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Finance and technology in early industrial economies: the role of economic integration

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Summary

This paper argues that the degree of economic integration may be an important determinant of the emergence of different patterns of both technology and finance in industrializing economies. Drawing on several recent advances in corporate finance, a simple general equilibrium model is developed which investigates how the degree of economic integration may affect firms' choice of technology, entrepreneurs' choice of human capital accumulation and banker's choice of the way finance is provided. The degree of economic integration is measured by the cost of transacting in goods, securities and factors markets. It is shown that economies which industrialize when they have already achieved a high degree of integration are more likely to adopt a simple, fungible technology and rely on arm's-length financial relationships (the "British" pattern). Economies which are still fragmented when they industrialize are instead more likely to adopt more specific technology and rely on the close financial ties of relationship-banking (the "German" pattern). The model also provides an explanation for the persistence of the patterns of industrialization as economic integration increases. It is argued that the fixed costs of relationship-banking, and their effect on the likelihood of early liquidation of firms, explains why integration that occurs after industrialization may exhibit "path-dependence", and preserve the existing patterns of both technology and finance. These results are used to interpret the early industrialization of Britain and Germany, and the persistence of their patterns with time.

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1. Introduction

Economists have given much attention to the effects of finance on firms' attitude towards innovation and risk-taking (see, for in-

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stance, Mayer, 1990; Roe, 1993; Aoki & Patrick, 1994; Edwards & Fischer, 1994). This has led to the identification of different patterns, which are interpreted as alternative equilibria which an economy may attain, like the "Anglo-Saxon", the "German" and the "Japanese" ones. While much research has gone into the nature of the complementarities which sustain these different patterns, less attention has been given to what determines their selection. We contribute to this line of research, showing that economic integration may determine the emergence of different patterns of industrial finance and of industrial innovation at the early stages of industrialization. We also provide conditions under which either persistence ("path-dependence") or convergence attain.

We develop a simple general equilibrium model to formalize the idea that close banking relationships are costly but enhance the value of projects by overcoming informational asymmetries, thus lowering the probability of inefficient liquidation. Arm's-length banking relationships, on the contrary, entail a lower cost of individual loans, but require a market for liquid claims which is costly to operate. Since with bank-based finance a firm faces liquidation less often, it finds it more convenient to adopt riskier technologies and more specific human capital than under arm's-length financing. This gives rise to a multiplicity of equilibria. There is a "British" equilibrium, with arm's-length financing, little investment in human capital and more fungible technology, and a "German" equilibrium, with close banking relationships and more human capital and specific technology.

We use the degree of economic integration as the determinant of equilibrium selection, through its effects on the cost of finance and production. Low integration entails less mobility of factors and higher transportation costs, and more costly execution of financial transactions. We show that there is a critical value of the degree of integration below which the "British" equilibrium is not feasible, allowing only the "German" equilibrium. We then show that when an economy integrates after having industrialized, it is likely to retain the "German" pattern—even if it would have adopted the "British" pattern had it industrialized after integration. This is because banking relationships have economic value.

Our model allows us a new interpretation of the rise and persistence of differences in British and German industrialization. While Britain was a unified nation from the beginning, Germany industrialized as a set of fragmented economic regions, which progressed towards unity only slowly and gradually. Once it became economically unified, its pattern of finance and investment did not revert to the British one, and the differences between the two countries persisted.

Our results contribute to the strand of research which explores the complementarities between financial and industrial systems, of which Aoki (1994) was one of the first examples. It takes as a starting point the large amount of literature showing that close banking relationships may overcome informational inefficiencies and support risky, long-term investment strategies (see, for instance, Townsend, 1979; Gale & Hellwig, 1985; Rajan, 1992; Dewatripont & Maskin, 1995; von Thadden, 1995). We borrow from the literature on venture capital the view that bank-based finance may contribute to the value of a project by raising its probability of success (see Gorman & Sahlman, 1986; Hellmann, 1994; Gompers, 1995). In an industrializing economy it seems appropriate to liken banks to venture capital, as they often act as a substitute for the lack of professional corporate services, and face acute informational asymmetries. Banks are also considered a useful institution to help firms identify and realize investment complementarities in developing economies (Da Rin & Hellmann, 1996). Another way relationship banking contributes to a project's value is by favouring debt renegotiations for distressed firms to a greater extent than market-based finance (Berlin & Loeys, 1988).

The only closely related paper, to the best of our knowledge, is by Baliga and Polak (1995), who look at the persistence of institutional differences in the final quarter of the last century. They, too, examine the coordination between financial and industrial strategies, but focus on scale of projects and numerosity of firms, and justify financial intermediation with presence of moral hazard. The two papers are indeed complementary. The rest of the paper proceeds as follows. Part two develops the model. Part three uses it to provide a reading of the British and German histories, comparing their main features. Some final remarks conclude.

2. The model

2.1. THE REAL SECTOR

We consider a simple overlapping generations economy, where a measure one continuum of agents live for two periods each generation. Agents are risk-neutral and care only for second period consumption. Thus, all income is saved, and invested at the interest rate r, which is constant and exogenously determined in the world markets. Each young agent is endowed with one unit of labour, which is supplied inelastically at the market wage rate w_t, where t denotes time. While working, each agent decides whether to set up a firm, or a bank, or to become a broker. We denote the amount of firms (financial intermediaries) in equilibrium by F_t and B_t, respectively.† An agent who decides to become an entrepreneur

† B stands for both bank and broker, our two types of intermediaries.

expends (costly) effort $e \in [0, 1]$ to set up his firm. Effort represents accumulation of project-specific human capital. Firms and financial intermediaries are set up by a single agent. When old, agents will consume all their savings. Those who have become entrepreneurs (bankers, brokers) run their firm (intermediary) and consume its profits.

There is one good in the economy, which can be consumed or employed as capital, and is used as the numeraire. Production requires labour and a fixed amount of capital, normalized to one. In each generation, some young agents set up firms and borrow capital.† In the second period workers are hired, production takes place and debt is repaid. Capital used in production completely depreciates at the end of the second period.

Firms and financial intermediaries are distributed uniformly over a circle with unitary circumference. Thus, F_t and B_t express the relative, "per capita" amount of firms and intermediaries. After it has been set up, each firm (bank) is randomly assigned to a location.

There are two available technologies. The "fungible" (f) technology entails a lower productivity than the "specific" (s) technology. On the other hand, the specific technology requires a higher specialization of capital, which makes it less suitable for alternative uses, and accelerates capital depreciation. Let $\tau \in \{f, s\}$ be the index of technology, and let $g(n)$ be a well-behaved production function, where n denotes the amount of labour employed. Output is $\alpha(\tau, e)g(n_t)$, where α is a time-invariant index of productivity which depends on technology and effort, such that $\alpha(s, .) > \alpha(f, .)$ for all levels of effort. Also, let $l(\tau)$ be the (liquidation) value of capital in alternative uses at the end of the first period, with $1 = l(f) > l(s)$. Thus, the specific technology allows higher productivity, but at the cost of reducing the value of capital in alternative uses.

There is uncertainty on the outcome of production, since the project might fail due to an idiosyncratic shock. At the end of the first period, once a firm has been organized, but before production takes place, a signal S on the level of productivity becomes available, which cannot be contracted upon.‡ The signal can be "good" ($S = g$) with probability β, or "bad" ($S = b$) with probability $(1 - \beta)$. A bad signal reveals negative information which decreases the

† We make the plausible assumption that the amount of capital necessary to set up the firm is much greater than the wage rate. Consequently entrepreneurs need to borrow from many lenders.

