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**Wirtschaftswissenschaftliche Fakultät  
der Eberhard-Karls-Universität Tübingen**

**Financial Regimes, Capital  
Structure, and Growth**

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**Financial Regimes, Capital  
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# Financial Regimes, Capital Structure, and Growth

by

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## Abstract

We develop a growth model with endogenous technological progress in which the financial sector plays an explicit role. Thereby we discuss the role of different financial regimes in the growth process. We contrast a bank-dominated financial system with a market-dominated system. In the first one a financial intermediary (a bank) is able to solve informational problems, however, at a cost. There is learning by doing in the banking sector. We ask for circumstances under which one of the two regimes emerges. We show that history matters and that the emergence of the low-growth regime is feasible. Furthermore, in a second step we allow for an endogenous capital structure choice of firms and analyze the evolution of the financial system and capital structure over time.

Keywords: innovation, growth, financial regimes, capital structure

JEL-Class.: G20, O31, O41

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# 1 Introduction

The role of financial institutions in economic development and the interaction between growth and financial development have been discussed for a long time (see e.g. Schumpeter (1936)). Recently, a growing empirical literature has stressed the positive effects of financial development on the growth process (see e.g. King/Levine (1993a) and Levine/Zervos (1996)). A by now rather substantial body of theoretical literature (cf., for example, Greenwood/Jovanovic (1990), Bencivenga/Smith (1991), King/Levine (1993b) and Obstfeld (1994)) has outlined various potential channels through which financial developments affect the real sector and the overall growth rate.

Financial systems do, however, not only differ with respect to their degree of sophistication. Rather, we also observe different *types* of financial systems: “[O]ne of the most striking differences between developed countries is the relative importance of financial markets and intermediaries in different countries. At one extreme we have Germany, where a few large banks play a dominant role and financial markets are not very important. At the other extreme is the U.S., where financial markets play an important role and the banking industry is much less concentrated”, as Allen/Gale (1995, p.180) put it. Bank-dominated systems are also found in Japan and, to a lesser extent, in France, while financial-market-dominated systems include Canada and the UK (see also Brealey and Myers (1996, sec. 14-5)). In the bank-dominated system, firms have long lasting financial relationships with banks. With these relationships, very often, the relationship to a single bank is dominant. Naturally, this single bank is quite well informed about the firm’s strengths and weaknesses. In addition, a universal banking system prevails. In the (financial) market-dominated system the banking industry is much less important and characterized by specialized banks (often required by law). The financial market is rather dynamic (e.g. with respect to financial innovations).

Against this background two sets of questions arise. First, with respect to a cross-country analysis, there are a number of questions relating to the causes and effects of different financial systems (calling for a comparative financial systems analysis). For example: what are the causes determining the evolution of different financial systems in a particular country? Is there a tendency towards convergence of the systems? What are the growth effects of different forms of financial systems? The second set of problems relates to the development of financial systems over time in one country and their effects on firms' capital structure and economic growth. How do mechanisms of interaction between real and financial development look like? How does financing of firms and their capital structure evolve over time?

We address these two problem sets in this paper with the help of a growth theoretical, dynamic general equilibrium model in which an explicit financial sector is included. We adopt a basic growth model with endogenous technological progress as pioneered by Romer (1990) and Grossman/Helpman (1991). By allowing for informational problems, financial intermediation becomes useful. Financial intermediation involves monitoring (in an ex-post as well as in an ex-ante sense) of innovative projects. Monitoring innovators is beneficial since the larger the share of financing of innovations through financial intermediaries, the larger the probability of success of R&D projects. However, monitoring is costly, workers employed in financial intermediaries have to paid the going wage. In equilibrium, the benefits and costs of intermediation have to balance. In order to generate interesting patterns of economic and financial development, it is assumed that there is learning by doing (l.b.d.) in financial intermediation: banks' ability to monitor firms is an increasing function of past experience of the banking sector.

In a first specification of the model, there is full specialization: either all funds are channeled from savers to investors via banks or there are no banks at all. The pattern of specialization is dictated by initial conditons. If banks are able monitors initially, then a bank-based financial system emerges, banks become even more productive

due to l.b.d., and the financial sector continues to be dominated by banks. If, on the other hand, banks' productivity is low initially, then the market-dominated regime occurs, banks become even more unproductive because there are no learning effects in banking, and financing via financial markets remains profitable. Because of the presence of l.b.d. effects, specialization in the "wrong" mode of finance is possible. Bank-based finance can occur as a result of suitable initial conditions, even though a higher long-run growth rate might be feasible with financial markets, and vice versa.

