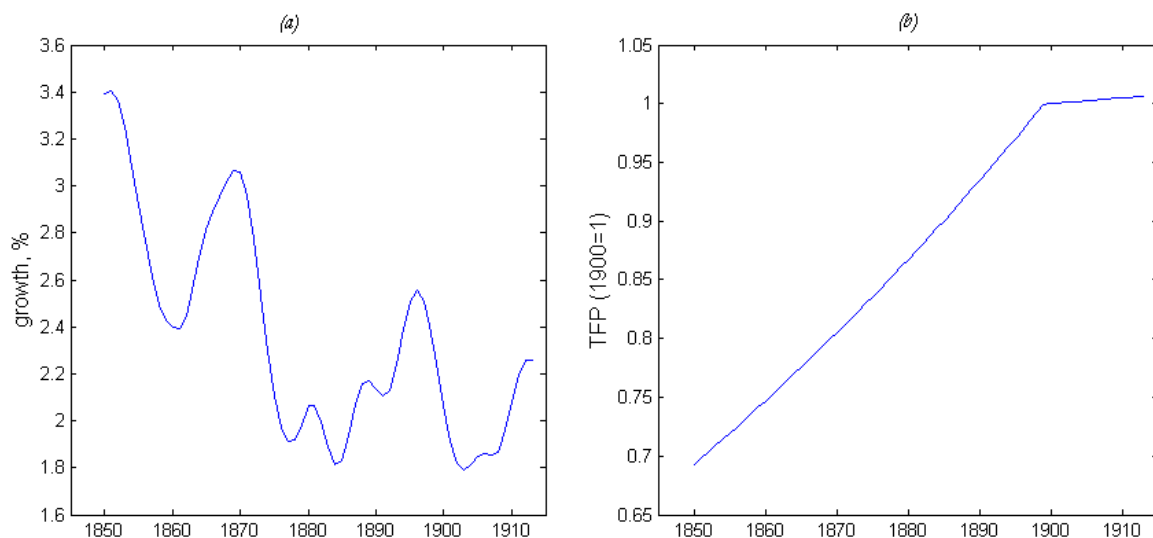
We can now proceed to consider the quantitative implications of our representative model in the light of empirical estimates of the effect of financial efficiency on depth.

4 Quantitative Implications of the Representative Model

We wish to calibrate our representative model and use historical measures of economic growth, financial depth, total factor productivity and financial efficiency (such as loan-deposit spreads) to test its explanatory power under various assumptions. Using such data, we can consider whether our candidate finance and growth model holds up: How closely can it capture actual changes in growth, efficiency and depth? We can also consider the importance of the efficiency-depth mechanism suggested in Section 3.2.2.

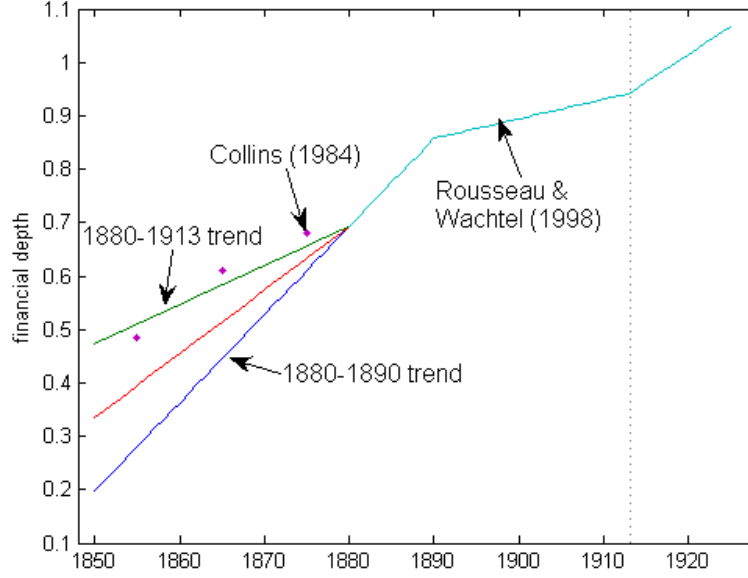
Such data requirements necessitate that we restrict our focus to a relatively short historical period. For the UK we look at the period 1850-1913. Detail of data sources and construction is given in Appendix Section A. Data for growth and TFP can be obtained with confidence from Crafts and Harley (1992) and Crafts (1995). A series for financial depth across 1880–1929 is also available, as in Rousseau and Wachtel (1998). We use this data to estimate the trend rate of change in the level of financial depth prior to 1880. Figures 1 and 2 depict the series we use.