‡ This is because the signal reveals "soft" information which cannot be enforced in court.

probability of success of the project.† Conditional on S the project yields:

$$y(n_t, \tau, e) = \begin{cases} \alpha(\tau, e)g(n_t) & \gamma + \sigma(S) \\ 0 & 1 - \gamma + \sigma(S) \end{cases}$$

where $\gamma > \sigma(b) > \sigma(g) = 0$. Since at the end of the first period capital has a value $l(\tau)$, it is efficient to liquidate the firm whenever $l(\tau)$ exceeds the expected value of continuing the project. Here is where finance enters our model, as the liquidation decision depends on how firms are financed.

2.2. THE FINANCIAL SECTOR

Firms can raise funds by issuing securities or by applying for a bank loan. Market-based finance entails distant, arm's-length relationships between borrowers and lenders, whose interaction is organized by "brokers". They collect standard accounting information from firms in order to market their securities, which are traded in a central market. The cost of organizing and operating a market for public debt is essentially a fixed cost, shared equally between all borrowers.‡ More precisely, we assume that the marginal cost borne by a borrower is $k(F_t)$, with $k(0) = \infty$, $k' < 0$, and $k'' > 0$. This amounts to say that there are external economies in organizing a market for securities, so that the cost of finance is driven essentially by the size of the market. Such economies exist because the cost of organizing the circulation of securities is substantially higher than the costs of gathering accounting information, which is constant for all firms, and equal to $\hat{b}$. Finally, a broker has to pay a cost ϕ^m to acquire the ability to intermediate securities.§

Bank-based finance, instead, entails close borrower–lender relationships, and the costly collection and processing of detailed "soft" information. Relationship banking has been shown to support riskier and longer-term investment strategies (see our discussion above). We take this as our starting point, and assume that bank-based finance enhances the probability of success of a project through (costly) monitoring. More precisely, a bank which has

† Alternatively, the bad signal could correspond to a negative shock on the value of the project when it succeeds. Since agents are risk-neutral the two are equivalent.

‡ The logic of our argument is clearly robust to any split of such costs between lenders and borrowers.

§ This can be viewed as the cost of a charter, or the capital required to operate an intermediary.

acquired monitoring capacity can raise the probability of success of a firm which received a signal $S=b$ from $(\gamma-\sigma(b))$ back to γ.† To acquire monitoring capacity at the time of setting up the bank, the banker bears a cost ϕ^b. Unlike market-based finance, there are no external economies of scale—an extreme result of our simple formalization.

To keep the analysis simple we assume that bank-based finance is extended through standard debt contracts, with a covenant which gives lenders the right to terminate projects once the signal on productivity becomes known. Following Sussman (1993), we also assume that the cost of monitoring a firm with distance z from the bank is equal to $b(z)$, with $b'(z)>0$. Since banks are equidistant from each other, the distance between any two of them is $1/B_t$, which contains F_t/B_t firms (in per capita terms). It is easy to show that there is a unique Nash equilibrium of the lending game between two neighbouring banks, in which each bank offers loans only to firms closer than $1/2B_t$. As the bank knows a firm's location, it can price-discriminate, and ask for a repayment constrained by the cost of monitoring its neighbouring bank. Figure A plots the cost functions of two neighbouring banks. The shaded areas measure the monopolistic rent accruing to each bank. Also, the bank can credibly commit to repay its depositors whenever it is solvent. This is because its local nature allows depositors to oversee its operations at a reasonably small cost. The market for deposits is instead assumed to be perfectly competitive. Finally, we let $\hat{b}=b(0)$.

The timing of actions, for each generation, is as follows. In the first period, young agents work for existing firms and decide whether to set up a firm or become bankers (brokers). Wages are saved and deposited with a bank, or invested in the capital market. Agents who set up a firm choose one of the two technologies, accumulate human capital and borrow one unit of capital. Those who set up a bank, build monitoring capacity and collect deposits, and those who become brokers set up a central market for liquid claims. Firms and banks are randomly assigned a location, which becomes common knowledge. Signals on productivity are revealed, and lenders decide whether to extend each loan or to terminate the project. In the second period bank monitoring takes place, securities are issued, firms hire workers and the product is produced and sold. Finally, uncertainty on project outcome is realized and creditors are repaid by successful firms.

† We overlook the possibility that monitoring raises the probability of success of a firm which has received a signal $S=g$, since it would add nothing to the analysis, but would complicate the algebra.

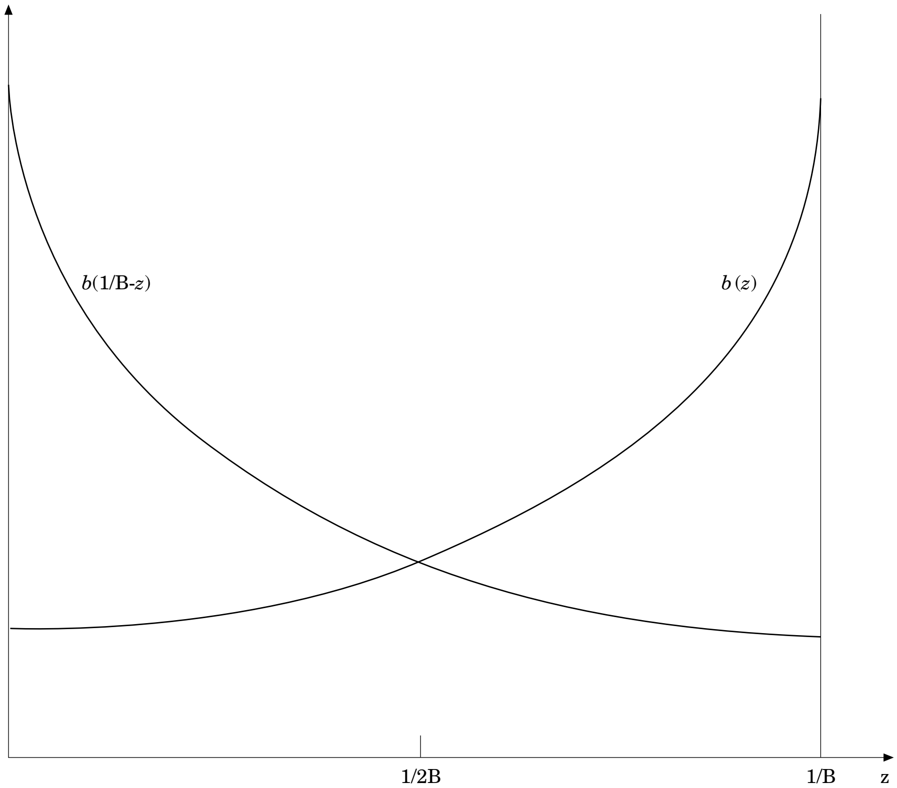

FIGURE A. Cost of bank-based finance.