In a second step, we address our second issue (evolution of the financial system over time). Assuming diminishing returns to financial intermediation, firms make use of both banks and open markets in order to finance their capital requirements. This scenario is used to provide an explanation of a stylized fact of the evolution of capital structure over time. According to this fact, firms rely in initial stages of a country's development mostly on self-financing, while switching at more mature stages of the country to debt-financing through banks (see Gurley/Shaw (1960) and Demirgüç-Kunt/Levine (1997)). In our model this development is rationalized by the fact that the banking sector becomes eventually more cost-effective, thereby decreasing capital costs of debt contracts. In turn, the volume of debt-financing grows, leading to cost-reductions (via l.b.d.) in the banking sector.

By focusing on the choice between different financial systems and on the evolution of firms' capital structure, our model departs from the existing literature on finance and growth, which is mainly concerned with explaining cross-country differences in long-run growth rates due to differences in financial sophistication within a given financial system (see for example de la Fuente/Marin (1995) and King/Levine (1993b)). An exception to this is the paper of Boyd and Smith (1996) who analyze the coevolution of the real and financial sectors in the economy by allowing for different finance instrument. The intensity of use of these instruments (debt and equity) changes over time in their model. In contrast to our approach, they, however, focus on the evolution of the aggregate composition of financing instruments rather than

at the firm level. Their results differ drastically from ours. They argue that, since financial intermediation associated with debt contracts becomes relatively more expensive, equity finance becomes the dominant mode of finance over time. In contrast, we outline the transition from self-finance to debt finance. In this process, financial intermediation potentially becomes more and more prominent. Furthermore, they adopt a standard neoclassical growth model whereas we focus on the finance of innovation in an endogenous growth framework.

The paper is organized as follows. In the next section, we outline the basic structure of the model. Section 3 contains the comparative financial systems analysis. Among other things, the determinants of resulting financial regimes are asked for. In section 4, we investigate the evolution of a given financial regime over time. In section 5, we discuss our main results and point to some further issues.

## 2 The Basic Set-Up

We consider a closed economy which is inhabited by  $\bar{L}$  households. Each household supplies one unit of labour inelastically and is characterized by the following intertemporal utility function at time  $t$

$$U_t = \int_t^\infty e^{-\rho(\tau-t)} u_\tau d\tau, \quad (1)$$

whereby  $\rho$  denotes the rate of time preference and  $u_\tau$  stands for instantaneous utility at time  $\tau$ . Consumers have a preference for variety which is expressed by the standard CES-function

$$u_t = \ln \left[ \int_0^{A_t} x_t(j)^\alpha dj \right]^{1/\alpha}, \quad \alpha \in ]0, 1[, \quad (2)$$

in which  $x_t(j)$  denotes consumption at  $t$  of the  $j$ -th differentiated good and  $A_t$  stands for the number of differentiated goods which are supplied in the market at time  $t$ .

The optimal intertemporal consumption path can be derived by maximizing the intertemporal utility subject to the intertemporal budget constraint. First, one ob-



tains the familiar Euler equation:<sup>2</sup>  $g_E = r - \rho$ , where  $E$  represents consumption expenditures and  $r$  is the risk-free market rate of interest.<sup>3</sup> We normalize prices such that  $E = 1$  at every moment in time, implying that  $r = \rho$  always holds. Second, one obtains the following demand functions:

$$x(j) = \frac{p_x(j)^{-\epsilon}}{\int_0^A p_x(j')^{1-\epsilon} dj'} \quad (3)$$

with  $p_x(j)$  denoting the price of the  $j$ 'th differentiated good and  $\epsilon \equiv 1/(1 - \alpha) > 1$  the constant elasticity of demand.

The production sector is vertically structured. On top of this vertical structure, differentiated consumption goods are produced with labor only. For one unit of each consumption good one unit of labour is required. In order to be able to produce a differentiated consumption good the respective blueprint is required. This blueprint is developed via R&D efforts. Successful innovators are granted infinitely-lived patents, so that each differentiated product is produced by a single firm only. This firm maximizes static profits by taking (3) into account. Facing the constant elasticity of demand  $\epsilon$ , firms charge the profit-maximizing price  $p_x = w/\alpha$  with a mark-up over their marginal production costs  $w$ . Inserting this equation and (3) into the static profit function  $G = (p_x - w)x$  gives equilibrium profits:

$$G = \frac{1 - \alpha}{A}. \quad (4)$$

The value of a patent is  $v_t = \int_t^\infty e^{-\rho(\tau-t)} G(\tau) d\tau$ . So far we have not deviated from the standard Grossman/Helpman (1991) model.

The costs a firm has to incur so as to acquire a patent are the costs of developing a new brand in the R&D lab. Let  $L_A$  denote the number of employees engaged in R&D. It is assumed that each researcher is able to carry out only one project, which

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<sup>2</sup>For a derivation see e.g. Grossman/Helpman (1991).