Figure 1: (a) Trend Economic Growth and (b) TFP



Clearly there is a great deal of change in economic growth, even when we extract

Figure 2: Financial Depth

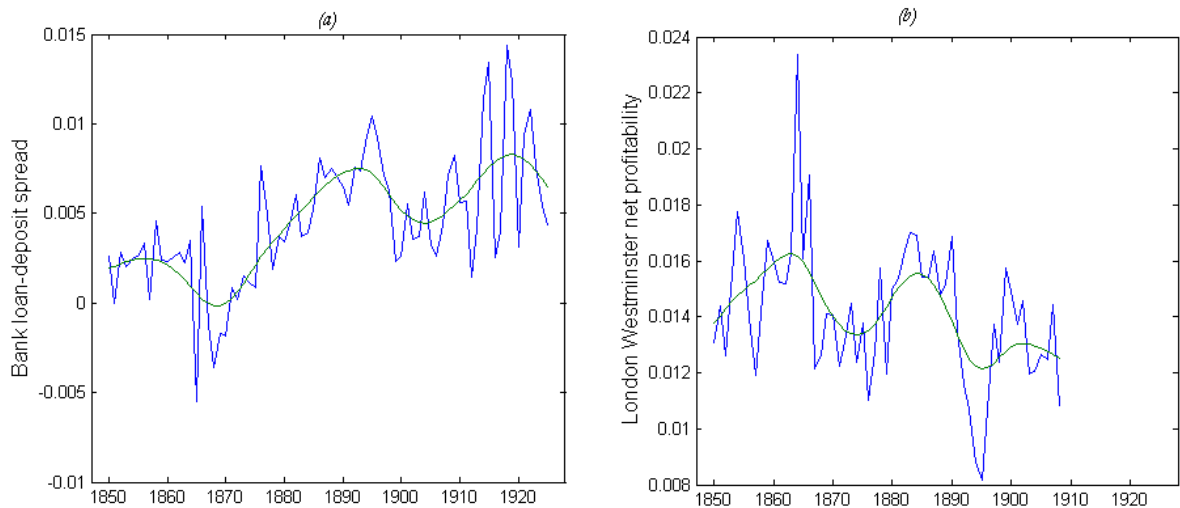


the trend component. Over the period, the general trend in growth is downwards, however. The trend in TFP, however, is plainly upwards. Financial depth is also trending upwards over the period. This runs *against* what we would expect to be the case given the trend in growth. Since the Rousseau and Wachtel (1998) series for depth begins in 1880, we cannot be certain about the level of depth prior to 1880. Instead we note that the trend rate of change in depth appears to be stable; we depict three potential trends for depth: First, using the high rate of change from 1880–1890; second, using the lower rate of change across 1880–1913; third, an average of the first two. This approach is supported by data in Collins (1984), which covers English banking for the period 1840–80. The *trend* in the ratio of Commercial Bank Deposits to Industrial Output using this data is very close the estimate using the low rate of change in Figure 2 – details are in the appendix. Of course, these data are not fully compatible with that in Rousseau and Wachtel (1998), so we take them only as indicative support for our method.

There are only a few options for a financial efficiency measure over this period in the UK. We construct two proxies here: The first is a loan-deposit spread at the Bank

of England derived from Mitchell (1988); the second is the profitability of the London Westminster Bank using data in Gregory (1936). Details of data sources and their manipulation are in the appendix. Broadly speaking, we suppose that the interest rate spread is negatively related to financial efficiency and that the bank profitability is positively related to financial efficiency. Both measures allow us to consider, in the manner of Rousseau (1998), the trend in financial efficiency. Figure 3 depicts the raw series and the Hodrick-Prescott trend. We will be using the trend series as our measures of efficiency.