2.3. THE LIQUIDATION DECISION

A crucial feature of our model is the liquidation decision, which creates a link between firms' choice of technology and the nature of the financial system. Liquidation occurs whenever the expected value under continuation is smaller than the liquidation value $l(\tau)$. We naturally assume that the expected value of the firm when $S=g$ is greater than its liquidation value—otherwise the firm would not have been set up in the first place. When $S=b$ the two forms of finance entail different expected values. In order to concentrate on the economically interesting case, we assume that with market-based finance, denoted by M, liquidation occurs irrespective of technology:

$$E_M[y(n_t, \tau, e) \mid S=b] = [\gamma - \sigma(b)]\alpha(\tau, e)g(n_t) < l(\tau) \qquad (1)$$

for $\tau = f, s$. With bank-based finance, denoted by B, monitoring restores the initial probability of success:

$$E_B[y(n_t, \tau, e) \mid S = b] = \gamma\alpha(\tau, e)g(n_t) > l(\tau) \quad (2)$$

for $\tau = f, s$.† This assumption reflects the fact that bank-based finance may contribute to the value of a project by raising its probability of success. This is common in the literature on venture capital, a form of finance which is akin to our concept of bank-based relationship finance (Gorman & Sahlman, 1986; Hellmann, 1994; Gompers, 1995). It fits the nature of an industrializing economy, where banks often act as a substitute for the lack of professional corporate services, and where informational asymmetries are most acute. Relationship banking also favours debt renegotiations for distressed firms more than market-based finance—increasing the chances of bank survival (Berlin & Loeys, 1988). Banks may also help firms identify and realize investment complementarities in developing economies (Da Rin & Hellmann, 1996). Finally, the recent literature on capital structure also supports our assumption. Williamson (1988) and Shleifer and Vishny (1992) suggest that the degree of asset specificity influences the governance attributes of alternative forms of finance. On the other hand, we take an extreme stance, whereby all firms which adopt the same technology and get the same signal are either liquidated or not; however, the model could be extended to allow for the case of firm heterogeneity. This would result in a more selective liquidation rule, whereby a greater measure of firms is liquidated with market-based finance than with bank-based finance, but our qualitative results would be preserved.

2.4. THE CHOICE OF TECHNOLOGY AND EFFORT

Entrepreneurs choose technology in order to maximize their expected profits. They take into account that $S = b$ may trigger liquidation, and so weigh the increased productivity with specific technology against its lower liquidation value. Our characterization of the liquidation decision implies that the choice of technology is determined by the form of external finance. Our assumptions create a strong "complementarity" between specific technology and bank-based finance. Bank-based finance makes specific technology more attractive by raising the probability of success of distressed

† This assumption is less restrictive than it appears. It could be shown to result from a framework where security holders receive an imperfect signal on firm productivity, whereas banks' monitoring capacity enables them to ascertain the true state of nature. We postulate this result in order to concentrate on the role of economic integration.

projects—those which have received a "bad" signal. Under bank-based finance entrepreneurs choose $\tau = s$. Likewise, under market-based finance they choose $\tau = f$. This implication of our assumptions reflects the results of the recent literature.

As for the choice of effort, we naturally assume that a higher e is more valuable when technology is specific, namely that $\partial\alpha(s, e)/\partial e > \partial\alpha(f, e)/\partial e$ for all levels of e. Effort is costly, as measured by a function $\varphi(e)$, such that $\varphi(0) = 0$, $\varphi(1) = \infty$, $\varphi'(e) > 0$ and $\phi''(e)$. This ensures that the level of effort is higher when techonology is specific. We denote it by $\bar{e}$, and denote by $\underline{e}$ the level of effort (human capital) when technology is fungible. Then $0 < \underline{e} < \bar{e} < 1$.

2.5. EQUILIBRIUM WITH BANK-BASED FINANCE

We now compute the equilibrium of our economy, starting with the case of bank-based finance. The cost of establishing monitoring capacity implies that there is only a finite number of banks. Equilibrium is given by banks' zero-profits conditions, which equates the expected revenue of a bank with the cost of providing finance plus the repayment of funds to depositors, taking into account that banks never liquidate projects. Let $R_{t+1}^{b}(z)$ be the repayment to a bank from a successful firm in location z. Then:

$$R_{t+1}^{b}(z) = (1+r)/\gamma + (1-\beta)b(1/B_t - z)/\gamma$$

The zero-profits condition can be written as:

$$2\gamma F_t \int_0^{1/2B} R_{t+1}^{b}(z)dz = (1+r)\phi^{b} + 2(1-\beta)F_t \times \int_0^{1/2B} b(z)dz + (1+r)\frac{F_t}{B_t}$$

combining these two expression we get the equilibrium condition:

$$(1+r)\phi^{b} = 2F(1-\beta)\lambda(B_t) \tag{3}$$

where

$$\lambda(B_t) \equiv \int_0^{1/2B_t} [b(1/2B_t - z) - b(z)]dz$$

is the monopolistic rent accruing to each bank when there are B_t of them. New banks enter until the rent equals the cost of acquiring monitoring capacity. Labour demand for the individual firm is $n(w)=(g'(w_{t+1}))^{-1}$. Aggregate labour demand is then $N_t^b=n(w_{t+1})F_t$, where b stands for bank-based finance. Equating demand and supply we get:

$$N_t^b=F_t n(w_{t+1})=1 \tag{4}$$

Entrepreneurs do not know their location when deciding whether to set up a firm, so they reason in expected terms:†

$$\gamma\left[\pi(w_{t+1}, s, \bar{e})-2B_t\int_0^{1/2B_t} R_{t+1}^b(z)dz\right]-(1+r)\bar{e}=0$$

where operating profits $\pi(w_{t+1}, s, \bar{e})\equiv\alpha(s, \bar{e})g(n(w_{t+1}))-w_{t+1}n(w_{t+1})$ are decreasing in w_{t+1}, provided the production function is concave enough. We can rearrange the above expression to get:

$$\gamma\pi(w_{t+1}, s, \bar{e})-(1+r)-2B_t(1-\beta)\int_0^{1/2B_t} b(1/B_t-z)dz=(1+r)\bar{e} \tag{5}$$

We can now determine the equilibrium of the system by solving equations (3)–(5) (all proofs are in the Appendix).

PROPOSITION 1: *With bank-based finance, there exists a unique stable equilibrium.*

2.6. EQUILIBRIUM WITH MARKET-BASED FINANCE

With market-based finance each borrower pays the amount $k(F_t)$. Let R_{t+1}^m be the repayment of a successful firm with market-based finance:

$$R_{t+1}^m=[(1+r)(1+k(F_t))-(1-\beta)+\beta\hat{b}]/\beta\gamma$$

Equilibrium is given by the zero-profit condition for brokers:

$$[\beta\gamma R_{t+1}^m+(1-\beta)]\frac{F_t}{B_t}=[k(F_t)+1](1+r)\frac{F_t}{B_t}+\phi^m(1+r)$$

† Our assumption of a continuum of agents ensures that there is no scarcity of capital.

Notice that the fixed cost of entry keeps the number of brokers finite. Combining these two expressions we get the equilibrium condition:

$$(1+r)\phi^m = \beta\hat{b}\frac{F_t}{B_t} \tag{3'}$$

Since some firms are now liquidated, aggregate labour demand is lower than with bank-based finance:

$$N_t^m = \beta n(w_{t+1})F_t = 1 \tag{4'}$$

Firms' expected profits now take into account that firms which have received a signal $S=b$ are liquidated:

$$\beta\gamma[\pi(w_{t+1}, f, \underline{e}) - R_{t+1}^m] - (1+r)\underline{e} = 0$$

which we can rearrange as:

$$\beta\gamma\pi\left(g'\left(\frac{1}{\beta F_t}\right)\right) + (1-\beta) = (1+r)(1+k(F_t)-\underline{e}) + \beta\hat{b} \tag{5'}$$

We can now determine the equilibrium.