<sup>3</sup>In the following,  $\dot{y}$  denotes the time derivative of a variable  $y$  and  $g_y \equiv \dot{y}/y$  stands for its growth rate. As long as it does not cause confusion, we omit time indices.

yields  $AL_A/a$  new blueprints if successful and nothing otherwise. Diversification is not feasible. Letting the probability of success be denoted as  $P$ ,

$$\dot{A} = PAL_A. \quad (5)$$

It is assumed that there are two distinguishable kinds of R&D projects. First, there are projects with success probability  $P = \beta$  whose outcome is costlessly observable, called type- $\beta$  projects. Second, there are projects with success probability  $P = \gamma$ . The result of these projects is observable only via monitoring activities. (In particular, this requires that banks cannot observe whether or not firms to which they have lent funds receive patents.) We call these projects type- $\gamma$  projects and assume  $\gamma > \beta$ , since otherwise there would be no role to play for these projects. Assuming  $\gamma < 1$ , all innovators choosing type- $\gamma$  R&D projects have to be monitored, for otherwise they would claim that their project has failed.<sup>4</sup> Monitoring is performed by competitive financial intermediaries, henceforth often called banks, which at least partially overcome the informational problems associated with type- $\gamma$  projects. However, monitoring involves a cost. Specifically, banks have to employ  $f$  workers in order to monitor one R&D employee engaged in type- $\gamma$  projects. That is, total labor demand of financial intermediaries is  $L_f = fL_A$ .

In order to generate interesting dynamics, it is necessary to allow for some variability in the effectiveness of monitoring. The simplest way to do so is to introduce external l.b.d. effects in the banking sector. As in models of growth through l.b.d. (like Arrow's (1962)), this keeps the analysis tractable because it keeps the banks' decision problem static: since the learning effects are external, no bank has an incen-

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<sup>4</sup>This implicitly assumes that the costs associated with an incentive-compatible contract exceed monitoring costs. In addition, the fact that monitoring of a particular project or firm is undertaken by a single financial intermediary requires that the benefits of delegated monitoring (i.e. the costs savings associated with avoiding multiple monitoring efforts) are larger than the costs of delegation (the costs of controlling the financial intermediary) incurred by depositors of the intermediary (see on all this Diamond (1984)).

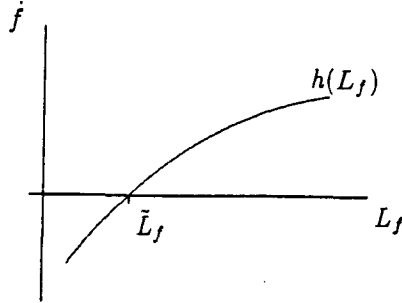


Figure 1: Banks' learning function

tive to invest in experience. Formally, l.b.d. in banking is captured by the following assumption:

**Assumption 1** *Let  $\dot{f} = h(L_f)$  with  $h'(L_f) > 0$  and  $h(\tilde{L}_f) = 0$  for some  $\tilde{L}_f \in ]0, \bar{L}[$ .*

According to Assumption 1, for l.b.d. to take place the intermediation sector has to exceed a certain critical size  $\tilde{L}_f$  (see Figure 1).

There is free entry into R&D and into banking, so that, in equilibrium, the patent value  $v$  is equal to the sum of R&D costs and monitoring costs. All markets always clear.

### 3 Bank-Domination, Market-Domination and Growth

Employing our basic set-up, we now turn to the comparative analysis of financial systems. We compare a bank-dominated financial system with a market-dominated system. In the latter system intermediation does not play a role. We proceed as follows. First, we analyze a bank-dominated system, in which financial intermediation has the task of monitoring innovators (Subsection 3.1). Second, we turn to a market-dominated system, where investment funds are channeled from households to firms

via a financial market (3.2). Finally, we compare the two systems. We ask which one will actually arise and if it is conceivable that the “wrong” system arises (3.3).

### 3.1 A bank-dominated system

In this subsection, the type- $\beta$  projects with costlessly observable outcomes are neglected. As a consequence, all researchers carry out type- $\gamma$  projects and, therefore, have to be monitored. We thus obtain what Allen/Gale (p.181) call the German model: “[T]he German model, loosely based on the actual German economy, is an economy in which financial markets are of limited importance or absent and their place is taken by financial intermediaries such as banks, pension funds, insurance companies and the like.”

With financial intermediation, total costs of innovation (R&D outlays plus monitoring costs) amount to  $c_A \equiv (1 + f)w/(\gamma A)$ . Free entry into innovation and into banking implies that innovative activities are undertaken as long as expected gains from innovation exceed the costs of innovation. In an equilibrium with ongoing innovation expected gains of innovation  $v$  must just equal  $c_A$ . Letting  $V \equiv 1/(Av)$ , the inverse of the total value of all innovating firms,  $v = c_A$  can be written as

$$\frac{1}{w} = \frac{(1 + f)V}{\gamma}. \quad (6)$$

Differentiating the definition of the patent value  $v$  gives us the following no-arbitrage condition, reflecting capital market equilibrium:  $G/v + g_v = \rho$  or, using the profit function (4),

$$g_v = (1 - \alpha)V - \rho - g_A. \quad (7)$$

Furthermore, by our choice of the numéraire,  $Ap_x = 1$ . Therefore, employment in production equals  $L_x = Ax = 1/p = \alpha/w$  or, using (6),  $L_x = \alpha(1 + f)V/\gamma$ . The labor market clears if total labor demand by innovating firms ( $L_A$ ), banks ( $L_f$ ), and producers of differentiated products ( $L_x$ ) is just matched by labor supply ( $\bar{L}$ ). Hence,