Figure 3: (a) Bank Loan-Deposit Spread and (b) London Westminster Profitability



Each of our candidate financial efficiency measures in Figure 3 suggests a similar trend: The Bank loan-deposit spread increased over the period; the net profitability of the London Westminster Bank fell. Further, the cyclical movements around this trend match up in a few periods. In other words, both of our proxies suggest that financial efficiency *fell* over the period in question. Of course, we are making the assumption that financial efficiency, as we mean it in the theory, is positively related to bank profitability and inversely related to bank spreads. The implied trend in efficiency might seem surprising; but we shall see that this fits in to our representative model of finance and growth.

We can now conduct a number of quantitative experiments. First, can we match growth rates given observed changes in financial depth and financial efficiency? Second, can we capture the trend in depth by calibrating the model to observed efficiency estimates? In doing this, we can also consider the role of a positive efficiency-depth relationship in the model extension of Section 3.2.2.

4.1 Can we match growth rates given observed depth and efficiency changes?

Let us define the coefficient of technological progress as $A = a\hat{A}$ where a is some constant and \hat{A} is our estimate of TFP. Similarly, let the cost of screening be $\eta_f = f_1\hat{\eta}_{f1}$ where f_1 is some constant and $\hat{\eta}_{f1}$ is our estimate of financial efficiency from the Bank loan-deposit spread. The second measure of efficiency, the London Westminster profitability, should be inversely related to the cost η_f ; so let $\eta_f = f_2(\bar{\eta}_{f2} - \hat{\eta}_{f2})$ where $\hat{\eta}_{f2}$ is our second measure of efficiency and where f_2 and $\bar{\eta}_{f2}$ are constants. In order to match observed changes in depth, we change the credit parameter λ according to,

$$\hat{\lambda}_t = \left[\hat{\mathcal{D}}_t^{-1} \phi_t^t a \hat{A}_t^2 \left\{ \frac{\hat{t}_t^*}{[\tau(1 - \hat{t}_t^*)]^\alpha} \right\} (1 - \alpha)^{1-\alpha} \psi^\alpha \right]^{\frac{1}{\alpha-1}}, \quad (17)$$

where \hat{t}^* evolves according to equation (3). We also require that $\hat{\lambda}_t \in (0, 1]$. It should be noted that this is the *opposite* to the standard depth-growth relation; here changes in financial efficiency are associated with opposite changes in depth according to equation (16) with $\frac{\partial \lambda_f}{\partial \eta_f} = 0$.

Our indirect estimates of the credit constraint come from estimated changes in financial depth which, combined with our estimates for TFP and efficiency, will generate an implied rate of growth, according to,

$$\tilde{\gamma} = \frac{1}{\theta} \left\{ a \hat{A}_t [\hat{\lambda}_t (1 - \alpha) (1 - \hat{t}_t^*)]^{1-\alpha} - \rho \right\}. \quad (18)$$

We choose parameters a , f_1 , f_2 , β , φ_1 and φ_2 in order to obtain a best fit and

set α , θ and ρ to standard values. The value for $\bar{\eta}_{f2}$ is simply fixed at some number greater than $\max\{\hat{\eta}_{f2}\}$. For these simulations we will let $\tau = 1$. The calibration for each simulation is given in Table 1.¹¹