PROPOSITION 2: *Whenever $k' < \bar{k}$, there exists a unique stable equilibrium with market-based finance.*

The result can be interpreted with the aid of Figure B, below. The equilibrium value of F_t is determined by the intersection of the two curves which represent the right- and left-hand sides of equation (5′). Under our assumptions, the right-hand side is higher at low levels of F_t, and intersects from above the curve corresponding to the left-hand side. However, the costs of running a market for liquid claims might be such that the cost paid by the marginal firm is never low enough to make it worth investing, once we take into account the negative effect that entrance by the firm has on profits. In this case the two curves would never cross. Thus, the nature of $k(F_t)$ is of foremost importance for the model.†

Both the bank-based and the market-based equilibrium are possible. Since firms, banks and brokers make zero profits, a plausible assumption is that the equilibrium which yields the higher social surplus (net of finance costs) will be selected. This

† It is conceivable that multiple equilibria may exist should $k(F_t)$ turn upwards and above a certain level of F_t. This might be due to a "congestion" effect, which we have excluded by assuming monotonicity of $k(F_t)$.

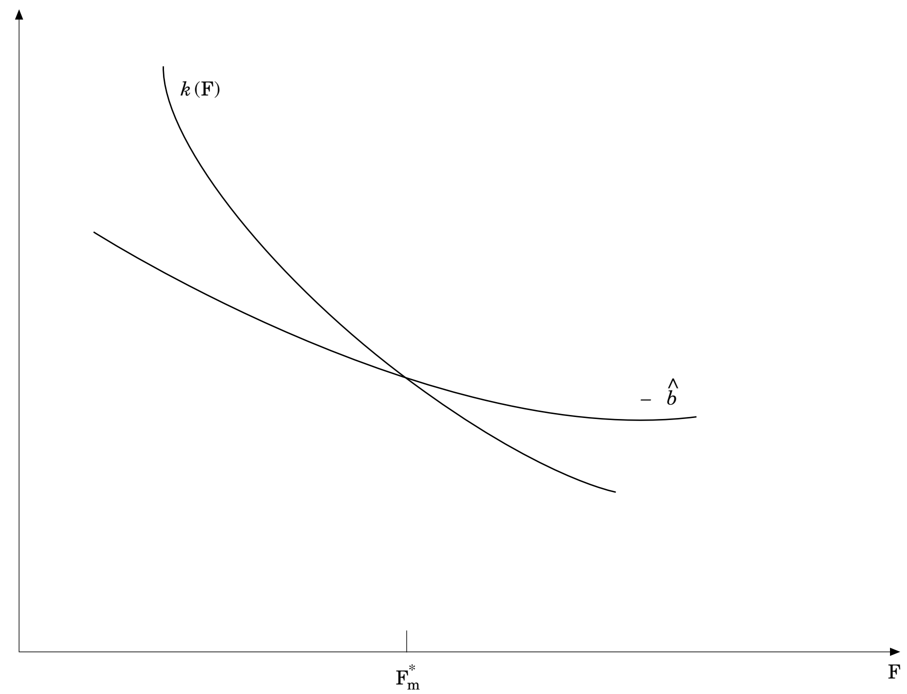

FIGURE B. Equilibrium with market-based finance.

depends on the actual constellation of parameters of the economy. For instance, a high probability of success, β, favours the market-based equilibrium, as it reduces the value of bank support. An analysis of equilibrium selection must then specify the different parameter constellations under which each would attain. Notice that we have ruled out any "mixed" equilibria, as all agents who choose to be financial intermediaries offer the same type of finance. This naturally stems from the fact that, with homogeneous agents, a mixed equilibrium would entail a duplication of costs which is inefficient. When finance is provided through banks, there is a monopolistic distortion in the pricing of financial services. This has to be compared to the cost of market-based finance, $k(F_t)$. Whether the equilibrium number of firms under market-based finance is high enough to make this cost lower than under bank-based finance depends on the values of the parameters, as can seen by comparing equation (5) with equation (5′). The advantage of market-based finance is the low cost of organizing the market for securities. However, firms are subject to a higher probability of default than with bank-based finance, $(1-\beta\gamma)$ instead of $(1-\gamma)$, so that their expected profits are reduced. The net effect, and so which equilibrium attains, depends on the actual values of the parameters. We are not interested in analysing these different constellations, as in considering how they may be affected by the degree of economic integration. We denote by ω_m and ω_b the constellations of parameters under which the economy achieves the market-based and the bank-based equilibria, respectively.

2.7. ECONOMIC INTEGRATION

We measure economic integration with the parameter $\rho \in [0, 1]$, where zero corresponds to complete fragmentation, and one to complete integration. Integration affects the cost of circulating capital, labour and goods across the economy. A fragmented economy entails customs duties and the cost of billing in different currencies. Agents bear exchange rate risk, and may have to defend their property rights under different laws. Workers may not be able to sell their services where they are most in demand. These factors influence the cost of production. We model this using "iceberg costs", a standard way to deal with regional barriers to trade. The idea is that using inputs from different regions and transporting the final products across them is costly. Formally, we assume that:

$$y = \rho[\alpha(\tau, e)g(n_t)] \tag{6}$$

As a result, lower integration discourages entry into the real sector. The effect of integration on the financial sector depends on the form of finance. Bank-based finance is likely to be little affected by integration. Close banking relationships are "local" in nature. We bring this to the extreme, and assume that bank-based finance is not affected at all by integration. The cost of market-based finance, on the contrary, depends on integration, as securities need to be packaged in standardized form and circulated. We assume that the cost of organizing securities markets (for the marginal firm) is now $k(F_t)/\rho$. The cost of acquiring accounting information, $\hat{b}$, remains unaffected. Our qualitative results do not depend on the specification of how integration affects the cost of finance. What is crucial is that the cost of bank-based finance is affected by integration to a lesser extent than the cost of market-based finance, expressing the fact that more are "local" in nature than securities markets. Once an economy becomes more integrated there are two positive effects on the level of economic activity. The "direct" effect of integration is due to lower costs of production. The "indirect" effect occurs only with market-based finance, as the cost of intermediating securities decreases.

PROPOSITION 3. *There exists a critical level ρ^* such that the equilibrium with market-based finance is feasible only if $\rho > \rho^*$.*

2.8. PATH-DEPENDENCE

In this section we consider the effect of integration on an industrialized economy. Consider an economy belonging to ω_m that industrializes with a degree of integration $\rho<\rho^*$, and so adopts the bank-based equilibrium. Suppose it later achieves a higher degree of integration, $\rho'>\rho^*$. Will it revert to the market-based equilibrium, or will it remain locked in the bank-based equilibrium?