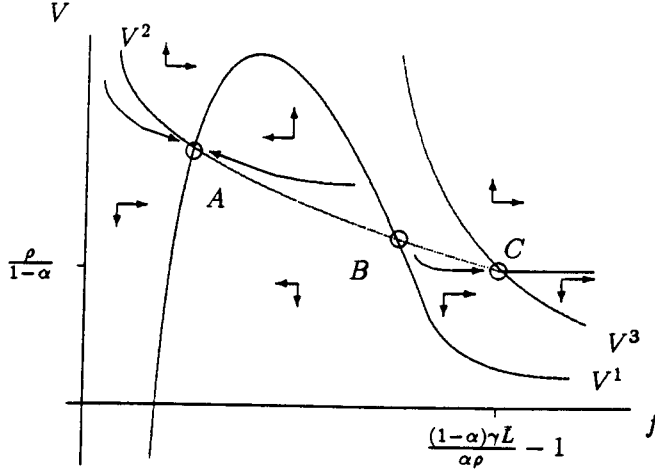


Figure 2: Equilibrium dynamics with a bank-dominated system

using (5),  $L_f = fL_A$  and the expression for  $L_x$ , we have

$$g_A = \frac{\gamma}{1+f} \bar{L} - \alpha V. \quad (8)$$

We can now distinguish two basic patterns. Depending on initial financial sophistication, our economy realizes a time path with positive or zero growth.

Consider first the positive-growth regime. From (8), this scenario emerges if, and only if,

$$V < \frac{\gamma \bar{L}}{\alpha(1+f)} \equiv V^1$$

(see Figure 2). We will describe the positive-growth equilibrium by means of a phase diagram in the  $(f, V)$ -space. One equation in  $f$  and  $V$  alone is obtained by substituting the expression for  $g_A$  in (8) into the no-arbitrage equation (7):

$$g_V = V - \rho - \frac{\gamma \bar{L}}{1+f}. \quad (9)$$

Hence, the  $g_V = 0$ -locus is given by

$$V = \rho + \frac{\gamma \bar{L}}{1+f} \equiv V^2. \quad (10)$$

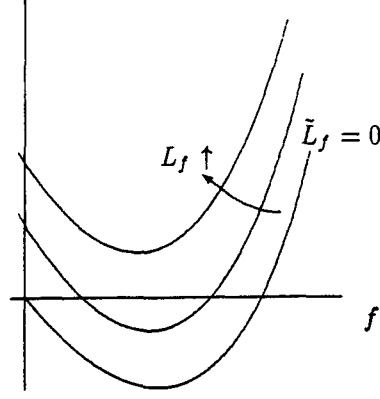


Figure 3: Existence of steady states

Turning to the second stationary locus,  $\dot{f} = 0$  if  $L_f = \tilde{L}_f$  from Assumption 1. Using  $L_f = fL_A$ , the R&D technology (5) and (8), one obtains  $\dot{f} = 0$  if

$$V = \frac{1}{\alpha} \left( \frac{\gamma \tilde{L}}{1+f} - \frac{\gamma \tilde{L}_f}{f} \right) \equiv V^3. \quad (11)$$

$V^3$  approaches minus infinity (zero), as  $f$  goes to zero (infinity). Moreover,  $V^3 < V^1$  for all  $f$ : the  $\dot{f} = 0$ -locus is located below  $V^1$  everywhere.  $V^2$ , on the other hand, intersects  $V^1$  at  $f = (1 - \alpha)\gamma\tilde{L}/(\alpha\rho) - 1$ . It is located below (above)  $V^1$  to the left (to the right) of this intersection. In the steady-state  $V^3 = V^2$  has to hold. Equating these two expression yields a quadratic equation in  $f$ :

$$\Gamma(f) \equiv f^2 - \frac{1}{\alpha\rho}[(1 - \alpha)\gamma\tilde{L} - \alpha\rho - \gamma\tilde{L}_f]f + \frac{\gamma\tilde{L}_f}{\alpha\rho} = 0. \quad (12)$$

The function  $\Gamma(f)$  is represented by an upward-opened parabola (see Figure 3). For  $\tilde{L}_f = 0$ , it has abscissa intersections at  $f = 0$  and at  $f = (1 - \alpha)\gamma\tilde{L}/(\alpha\rho) - 1$ . According to (12), increases in  $\tilde{L}_f$  shift the parabola upwards, thereby shifting the first abscissa intersection to the right and the second one to the left. Abscissa intersections cease to exist when  $\tilde{L}_f$  becomes sufficiently large. We assume that this is not the case:

**Assumption 2**  $\tilde{L}_f$  is sufficiently small, such that (12) has two positive solutions.

Consequently, the  $\dot{V} = 0$ -locus and the  $\dot{f} = 0$ -locus intersect twice in the positive-growth regions, i.e. two steady-state equilibria with positive growth exist. The innovation rate in these equilibria is given by

$$g_A = (1 - \alpha) \frac{\gamma \bar{L}}{1 + f_e} - \alpha \rho, \quad (13)$$

whereby  $f_e$  is the equilibrium administration costs implicitly defined by (12).

We proceed to show that the large- $f$  equilibrium (point  $B$  in Figure 2) is unstable, while the low- $f$  steady state (point  $A$ ) is a saddle point. To see this, note first that the  $g_V = 0$ -locus is unstable: above (below) it  $V$  rises (falls). Second, at all points vertically above the  $\dot{f} = 0$ -locus  $g_A$  is smaller than on the stationary locus (see (8)), so that  $L_f = fL_A = fg_A/\gamma$  is smaller, which implies that financial expertise depreciates:  $\dot{f} > 0$ . Vice versa,  $\dot{f} < 0$  below the  $\dot{f} = 0$ -locus. Figure 2 shows that  $B$  is unstable, whereas  $A$  is a saddle point. Since  $f$  is a state variable, this implies that  $B$  is not an economically meaningful outcome of the model.

The no-growth regime is easily analyzed. Since  $L_f = fL_A = 0$ , financial sophistication depreciates,  $\dot{f} > 0$ ; the economy always moves to the right. The  $g_V = 0$ -locus is given by the horizontal line  $\rho/(1 - \alpha)$ . It is unstable. Note that a saddle path approaches point  $C$ , the no-growth equilibrium point given by the intersection of  $V^2$  and  $V^1$ .

We can summarize our findings in:

**Proposition 1** *Given that the critical employment level in the banking sector is not too large, we find multiplicity of equilibria. Besides a saddle-point stable equilibrium with positive long-run growth, a stable zero growth equilibrium exists. Which one of the equilibria will finally be approached depends on initial condition with respect to the banking sector's productivity.*

This is our first history-versus-expectations result: if banks are too unproductive initially, then growth does not get underway, and banks' productivity declines even further – the economy is locked into a no-growth trap due to lack of financial expertise.

### 3.2 A market-dominated system

So far we have assumed that only type- $\gamma$  projects exists, i.e.:

- innovation projects are financed by loans,
- information acquisition is costly and,
- financial intermediaries (banks) have significant expertise in collecting information.

In this subsection we assume that only type- $\beta$  projects can be carried out. As a result, one obtains a market-oriented financial system, in which

- innovative activities are financed via bonds or equity,
- there are no administrative costs, but,
- the probability of failure,  $(1 - \beta)$ , associated with each R&D-project is larger.

Allen/Gale (1995, p.183) call this the U.S. model: “[T]he U.S. model is (...) an economy in which financial markets play the dominant role and intermediaries are unimportant.”

Setting  $P = \beta$  in (5), we can express the R&D function as  $\dot{A} = \beta A L_A$ . The costs of a successful innovation project then are  $c_A = w/(A\beta)$ , free entry into R&D requires  $c_A = v$  or  $1/w = V/\beta$ . Using  $L_x = \alpha/w$  and  $L_A = g_A/\beta$ , the labour-market clearing condition  $\bar{L} = L_x + L_A$  becomes

$$g_A = \beta \bar{L} - \alpha V. \quad (14)$$

The no-arbitrage equation (7) continues to hold. Together with (14), it determines the equilibrium trajectories of  $g_A$  and  $V$ . The economy jumps into a steady state with  $g_V = 0$  and

$$g_A = (1 - \alpha)\beta \bar{L} - \alpha \rho, \quad (15)$$



which is assumed positive. Comparing the equilibrium rates of innovation in both financial regimes (see (13) and (15)), we find that the speed of innovation in the bank-dominated system exceeds the one in the market-oriented system if the critical employment level  $\tilde{L}_f$  is small (leading to an  $f$  close to zero). In a nutshell, this implies that the bank-dominated system leads to higher growth if its capacity to monitor potential innovators comes into use at sufficiently low costs, leading to a relative better outcome (compared to the market-oriented system) with respect to innovative success.

### 3.3 The possibility of regime switches

Against the background of the two preceding subsections we now pursue the question under which circumstances a regime switch can be feasible. We ask whether it is profitable for individual investors in each of the two financial regimes to enter into the alternative mode of finance.