Table 1: Calibrations for the Model of Growth and Depth

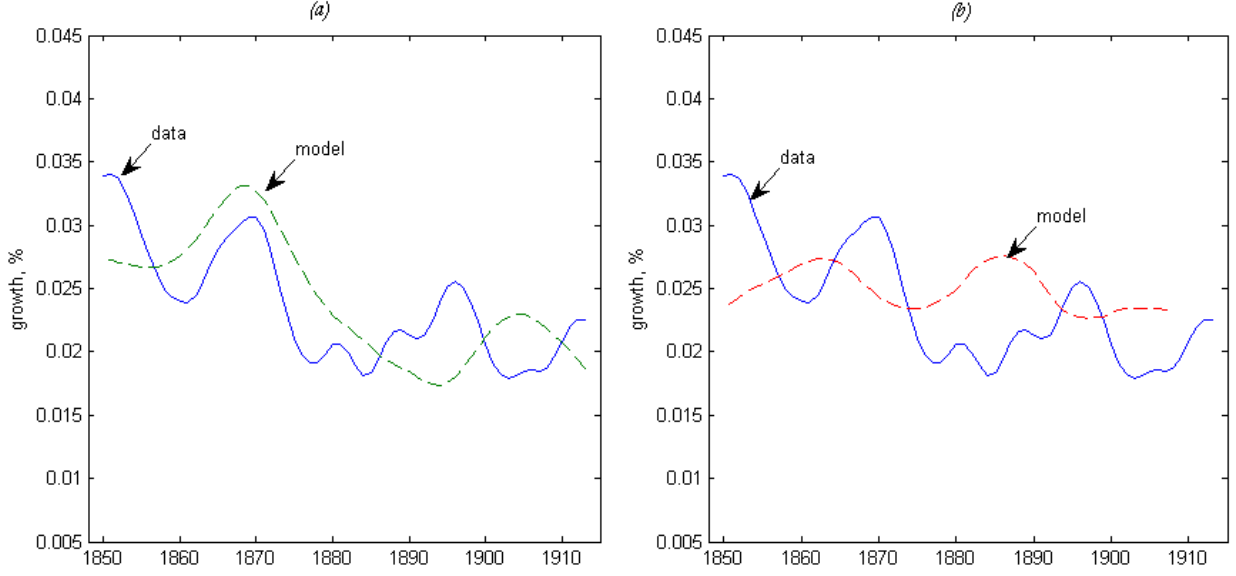
		<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>
capital share	α	0.67	0.67	0.67	0.67
elasticity of substitution	θ	5	5	5	5
subjective discount rate	ρ	0.02	0.02	0.02	0.02
likelihood of success	β	0.4	0.4	0.4	0.4
proportion of zero ability	φ_1	0.4	0.4	0.4	0.4
proportion of low ability	φ_2	0.3	0.3	0.3	0.3
coefficient on TFP	a	3.5	3.5	3.5	3.5
coefficient on screening	f_1	2.5	.	2.5	.
coefficient on screening	f_2	.	1.5	.	1.5
screening parameter	$\bar{\eta}_{f2}$.	0.02	.	0.02
parameter on financial investment	η_x	0.3	0.3	0.3	0.3
credit constraint parameter	λ	.	.	0.01	0.01

Figure 4 shows the model implications for growth using, in panel (*a*), the Bank measure for efficiency (Calibration *I*) and, in panel (*b*), the profitability measure (Calibration *II*). We use the 1880–1913 trend for financial depth back to 1850 since this is closest to the trend suggested in Collins (1984).

The model performance in matching growth rates is generally good. The efficiency measure derived from the Bank rate spread performs well over the period, capturing the downward trend in growth and some of the cyclical movement. The measure derived from the London Westminster Bank profitability performs less well; implied cycles in growth are opposite to those observed in the data. But the implied growth rate does trend downwards. Overall, to some extent we succeed in capturing changes in trend growth. This is not despite but because of the presence of a negative relationship between financial efficiency and depth in our model. As noted above, the trend in depth over the period was upwards, while that of growth was downwards. So the

¹¹The model implications are generally robust to changes in parameter values. Though we choose values here to best fit the *levels* of growth, simulated movements in growth and depth are very robust.