We address this question by slightly modifying the process of intermediation. Firms outlive entrepreneurs, and a successful firm starts over at the end of its second period with a new project and a new entrepreneur. Similarly, banks outlive bankers. We then assume that the costs of market-based finance is not affected by time: circulating securities requires the same resources each period. The cost of bank-based finance—which is based on building close relationships—decreases with time for firms which have been successful in the past. In particular, we choose to simply decrease the cost $b(z)$ by a constant x. This means, not only does the cost of finance decrease with time for successful firms, but they pocket all the savings as banks keep their rents constant. While the first part of the assumption is crucial, our results are robust to other sharing rules.†

The simplifying nature of our assumptions rules out mixed equilibria, as well as the possibility for successful firms to "build a reputation" and become able to issue securities. This reflects our focus on the evolution of an economy's pattern of finance and investment, and not on the financing options available to single firms as in Diamond (1991). In a developed economy with mature financial markets, it is likely that firms may exploit different forms of financing. Our goal, instead, is to show that such availability of financing options may not arise in the first place.‡

Since each period γF_b^* firms survive on to the next period, their banking relationships survive as well. It is easy to check that this amount of firms is also time-invariant. Consequently, the total

† The way we model cost reduction is over-simplistic, but it can account for several alternatives. A richer model would build endogenously the changes in the rent and in its distribution. For instance, Dinc (1996) studies the effects of bond market deregulation on firm borrowing choices using an infinitely repeated game framework. There, persistence of close banking relationships is based on banks' need to build a reputation for adopting efficient liquidation decisions. Baliga and Polak (1995), instead, base their analysis on a multiple-stage game where different levels of the (endogenously determined) cost of monitoring induces different equilibria.

‡ In the next section we will see that many German firms issued equity and bonds. Yet, they did so under the strict tutelage of banks, which dominated the issue business. This was clearly a case where bank-based finance "captured" the capital markets as well.

(per period) cost saving, with respect to the static model, is equal to $x\gamma F_b^*$. Our last result is then:

PROPOSITION 4: *Suppose an economy with parametric structure within ω_m has industrialized with a degree of integration $\rho_0<\rho^*$, thus adopting the bank-based equilibirium. Suppose that the economy later achieves a higher degreee of integration, $\rho_1>\rho^*$. Then it will revert to market based finance only if $\gamma<\gamma_1^*$.*

3. Finance and technology in British and German industrialization

We can now use our results to interpret the early industrialization of Britain and Germany.† This corresponds to the period between 1750 and 1820 in Britain, and between 1830 and 1870 in Germany (see Gerschenkron, 1962; Crafts, Leybourne & Mills, 1991). Once joint-stock companies were allowed, issues of market structure and scale of production came to play a major role, for which our model is not adequate.

3.1. ECONOMIC INTEGRATION

Britain and Germany reached industrialization at different stages of economic integration. Britain became a nation before industrializing, resulting in a high integration of product, labour and capital markets. Reliance on nationwide markets was favoured by common currency, a common business culture and homogeneous enforcement and legal systems. Thus, secured financial claims became widely accepted, since creditors were confident in the possibility of recovering their credits in case of bankruptcy. The evolution of modern commercial law at the beginning of the 18th century, was also favourable to the use of traded securities (Cottrell, 1980: p. 6). Integration allowed the free circulation of factors of production, as well as of entrepreneurs. Secondary markets for capital and machinery were also active (Landes, 1965: p. 297; Milward & Saul, 1973: pp. 190–191; Mathias, 1979: p. 96). The high natality and death rate in British industry contributed to create a market for salaried managers (Cottrell, 1980: p. 35). This encouraged entrepreneurs to invest in skills which could be

† A huge literature has developed on all facets of the industrialization of both countries and the way it was financed. Among many others, on Britain, see King (1936), Deane (1965), Landes (1965), Cameron (1967), Crouzet (1982), Collins (1984), Kindleberger (1984), Crafts (1985) and Kennedy (1992). On Germany, see Tilly (1966, 1989), H. Pohl (1984), M. Pohl (1982), Henderson (1984), Kindleberger (1984) and Feldenkirchen (1991).

exploited in many situations, so that the failure of one venture would not lead to personal disruption. Indeed, many entrepreneurs started over several times, shifting among related businesses.

In Germany, on the contrary, the fragmented nature of local economies persisted throughout the early stages of industrialization. There were still 38 states after Versailles, with different legal systems (Code Napoleon, Roman law, Saxon law), currencies (seven different systems), social structures, business attitudes and even measurement systems (Clapham, 1955: p. 88). Integration of these economies was slow and partial. Even Prussia, the largest and dominant state, was divided in two large areas, Rhenania and Westphalia in the West, and Saxony in the East (Borchardt, 1991). Such divisions hampered the creation of common markets for goods and production factors. For instance, guild regulations limited the mobility of skilled labour well into the 1870s (Tripton, 1976: ch. 3). The first step towards a "national economic space" was the creation of the Customs Union (*Zollverein*) in 1834. Henderson (1984) describes the difficulties faced by the *Zollverein* in its development. He shows how little it contributed to enforcement of property rights, coinage and business practices. The *Zollverein* expanded slowly. During the 1850s and 1860s an increasing number of states joined it, but it was only with the Northern German Confederation (1866) that a unified economic space started to appear. Even tariff elimination was not sufficient to achieve true integration. Dunke (1991) stresses the regional nature of German industrialization, and Tripton (1976: pp. 35–36, and 66–67) forcefully shows that regional specialization was very low throughout the 1860s, and inter-regional trade weak. The Western regions were the first to form a large integrated economic area, with relatively free markets for goods, capital and labour; they were also the first to industrialize.† Unification (1871) brought political unity, but effective integration required even more time. A Prussian commercial code was introduced only in 1869, and a German one only in 1898 (Pohl, 1982: p. 171).

3.2. BRITAIN

Britain started industrializing from the 1750s, pioneering the Industrial Revolution. Until the 1820s, incorporation of firms and banks was obstacled by legislation and business practices. Firms

† Important in this respect was the construction of the railways network in the 1840s and 1850s (Fremdling, 1991). It had a positive effect on import substitution of iron materials and adoption of modern technology. Domestic production of locomotives, then complicated state-of-the-art machines, was very quick: by 1852 60% of them were made in Germany (Milward & Saul, 1973: p. 209).

were typically small partnerships. British entrepreneurs were "men of trade", with a particular attitude for achieving rational organization of simple forms of production—as forcefully illustrated by Landes (1965).† Their success rested largely on introducing more effective forms of production which directly responded to an existing demand.‡ Indeed, British industrialization was based mostly on consumer goods. A capital goods industry developed only in the early 19th century, when demand for spinning and weaving machines, and for power engines became strong and stable. Till then it was common for entrepreneurs to contract craftsmen to build simple machines and standardized tools, for which wood was often used rather than iron.

Our model holds that complementarity between finance and technology is such that an integrated economy is likely to industrialize by adopting simple technology and safe forms of production. This was indeed true in the case of Britain. British entrepreneurs improved on existing techniques without engaging in the systematic development of new products or processes. They rarely had formal technical training. They were often enriched traders or artisans with ingenious—but informal—knowledge of their field, who tinkered and improved on others' experiments. Even inventors were more practical men than scientists. Watt and Newcomen, who made the use of steam power possible, were skilled, creative artisans. The development of thermodynamics came after their intuitions, and was pursued at the French Éole Politechnique (Landes, 1965: p. 333).

Wrigley (1987) documents such different attitudes of British and German entrepreneurs. This was certainly the case for textiles, where the adoption of technical improvements was largely due to the tinkering effort of entrepreneurs, who never showed a systematic approach towards developing new processes.§ Many inventions were the fruit of serendipitous activity. Mechanization and steam power were adopted slowly and only became widespread in the 19th century (Crouzet, 1982: pp. 198–204). For instance, Cartwright's power loom (1787) remained a technical novelty until after the Napoleonic Wars. Such slow adoption of innovations was sometimes due to the need to reorganize the whole production process to accommodate them, which was in itself a risky decision.