Given the state of financial development in the banking sector, it is profitable (and hence possible) to enter into a bank-dominated system if and only if the costs of setting up a successful innovation project via the financial market (i.e. with bonds or equity) are smaller than the ones with credit finance. Looking at this choice at a certain point in time  $t$  shows that it is profitable to enter into a bank-dominated system with bond or equity finance if  $v\beta A > w$ . But  $\gamma vA = w(1 + f_t)$  on a bank-dominated growth path (see equation (6)). Hence, entry is profitable exactly if

$$\frac{\beta}{\gamma} > \frac{1}{1 + f_t}. \quad (16)$$

On the other hand, in a market-oriented system (with  $\beta vA = w$ ) entry with credit finance is profitable ( $\gamma vA > (1 + f)w$ ) if and only if

$$\frac{\beta}{\gamma} < \frac{1}{1 + f_t}. \quad (17)$$

Now, assume that banks are initially sufficiently inefficient, such that (16) is valid. Entry into a bank-based system would be possible. Therefore a market-based system emerges. Assuming that the economy jumps into the market-dominated steady state described above,  $\dot{f}$  is negative: expertise in intermediation diminishes because there is no banking. As a result, (16) will be satisfied forever, entry of financial intermediaries remains unprofitable in the future. Thus, a low *initial* productivity in the banking sector dictates the emergence of a market-based system, although the equilibrium rate may be higher with banking provided that the *steady-state* level of  $f$  is sufficiently small. Similarly, assume that (17) is satisfied initially, so that there is financial intermediation. Assume further that  $f$  is above the value which characterizes the steady state with banking and that the economy follows its saddle path in Figure 2. Then  $f$  declines, banks becomes even more productive, (17) continues to hold, and the economy sticks to its bank-based financial system. Nevertheless, the steady state with banking may display slower growth than the steady state with financial markets. This illustrates the possibility that a high *initial* productivity in the banking sector implies the emergence of a bank-based system, although faster *long-run* growth is realized with financial markets. In sum, unfavourable initial conditions may lead to an inferior growth rate regime. History, not expectations, matters in our model.

**Proposition 2** *The long-run growth performance of the bank-dominated regime relative to the one of the market-oriented regime depends on the banking sector's steady-state productivity relative to its monitoring success. Which one of the financial regimes emerges in the long-run, however, depends on initial conditions. With unfavourable initial conditions, the financial regime with the lower long-run growth rate prevails in the long run.*

## 4 Capital Structure and Growth

In the preceding chapter innovation projects were either completely financed with the help of financial markets or with bank credit. In the financial market literature it is, however, argued that in the course of the growth and development process capital structure patterns change significantly. In initial periods of development the main source of firms' finance stems from self-finance (wealth of firm owner and related family as well as retained earnings). In later stages of development bank credits become more and more relevant (see e.g. Demirgüec-Kunt/Levine (1996)). Finally, financial markets (bonds and equity) come into force.

We will try to tackle this issue, especially the transition from self-finance towards debt-finance, by allowing for endogenous capital structure of firms which evolves over time. We concentrate our discussion on the decision of self-financing versus debt finance supplied by financial intermediaries.

The basic idea we want to adopt resembles the one in the last section but goes one step further. We assume that financial intermediaries represent inside investors. They acquire private information about the firms they are investing in.

Financial intermediaries are able to screen potential innovation projects. This screening process is, however, imperfect. By mustering screening effort, banks are selecting more promising innovation projects. In addition, they provide managerial assistance in the course of the R&D process<sup>5</sup>. The more resources the financial intermediaries put into these activities, the larger is the probability of success of the projects supported. We assume that the incentive of investing in screening activities and providing managerial skills increases with the financial intermediaries' share in

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<sup>5</sup>Financial intermediaries have an advantage compared to the entrepreneur which they can contribute into the relationship with the entrepreneur in a number of areas (cf. Sahlman (1990)). Examples are the establishment and refinement of business plans, institutional knowledge (e.g. how to deal with administrative bodies), bringing together management teams, and assisting to introduce new products to the market.

overall finance<sup>6</sup>. This can be justified as follows. The larger the share of external debt finance, the larger is the incentive for banks to invest in increasing the probability of success of the project under consideration since a larger amount of their money is at stake. It becomes more important to select the projects with a high probability of failure or small expected returns.<sup>7</sup> With sufficiently convex costs, however, it is never optimal to ensure a zero probability of failure. Rather than modelling the banks decision problem in detail, we use, for matters of simplicity, our framework of the preceding section to represent this idea. We assume that the probability of success of an innovative project increases at a decreasing rate with the share of the external debt finance of the project,  $\phi$ , leading us to the following R&D function

$$\dot{A} = \gamma(\phi)AL_A, \quad (18)$$

with  $\gamma' > 0$  and  $\gamma'' < 0$ .