Figure 4: Modelling Economic Growth with Financial Efficiency and Depth



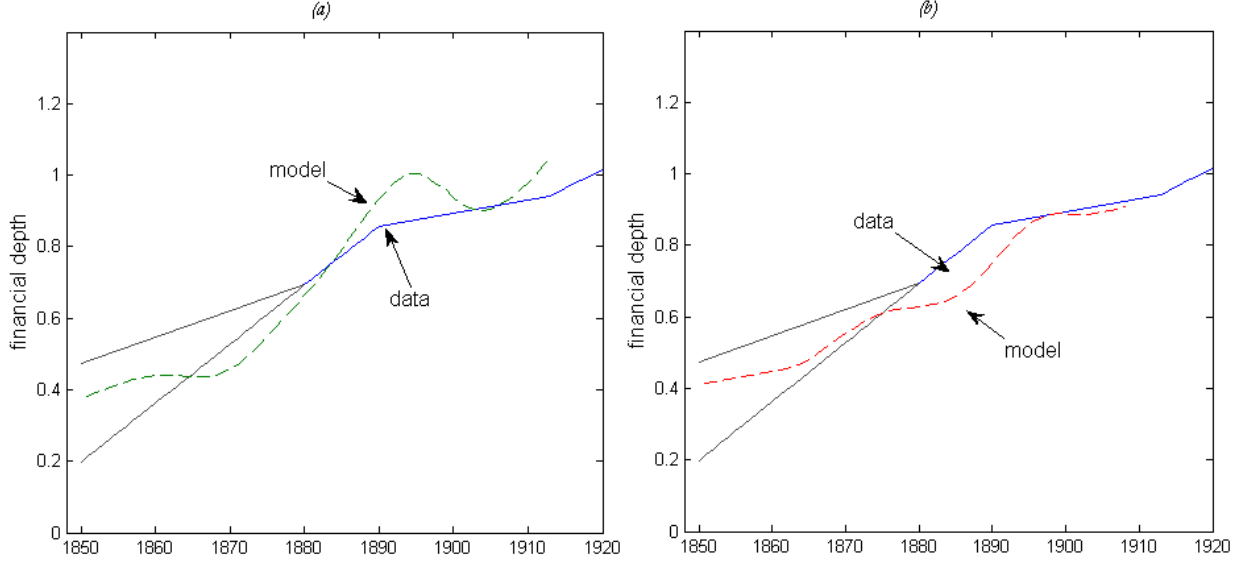
positive relationship between financial efficiency and growth holds up; that between financial depth and growth does not. Recent work by Rousseau and Wachtel (2006) has also suggested that this may indeed be the case.

4.2 Do we match financial depth given observed efficiency?

We can make the point about the relationship with financial depth more clearly by deriving the levels of financial depth which are implied by observed efficiency and TFP values. Using equation (9), we can solve for implied depth from estimates of TFP and efficiency. Figure 5 shows results for the Bank loan-deposit spread (panel (a), Calibration *III* in Table 1) and the London Westminster profitability (panel (b), Calibration *IV*). Clearly, our estimates of efficiency and TFP enable us to match the data on depth very closely.

Suppose instead that we impose a relationship between efficiency and the credit constraint that would result in a positive depth-growth relationship. Consider the model in which the credit constraint is determined endogenously, as in Section 3.2.2. We wish to consider the elasticity of depth with respect to financial efficiency, equation

Figure 5: Modelling Financial Depth with Efficiency and TFP



(16). By imposing this relationship, we capture the channel through which increased efficiency leads to increased depth via its effect on the credit constraint.

But it turns out that we cannot simultaneously match a meaningful negative elasticity¹² between depth and efficiency while also matching growth rates. This should not be surprising. The fit between the model and the data in Figure 5 is good. When we impose a very different relationship between efficiency and depth, we are able to match estimates of neither depth nor growth. We are led to conclude that a model in which we do not impose that efficiency and depth are positively correlated is the one which best fits the data.

5 Conclusion

We have found some support for the view that financial efficiency plays a part in the level of trend growth in an economy. We developed a representative finance and growth model incorporating such an efficiency-growth channel and showed that its numerical implications are broadly in line with the data. The interaction between

¹²I.e., one even barely in accordance with estimations such as those of Rousseau (1998).

growth, efficiency and depth is less straightforward, however. The theoretical model allowed us to identify the channel through which increases in efficiency can increase depth at the same time as growth; but we have also seen that this relies upon credit-effects dominating. The quantitative findings of our model support the view that a positive depth-growth link is absent.

How can we reconcile this with the consistent finding that depth is associated with increased growth? It may be that the finance and growth relationship is not a static one over time, but that it changes as the economy develops or for other, exogenous, reasons. The strength of the credit-channel, through which increases in efficiency lead to increases in depth, might simply be insufficient over the current period of study. But the fact that this is so clearly the case suggests that empirical estimations of the depth-growth link, across time and across countries, might not be the best foundation from which to draw policy implications.

We have not presented an econometric model of finance and growth. Were we to do so, we may indeed find some positive correlation between depth and growth. But within the confines of a theory of endogenous growth, we can only draw conclusions from relationships which are defined within the model. The connection between efficiency and depth must be explicit. The best model of finance and growth is one which departs from the depth-causes-growth result common in most empirical literature. Reconciling the difference between what econometric results consistently find, and what is possible in a model of finance and growth, is a subject for future research.