† For instance, Landes (1965: pp. 298, 321 and 580–581). This view is shared by Payne (1974: pp. 13–24) and by Crouzet (1982: pp. 185, and 199–200).

‡ See Landes (1965: p. 334), and Payne (1978: pp. 186–187). One instance was that of the progress in bleaching and dyes which was generated by the needs of the textile industry (Landes, 1965: p. 338).

§ See Landes (1965) and Crouzet (1982). Germany was quick to catch up in worsted textiles, where mechanization was more intense, and on a scale larger than in cotton (Milward & Saul, 1973: p. 399). Germany even became a large exporter of specialized textile machinery (Milward & Saul, 1973: p. 196).

The introduction of Cort's process for iron puddling was one such instance (Musson, 1979: pp. 98–99). The process, patented in 1873, became widely adopted in only the 1790s, when several iron masters—reassured of its viability—started investing large sums in it. Once difficulties were encountered in experiments, these were left aside until an alternative became available thus making it attractive to pursue them further.† The lag between "invention" and "innovation" was often long.‡ Interestingly, a pattern of simple production and innovation was typical not only of textiles, but of all sectors. This kept the riskiness of new ventures low. The progress in alkalis (bleaching powder) was due to the incremental findings of a few "empiricists" (Landes, 1965: pp. 339–343). The Leblanc soda process, patented in 1780, was adopted in only the 1820s. As Landes (1965: p. 343) wrote, "many of the advances were the work of self-taught 'chemists' and the more successful enterprises were characterized not so much by innovations in chemical process as by the effective organization of the factors of production within the prevailing scientific and technological framework". A formal body of knowledge, which could be transferred independently of personal experience, was slow to develop, and inventions were conceived as solving immediate problems. There was a deep wedge between scientific knowledge and industrial applications. The potting process for refining pig iron, patented in the early 1770s, was adopted only a decade later, when other technical advances, which were developed independently, made it commercially viable (Hyde, 1977: pp. 84–86). This was also similar for smelting and puddling (Hyde, 1977: p. 117). Watt waited seven years for his engine to become commercially viable, due to the lack of regular production of the necessary parts (Landes, 1965: p. 333), as few firms specializing in machinery had appeared (Musson & Robinson, 1969).

Integration of markets and the fungibility of entrepreneurs allowed them a substantial mobility, across sectors and across regions.§ Together with wide availability of technology and small scale of operation, this resulted in low barriers to entry in most sectors (Milward & Saul, 1973: p. 190; Hyde, 1977: p. 137). The high divisibility of capital favoured incremental investment, so that capacity could be adjusted to the dynamics of demand (Feinstein & Pollard, 1988: ch. 2–3). Reliance on standardized capital was common in all sectors. The fixed to working capital ratio was low (Cameron, 1967: p. 16; Cottrell, 1985: p. 33)—rarely higher than

† Hyde (1977: ch. 12) provides examples of such attitude for the iron industry, and Mathias (1979: p. 60) for steam power.

‡ Examples were coke smelting and steam power (Mathias, 1983).

§ Pollard (1964) Landes (1965: p. 304) and Musson and Robinson (1969: p. 222).

50%, and typically around 15%.† As a consequence buildings accounted for a large share of capital and could themselves be easily redeployed. Textile mills, for instance, were often general purpose, so that they could be switched between different production at low cost (Milward & Saul, 1973: p. 190).

The financing patterns of early British industrial firms also conform to the predictions of our model. Partners contributed most of the start-up capital of their firms.‡ External finance was needed mostly for working capital. Extremely rare were cases of bankers providing start-up or fixed capital (Cottrell, 1980: p. 15). When this happened it was mostly to finance the industrial undertakings of partners in the bank, and was usually, and predictably, a failure (Pressnell, 1956: ch. 10).

Intermediation for the accumulation of industrial capital emerged when London and local ("country") bankers appeared around the middle of the 18th century. They were all small partnerships—required by law not to exceed six members. London and country bankers assumed different roles. Country bankers came from trading and small industry, and provided local firms with short-term credit (Pressnell, 1956). They always retained a strictly local character: still in 1798, 98% of country banks were single branched (Pressnell, 1956: p. 127). The number of such bankers increased steadily with time: less than a dozen in 1750, they became about 500 in the 1820s (Pressnell, 1956: p. 11). Low capital requirements and light regulation contributed to keep banking fairly competitive, and entry relatively easy (Cameron, 1967: p. 26).

Credit was extended through two main instruments: overdrafts and "bills of exchange" (or "inland bills"). Bills were created by firms accepting a payment obligation (usually a short-term receivable) from a debtor (typically a customer). Bills did not bring any governance rights with them, just the promise to pay a specified sum at maturity.§ Both bills and overdrafts were employed for financing the acquisition of working capital. Besides reputation, the value of its working capital was an important determinant of a firm's credit availability (Pressnell, 1956: pp. 294–296).

Once issued, a bill was discounted by the local banker, who held it to maturity or rediscounted it further with other bankers.¶

† Pollard (1964: pp. 301–304), Cameron (1967: pp. 36–38) and Mathias (1983: p. 133) provide several examples.

‡ Anderson (1969), for instance, documents the wide use of mortgages to provide funds for industrial firms in Lancashire, where the cotton industry flourished.

§ Pressnel (1956: p. 293) documents the efficiency of the collection system which supported liquidation of assets backing bills of exchange.

¶ For a description of banking practices, see Rae (1896: pp. 238–251) and Easton (1907: p. 150).

Rediscounting, which was the main source of refinancing for country bankers, resulted in a flow of funds across regions. Country bankers in industrial (borrowing) counties provided bills, and their colleagues of agricultural (lending) counties bought them to invest the savings of their clients. London bankers provided a central marketplace through which securities were channelled. The local nature of country banks indeed required the existence of some type of central intermediary (King, 1936: p. 6).

The Bank of England had been financing the government through securities and loans, and about 50 bankers had been active in London since the late 17th century to form a rudimentary money market where public securities were exchanged.† They traded in government securities and supplied asset management services to merchants and wealthy aristocrats (Pressnell, 1956: p. 75; Cameron, 1967: pp. 23–27). The pre-existence of a market for government debt then helped the rise of a market for private debt, since it had already absorbed part of the cost of organizing it. Soon London bankers were joined by bill brokers, who put in contact country bankers with excess liquidity or a need for funds (Scammell, 1968: pp. 117–119). Later on, discount houses also evolved as agents for country bankers, providing them with discounting services (Pressnell, 1956: ch. 4; Nevin & Davis, 1970: ch. 2). Thus, a market for liquid securities allowed efficient financing flows across the country.‡

An important feature of the substantial anonymity of the market was the low reliance on mechanisms of corporate control. Claims were guaranteed by the assets of the acceptor of the receivable and, in case of default, by all parties endorsing the bill (Pressnell, 1956: pp. 89–90; Easton, 1907: pp. 153–157). Bills had small value, were backed by working capital and were issued by firms distant from their lenders, so that these did not have the incentive to invest in monitoring and control. Bankers, when initially discounting a bill, checked that the short-term liquidity of the borrower was adequate to the maturity and amount of the credit. This was enough to keep them away from active governance of firms, as they could cash the collateral in case of insolvency.