The costs of achieving with the higher share of external debt finance a higher probability of success increase with the bank's share of involvement in project finance. More precisely, financial intermediaries employ  $\phi fL_A$  workers in order to achieve the higher probability of success. With respect to these costs *Assumption 1* applies. Hence, total costs of a successful innovation project are:

$$c_A = \frac{(1 + f\phi)w}{\gamma(\phi)A}. \quad (19)$$

The potential innovator's objective function with respect to funds from the financial intermediary is her expected net gain from the project. The innovator chooses the optimal share of funds from the financial intermediary such that the difference between expected gains from the project ( $\gamma v$ ) minus costs  $(w(1 + f\phi))/A$  is maximized.

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<sup>6</sup>The remaining share of finance is provided by private investors (family, business angels) or stems from earnings of the entrepreneur from other successful projects or her initial wealth.

<sup>7</sup>In the latter case, the probability of failure used in our formal analysis in the following is a short-cut of the expected payoffs of the entire project under consideration.

Hence, we find for the first order condition (FOC) with respect to the optimal share of the intermediary in project finance:

$$\gamma'v - \frac{w}{A}f = 0. \quad (20)$$

Owing to free entry in the R&D-sector, the value of a successful innovation project,  $v$  is equal to its costs,  $c_A$ . Plugging this into the FOC reveals that value maximization of the innovating entrepreneur just corresponds to the minimization of R&D costs.

Inserting our modifications in this section into the basic structure of the model outlined in section 2 allows us to restate the crucial equations in the following manner. For the labor market clearing condition we find:

$$\bar{L} = \alpha V \frac{1+f\phi}{\gamma} + g_A \frac{1+f\phi}{\gamma}, \quad (21)$$

and hence,

$$g_A = \frac{\bar{L}\gamma}{1+f\phi} - \alpha V. \quad (22)$$

Furthermore, we can express the no-arbitrage condition as

$$g_V = V - \rho - \frac{\bar{L}\gamma}{1+f\phi}. \quad (23)$$

We concentrate only on the positive growth and innovation regime. We find the steady state with positive innovation at the intersection of the two isoclines,  $\dot{f} = 0$  and  $\dot{V} = 0$ . Plugging (22) into the differential equation describing the evolution of  $f$ , we find as a condition for  $\dot{f} = 0$ :

$$V^4 = \frac{1}{\alpha} \left( \frac{\bar{L}\gamma}{1+f\phi} - \frac{\tilde{L}_f}{f\phi} \right). \quad (24)$$

Solving (23) for  $\dot{V} = 0$  yields:

$$V^5 = \rho + \frac{\bar{L}\gamma}{1+f\phi} \quad (25)$$

In the long-run equilibrium  $V^4 = V^5$  has to hold.

In order to analyze our set-up more explicitly, we introduce now an explicit  $\gamma$  function which has the property that the probability of failure increases at a decreasing rate with the degree of involvement of the intermediary. In addition, at the two extremes,  $\gamma(0) = 0$  and  $\gamma(1) = 1$  has to hold. The function

$$\gamma = 1 - (\phi - 1)^2 \quad (26)$$

has all these properties.

Using (26) in (20) and solving for the optimal  $\phi$  gives us<sup>8</sup>

$$\phi^* = (\sqrt{1 + 2f} - 1)f^{-1}. \quad (27)$$

With our screening technology the second order condition holds. Differentiating (27) yields  $\partial\phi^*/\partial f < 0$ . The more productive the financial sector the larger the share of the financial intermediary in project finance.

Equating (24) with (25) gives us the following condition for a steady-state equilibrium with positive innovation rates:

$$\tilde{\Gamma} \equiv \frac{1}{\alpha} \left( \frac{\bar{L}\gamma(\phi^*)}{1 + f\phi^*} - \frac{\tilde{L}_f}{f\phi^*} \right) - \rho - \frac{\bar{L}\gamma(\phi^*)}{1 + f\phi^*} = 0, \quad (28)$$

whereby  $\phi^*$  is given by (27).

The  $\dot{V} = 0$  line has the same shape as the one in chapter 3. This can be seen by noting that  $\text{sign}(\partial\gamma/\partial f) = \text{sign}(\partial\phi^*/\partial f) < 0$  and that  $f\phi^* = \sqrt{1 + 2f} - 1$  with  $(\partial f\phi^*)/\partial f > 0$ .

The same is true for the second isocline. The  $\dot{f} = 0$  line is characterized by the same basic shape as the one in figure 1. Note that  $f\phi^*$  approaches 0 with  $f$  approaching zero and hence  $V^1$  approaches  $-\infty$ . With an increasing  $f$ ,  $V^1$  increases, cutting eventually (given that  $\tilde{L}_f$  is not too large) from below. Numerical analysis

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<sup>8</sup>There is a second solution to the resulting quadratic equation which is, however, negative. Furthermore, (27) holds if  $f$  is not too small, giving us a  $\phi^* \in ]0, 1[$ . With a large  $f$  we get corner solutions ( $\phi = 1$ ).