References

- Acemoglu, D. and Zilibotti, F. (1997). ‘Was Prometheus Unbound By Chance? Risk, Diversification and Growth’. *Journal of Political Economy*, 105(5):709–51.
- Aghion, P. and Bolton, P. (1997). ‘A Theory of Trickle-Down Growth and Development’. *Review of Economic Studies*, 64(1):151–72.
- Aghion, P., Howitt, P., and Mayer-Foulkes, D. (2005). ‘The Effect of Financial Develop-

- ment on Convergence: Theory and Evidence'. *The Quarterly Journal of Economics*, 120(1). 173-222.
- Bairoch, P. (1982). 'International industrialization levels from 1750 to 1980'. *Journal of European Economic History*, 11(1):269-334.
- Barro, R. J. and Sala-i-Martin, X. (2004). *Economic Growth*. MIT Press, 2nd edition.
- Beck, T. and de la Torre, A. (2007). 'The Basic Analytics of Access to Financial Services'. *Financial Markets, Institutions & Instruments*, 16(2):79-117.
- Beck, T., Demirgüç-Kunt, A., Laeven, L., and Levine, R. (2005). 'Finance, Firm Size, and Growth'. Policy Research Working Paper Series. The World Bank. No. 3485.
- Beck, T. and Levine, R. (2005). 'Legal Institutions and Financial Development', in Ménard, C. and Shirley, M. M. (eds.). *Handbook of New Institutional Economics*. Springer.
- Beck, T., Levine, R., and Loayza, N. (2000). 'Finance and the Sources of Growth'. *Journal of Financial Economics*, 58(1-2):261-300.
- Blackburn, K. and Hung, V. T. Y. (1998). 'A Theory of Growth, Financial Development and Trade'. *Economica*, 65(1):107-24.
- Bordo, M. S. and Rousseau, P. L. (2006). 'Legal-Political Factors and the Historical Evolution of the Finance-Growth Link'. NBER Working Paper No. 12035.
- Bose, N. and Cothren, R. (1996). 'Equilibrium Loan Contracts and Endogenous Growth in the Presence of Asymmetric Information'. *Journal of Monetary Economics*, 38(3):363-76.
- Capasso, S. (2004). 'Financial Markets, Development and Growth: Tales of Information Asymmetry'. *Journal of Economic Surveys*, 18(3):267-92.
- Collins, M. (1984). 'The Business of Banking: English Bank Balance Sheets, 1840-80'. *Business History*, 26(1):43-58.
- Crafts, N. F. R. (1995). 'Exogenous or Endogenous Growth? The Industrial Revolution Reconsidered'. *The Journal of Economic History*, 55(4):745-72.
- Crafts, N. F. R. and Harley, C. K. (1992). 'Output Growth and the British Industrial Revolution: A Restatement of the Crafts-Harley View'. *The Economic History Review*, 45(4):703-30.
- Demirgüç-Kunt, A. and Levine, R., editors (2001). *Financial Structure and Economic Growth: A Cross-Country Comparison of Banks, Markets and Development*. MIT Press.
- Driffill, J. (2003). 'Growth and Finance'. *The Manchester School*, 71(4):363-80.
- Greenwood, J. and Jovanovic, B. (1990). 'Financial Development, Growth and the Distribution of Income'. *Journal of Political Economy*, 98(5):1076-1107.