† Nevin and Davis (1970) and Collins (1984), among others, provide good accounts of the early evolution of the British financial system.

‡ Bisschop (1910: ch. 3), King (1936: ch. 1), Joslin (1966) and Anderson and Cottrell (1974: pp. 151–155). It developed despite the fact that the Bank of England refrained from granting bills much rediscounting, at least for those rather common bills with more than 65 days to maturity (Scammell, 1968: p. 125; Richardson, 1974: p. 208). The Bank did so in order to defend its privileged position of liquidity issuer.

3.3. GERMANY

Apart from occurring at a later point in time, the German industrialization exhibited a different pattern from the British one. As in Britain, firms were mostly partnerships, though in Germany "silent commandites" (*Kommanditgesellschaften auf Aktien*), in which non-managing partners enjoyed limited liability, were also allowed. German entrepreneurs took a more aggressive and riskier attitude towards innovation than their British colleagues. They aggressively pursued innovative businesses, becoming leaders in the development of new technologies, and creating their own markets by improving systematically on existing technology, introducing new processes and developing new products (Landes, 1965: pp. 580–581). German industrialization was based more on capital than on consumer goods, that is, in sectors where technological prowess was more important.

Firms were managed by technically trained people who came from a tradition of formal scientific education (Haber, 1958: p. 71; Landes, 1965: pp. 375–380). Between 1851 and 1870, 38% of entrepreneurs had a (mainly technical) academic background, up from 16% in the previous two decades (Kocha, 1978: p. 533). Formal technical training and practice enabled entrepreneurs to understand advanced production technologies, and recognize the value of envisioning innovation (Kocha, 1978: pp. 524–534). Entrepreneurs themselves were often engineers or chemists, able to quickly absorb foreign innovations and techniques, and improve on them. German entrepreneurs constantly visited England and France in order to learn their methods of production; Alfred Krupp, for instance, visited Britain in 1838 to study steel production.†

Investment in specific knowledge and human capital helped them to adopt, and improve upon, state-of-the-art forms of production, in all sectors (Landes, 1965). One example was the adoption of iron coke smelting, which required the construction of specialized plants. Its share of total iron production rose from 40% in 1852 to 88% in 1862 (Landes, 1965: p. 445). Other instances were the quick adoption of cotton spinning (Landes, 1965: p. 452) and quick development of custom machines for the textile industries in Saxony and Westphalia (Henderson, 1984: pp. 144–148). This reliance on technical prowess and on innovation became the hallmark of German industry. Production of steel was based on the exploitation of the Siemens–Martin process, more technical and costly than the Bessemer process which was adopted by most British producers (Landes, 1965: p. 488). In mining and iron-making a large demand was generated by the construction of the railway network—mostly

† Henderson (1984: ch. 6) reports similar cases of entrepreneurial activism in textiles, machines and mining.

in the 1840s and 1850s.† The ability to incorporate quickly the technical advances which took so much time to develop in England allowed firms in Rhenania and Westphalia to supply a large part of the required iron and steel—though imports from Britain were substantial, indigenous production grew faster than demand.‡

The German chemical industry provides a major example of investment in technical capacity. The constant development of new processes and products allowed German chemical firms, managed by professional chemists, to establish themselves at an early stage. German entrepreneurs turned chemicals into a fundamentally "scientific" industry that was the most innovative and the most technical.§ The quick adoption of the Leblanc soda process, which had long been neglected in Britain, is a clear example of this ability to adopt successfully the discoveries of others. In sulphuric acid, the French discoveries by Clément, Désarnes and Gay-Lussac were also implemented quickly and profitably (Haber, 1958: p. 10). A similar pattern was that of metallurgy, which like the Thomas–Martin process, was originated abroad and to be widely adopted in Germany. Of foremost importance was the quick development of the synthetic dyes industry, which was started by the serendipitous discoveries of Perkins (a Briton) in 1856. In 1862 there were nine British and seven German firms (Beer, 1959: p. 30; Milward & Saul, 1973: pp. 229–238). For the rest of the decade the British firms enjoyed a "first mover" advantage, and dominated this rapidly growing market. They seemed secure, as dyes were primarily used in textiles, where Britain had a large share of the market. However, German firms developed strong, and costly, technical capabilities, while British firms never went further than simple refinements of Perkins' basic methods. By the early 1870s the field was dominated by the aggressive German firms: BASF, AGFA, Bayer and Hoechst.¶ This pattern of investment in new technology was not limited to inherently "scientific" sectors like chemicals, for instance, customized textile machinery also developed quickly and soon Germany became a net exporter (Milward & Saul, 1973: p. 196).

The German financial system strongly supported such aggressive and risky investments in new technology. It indeed exhibited the

† The German railway length grew from 6 km in 1835, to 2143 km in 1845, 7826 km in 1855 and 13 900 km in 1865 (Mitchell, 1980: table G1).

‡ The production of pig iron rose by more than 300% between 1840 and 1860, and by the same rate over the next decade. The production of coal rose by 400% between 1840 and 1860, and more than doubled over the next decade (Tilly, 1966: p. 9). One reason for this success was also the (technically demanding) vertical integration between coal and iron mines, which was adopted much more quickly than in Britain (Landes, 1965: p. 491).

§ Landau and Murmann (1997) reconstruct how German firms caught up with British ones by the early 170s, and provide further references.

¶ For a more detailed account of the development of the German chemical industry, and of the influence of the banking system on it, see Da Rin (1977).

features predicted by our model. By contrast with Britain, a large fraction of investment was financed externally. One reason was the lower wealth of German entrepreneurs. Another was the large share of fixed, over working capital due to the concentration on mining and specialized productions. Intermediation emerged in the form of *Privatbankiers*. They were small local partnerships with unlimited liability. Corporate banks were slow to form since charters were sparingly granted to banks until the liberalization of incorporation in 1871.† There were, however, few regulations restricting entry for non-incorporated banks. *Privatbankiers* concentrated in the most economically active regions: the Rheinish and Ruhr districts, and Berlin.‡ During the 1830s the most active among them started financing local industrial firms.

Privatbankiers financed capital accumulation with forms of finance that gave them substantial control rights—such as rolled-over current account advances or shareholdings. Bankers often took up managerial positions in their clients' firms, as entrepreneurs had little training in management.§ Shareholdings were the other common way used to extend industrial finance. Not only did bankers participate in equity capital, but they also actively fostered new ventures, encouraging entrepreneurs to assume high risks (Da Rin, 1996). Close relations between bankers and entrepreneurs were a main factor in granting credit; except for mortgages, collateral was little used (Tilly, 1966: pp. 83–91). Bankers were often members of the board (*Aufischtsrat*) of joint-stock companies (*Aktiengesellshaften*), or took part in the management board (*Vorstand*) of limited liability partnership (*Kommanditgesellshaften auf Aktien*). Most Rheinish joint-stock companies founded between 1830 and 1870 thus had at least one banker on their board, due to shareholdings, statutory privileges or proxy votes, which were popular from the outset (Tilly, 1966: ch. 7). A few of the larger *Privatbankiers*, and a handful of joint-stock banks, engaged in investment banking activities, organizing shares and bonds issues for their clients. Issues were floated on the local stock exchanges (Berlin, Frankfurt, Köln, Hamburg, Munich).