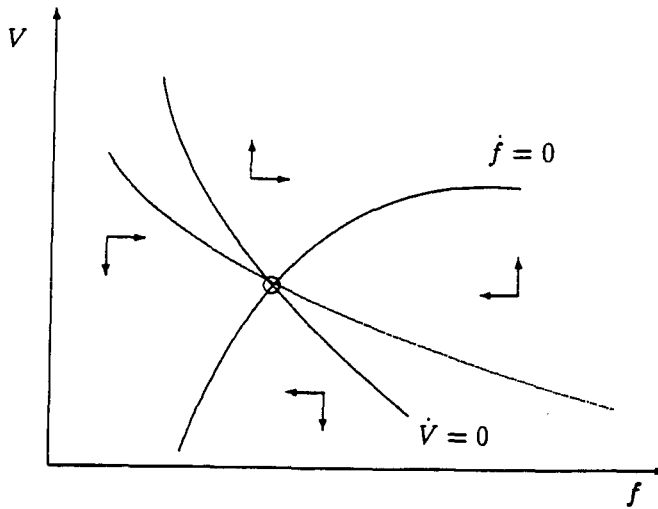


Figure 4: Equilibrium dynamics with endogenous capital structure

reveals that in this case there exists a second intersection. Since this equilibrium is, however, an economically uninteresting unstable node, we concentrate on the first point of intersection. This equilibrium and the related equilibrium dynamics are depicted in figure 4.

The equilibrium is approached on a unique path, i.e. it is saddle point stable. Starting with a rather unproductive banking sector, the economy accumulates knowledge in the financial sector along this path and productivity of the financial intermediation sector increases. At the same time the capital structure of firms changes leading to a higher degree of financing via the financial intermediary. Minimization of expected costs of a successful R&D project calls for a larger share of external debt finance. Screening and the services the financial intermediary provide for the innovative firm become less costly. The enhanced productivity of the financial intermediary makes it optimal for firms to demand a larger share of finance from the financial intermediary. The reverse is true if we start with a small  $f$ . In this case, total employment in the intermediation sector is rather small due to the high productivity of each employee in the financial sector, leading to depreciation of knowledge and consequently to a decreasing share of financial intermediation in project finance.

If initially the financial sector is very unproductive, we end up in a development trap. The optimal share of finance via financial intermediation is low and hence the economy's innovation sector is characterized by a high degree of failure of innovation projects. Anticipating this, households are not willing to lend resources to finance innovation projects neither directly nor indirectly via banks. This is the case if we start to the right of the  $g_A$ -line, i.e. if  $V^+ > \bar{L}\gamma(\phi^*)/[\alpha(1 + f\phi^*)]$  (see (22)).

We can summarize our findings in

**Proposition 3** *Given that firms are allowed to choose their optimal capital structure, they will choose a larger share of finance from financial intermediaries the more productive the financial intermediary is. An economy starting initially with a very unproductive banking sector will end up in a development trap. With intermediate levels of  $f$ , the economy starts with a high degree of self-finance which will diminish over time. At the same time the degree of finance via the financial intermediary increases.*

With this last result we are able to explain one of the crucial stylized facts with respect to the evolution of capital structure over time.

## 5 Summary

By incorporating a financial sector into an endogenous growth model, we provided a simple framework enabling us to investigate various issues concerning the relationship between growth and finance and the development of the financial sector over time.

If the banking sector is able to improve the probability of success of innovators significantly and at rather low costs it will provide a higher steady-state growth rate. As in trade models with l.b.d., here, too, history plays a role (see Grossman/Helpman (1995, Section 2)). Depending on initial conditions, it is possible that a growth-inferior regime and steady-state growth path emerges. This is the case if banks



are rather unproductive initially, so that a market-dominated system emerges, even though after financial sophistication the banking regime would imply higher steady-state growth.

By allowing for endogenous capital structure choice in our framework, we provide an explanation for the empirically observed pattern of capital structure from self-financing towards a higher share of financial intermediaries in project finance. Over time, with ongoing l.b.d., the productivity of the intermediation sector increases, allowing for screening of projects and providing (managerial) services to the innovating firm at lower costs. This advantage leads entrepreneur to demand a larger share of finance from intermediaries.

The financial sector in our model is modelled in a simple manner in order to ensure tractability. It is important to stress the limitations of our approach in this direction and to outline some further routes of research. Financial markets are completely passive in our analysis, whereas the literature on the effectiveness of corporate governance in different financial regimes stresses the active role of financial markets in this respect (see e.g. Shleifer/Vishny (1997)). It would be interesting to extend our model in this direction and to allow for a more active financial market. Furthermore, we did not distinguish between different financial instruments with different pay-off streams (say debt and equity). In our framework, this was not necessary since idiosyncratic risks could be diversified away. If this is, however, not feasible anymore, it is crucial to distinguish different financial instruments (provided by different financial regimes) involving different levels of risk.

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