- Gregory, T. E. (1936). *The Westminster Bank: Through A Century*, volume II. Curwen Press.
- Grossman, G. and Helpman, E. (1991). ‘Quality Ladders in the Theory of Economic Growth’. *Review of Economic Studies*, 58(1):43–61.
- Jayaratne, J. and Strahan, P. E. (1996). ‘The Finance-Growth Nexus: Evidence from Bank Branch Deregulation’. *The Quarterly Journal of Economics*, 111(3):639–70.
- King, R. G. and Levine, R. (1993a). ‘Finance and Growth: Schumpeter might be right’. *Quarterly Journal of Economics*, 108(3):717–37.
- King, R. G. and Levine, R. (1993b). ‘Finance, Entrepreneurship, and Growth: theory and evidence’. *Journal of Monetary Economics*, 32(3):513–42.
- Levine, R. (2005). ‘Finance and Growth: Theory, Mechanisms and Evidence’, in Aghion, P. and Durlauf, S.N. (eds.). *Handbook of Economic Growth*. Elsevier.
- Levine, R. and Zervos, S. (1998). ‘Stock Markets, Banks, and Economic Growth’. *American Economic Review*, 88(3):537–88.
- Manning, M. J. (2003). ‘Finance Causes Growth: Can We Be So Sure?’. *Contributions to Macroeconomics*, 3(1):Art.12.
- Mitchell, B. R. (1988). *British Historical Statistics*. Cambridge University Press.
- Morales, M. F. (2003). ‘Financial Intermediation in a Model of Growth Through Creative Destruction’. *Macroeconomic Dynamics*, 7(3):363–93.
- Rousseau, P. L. (1998). ‘The Permanent Effects of Innovation on Financial Depth: Theory and US historical evidence from unobservable components models’. *Journal of Monetary Economics*, 42(2):387–425.
- Rousseau, P. L. and Wachtel, P. (1998). ‘Financial Intermediation and Economic Performance: Historical Evidence from Five Industrialized Economies’. *Journal of Money, Credit and Banking*, 30(4):657–78.
- Rousseau, P. L. and Wachtel, P. (2006). ‘What is Happening to the Impact of Financial Deepening on Economic Growth?’. Stern School of Business, Working Paper 06-15.
- Townsend, R. M. and Ueda, K. (2006). ‘Financial Deepening, Inequality, and Growth: A Model-Based Quantitative Evaluation’. *Review of Economic Studies*, 73(1):251–293.
- Trew, A. W. (2006). ‘Finance and Growth: A Critical Survey’. *Economic Record*, 82(259):481–90.
- Trew, A. W. (2007). ‘Towards the Microfoundations of Finance and Growth’. Unpublished PhD thesis, University of St Andrews.
- Tsiddon, D. (1992). ‘A Moral Hazard Trap to Growth’. *International Economic Review*, 33(2):299–321.

Wright, R. E. (2002). *The Wealth of Nations Rediscovered: Integration and Expansion in American Financial Markets*. Cambridge University Press.

A Data Appendix

Economic Growth. We use here the ‘revised best guess’ from Crafts and Harley (1992, Table A3.I) for the industrial production series. This is a standard reference for such data, and it shows a similar pattern to that in Bairoch (1982). The advantage of the Crafts and Harley dataset is that they provide annual values. We de-trend the output series across the entire period of their data, using a Hodrick-Prescott filter with $\lambda = 100$, before deriving the trend growth rate for 1850–1913.

Total Factor Productivity. We take the growth rates of TFP from Crafts (Table 2) and normalise to 1900=1.

Financial Depth. We use a standard measure of financial depth, the ratio of total financial institutions assets to national output; see Rousseau and Wachtel (1998, Table 1). We linearly interpolate between data values and extend the series back to 1850 using the trend rate of change from both 1880–1890 and 1880–1913. We also give in the paper an unweighted average between the two trend lines. All three lines are shown in Figure 2. We also calculate an estimate for financial depth prior to 1880 using data in Collins (1984). We scale the ratio of Commercial Bank Deposits (Collins, Table 1) to Industrial Output (Crafts and Harley, Table A3.I) so that it is comparable to the Rousseau and Wachtel data. We thus identify that the actual *trend* in financial depth might not be too far from our estimate with the 1880–1913 trend.

Financial Efficiency. The first measure of efficiency takes daily changes in the Bank Rate/Minimum Lending Rate from Mitchell (1988, Table ‘Financial Institutions 14’) and averages across each year for the period 1850–1925. We subtract from the lending rate annual averages in the Rates for Three Months’ Bank Bills (*op. cit.*, Table ‘Financial Institutions 15.B’). We extract the trend from the resulting series using Hodrick-Prescott filter with $\lambda = 100$. The second measure of efficiency is calculated

from data in Gregory (1936, pp. 304–7). For a consistent measure we use only data from the London and Westminster Bank over the period 1850–1908. Our measure of profitability takes the ratio of Net Profits to the sum of consistently available asset series: Cash in Hand and at Bank; Money at Call and Short Notice; Loans and Discounts; and, the sum of Investments. We find the trend component in the same way as before.

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