In contrast with Britain, *Akzepten* (titles of credit similar to bills of exchange) were used sparingly (they amounted to less than a quarter of bank assets), mainly with trade-oriented industries like textiles. Markets for bills were local and thin, their circulation

† Riesser (1911), Tilly (1966) and Pohl (1982) provide a comprehensive treatment of the history of German banking.

‡ For a comprehensive study of Rheinish *Privatbankiers*, see Tilly (1966).

§ Tilly (1966: ch. 6), shows that advances accounted for around 50% of the total assets of Rheinish *Privatbankiers* throughout the 1860s. Da Rin (1966) documents their close involvement with the management of their clients' firms.

hampered by different state legislations and obstacles to the circulation of information. Local money markets then developed late and slowly.† Therefore, both sources and destinations of finance were by and large regional, and no national capital market existed until unification.‡

Bankers developed the skills and capabilities for technically evaluating ventures and for playing an active role in corporate governance. They engaged in coordination activities such as circulating information among clients, consulting, arranging acquisitions or suggesting new businesses, in a fashion which resembles modern venture capital activities.§ It was common for a banker to help its clients find customers and suppliers, lobby with local authorities and provide legal counselling. This brought about an intimate knowledge of businesses which allowed bankers a careful appraisal of their prospects. This was crucial both for start-ups and for firms which ran in distress, for which the liquidation decision could be taken efficiently. Shareholdings also encouraged banks to avoid liquidation whenever economically efficient, since they could then participate in future profits. Consider again the chemical sector. Firms like BASF, AGFA and Degussa were all founded and incorporated with the assistance of *Privatbankiers*, who invested in their equity, and allowed them to take a long investment horizon.¶

4. Conclusion

This paper has proposed the role of economic integration as one important determinant of the emergence and evolution of alternative patterns of industrial finance and investment. Drawing on recent contributions in corporate finance, our model has characterized the role economic integration plays in favouring bank- vs. market-based patterns of industrialization, and the conditions under which their persistence should be expected. Thus, we have

† Only after the 1850s in the most active region, Rheineland (Tilly, 1966: p. 72).

‡ Riesser (1911: pp. 30–35). The financial press only developed in the late 1850s, and dealt mainly with Frankfurt.

§ Riessser (1911) provides several such instances and Da Rin (1966) an interpretation of them.

¶ Kirchgässer (1988: pp. 68–69) details the involvement of the banker W. H. Ladenburg with BASF, and earlier with its predecessor, the Chemische Fabrik Sonntag, Engelhorn, Dyckerhoff und Clemm, founded in 1862. AFGA was founded in Berlin in 1867 with the help by the banker Mendelssohn-Bartholdy, who also became a partner. Also its parent company, Kunheim, had been founded with the help of a banker (Haber, 1958: p. 48). DEGUSSA, later to become a leader in electrochemicals, received credit from Jewish Frankfurt houses to establish its own research laboratories (Beer, 1959: ch. 8).

provided one of the still few contributions to comparative financial theory.

The model has proved a useful guide in the interpretation of the early industrializations of the British and German economies. In Britain production was organized in a fungible way, and innovation was the result of slow accumulation and improvements on existing processes and technologies. Their entrepreneurial spirit kept human capital highly redeployable. Finance was provided by arm's-length bankers, through liquid securities traded in the discount market. Securities gave no control rights to creditors, but ensured a relatively efficient liquidation process. In Germany, production developed with emphasis on innovation. Entrepreneurs, often technically trained, adopted risky projects and adopted specialized forms of production, concentrating on technologically oriented capital goods sectors. Finance, based on shareholdings and long-term loans, gave much power to creditors, and allowed them to influence managers. Late integration resulted in Germany retaining its initial pattern of finance and investment. The historic process of equilibrium selection well reflects the predictions of our model.

Beyond their contribution to the understanding of the early phases of industrialization of modern economies, these results provide material for designing economic policy in developing or transitional economies. In particular, some light is shed on the long-term effects of the interaction between financial and technological choices in a developing economy. More research is certainly necessary to develop a fuller understanding of the effects of the "political economy" of a nation on its pattern of development. The present work has simply tried to provide a rigorous conceptual framework to guide an empirical recognition of the first two cases of industrialization.

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Appendix

Proof of Proposition 1. First, notice that our model is time-independent, in the sense that under both financial regimes the equilibrium values of variables do not depend on their pre-determined values. So we can drop time subscripts. From equation (4) we can derive the equilibrium value of the wage rate as a function of F: $w=g'(1/F)$. Then denote with $\delta(B)\equiv 2B\int_0^{1/2B} b(1/B-z)dz$ the price paid by firms for bank monitoring. It is easy to check that $\lambda(B)=2F(1-\beta)/\phi(1+r)$. We can modify equation (5) to get:

$$\gamma[\pi(g'(1/F),\tau=s,\bar{e})-(1+r)(1+\bar{e})-(1-\beta)\delta(B)]=0$$

together with equation (3) this gives the (unique) equilibrium number of banks and firms, which we denote by B_b^* and F_b^*. Stability follows from the slope of labour demand, and the fact that the right-hand side of equation (5) is negatively sloped in w_{t+1}. □

Proof of Proposition 2. From equation (4′) we get the equilibrium value of the wage rate: $w=g'(1/\beta F)$. We can insert it into equation (5′) which gives the equilibrium number of brokers, which we denote by B_m^*. Then equation (3′) is used to derive the equilibrium number of firms, which we denote by F_m^*. Stability follows as in Proposition 1. □

Proof of Proposition 3. From equation (5′) and the continuity of ρ it follows that $k(F)/\rho$ increases as ρ goes to zero. Then there exists a value ρ^* such that the right-hand side of equation (5′) is higher than the left-hand side for any level of F_t. Therefore, the market-based equilibrium cannot attain for $\rho<\rho^*$. □

Proof of Proposition 4. Once the economy achieves a degree of integration ρ_1 both equilibria are in principle feasible. Since the economy belongs to ω_m it would adopt the market-based equilibrium, in the static model.† However, now the cost-saving in banking has to be taken into account. Thus, the decision on which equilibrium attains boils down to comparing the net total product which is generated in either case.

Using equations (3)–(5) and (3′)–(5′) we achieve the net social product for both cases. For the market-based equilibrium we have:

$$\beta\gamma(\pi(F_m^*,\rho_1)F_m^*-\hat{b}F_m^*]-(1+r)\left[eF_m^*+\frac{k(F_m^*)}{\rho_1}\right]-(1+r)B\phi_m \qquad (7)$$

where we take into account that firms' profits depend on the degree of integration through equation (6). For the bank-based equilibrium we have:

$$\gamma[\pi(F_b^*)F_b^*-(\delta(B)F_m^*-x\gamma F_b^*)]-(1+r)[\bar{e}F_b^*]-(1+r)B\phi_b \qquad (8)$$

By comparing these two expressions, it is then possible to derive the value γ_1^* which equates them. Whenever $\gamma\geqslant\gamma^*{}_1$ the economy

† A technical point. Notice that ω_m generically depends on the degree of integration ρ. We thus focus on the case where the economy belongs to $\omega_m(i)$ for all $\rho\geqslant\rho_1$. This is the case where we woud least expect the economy to persist in the bank-based equilibrium.

gain from preserving bank finance is high enough to ensure its persistence. When $\gamma<\gamma_1^*$, instead, the cost saving due to preserved financial relations is not high enough, and the economy reverts to market-based finance. □