

ALEXIS DERVIZ\*

**CROSS-BORDER RISK TRANSMISSION  
BY A MULTINATIONAL BANK****Abstract:**

A model of international banking, with a stress on manager human-capital (borrower monitoring) and majority-shareholder human capital (manager auditing) is constructed to study the impact of exogenous shocks in one country on credit creation in another. I show that the presence of the two cited categories of non-transferable skills in banking technology reduces the role of the standard portfolio-diversification motive in the cross-border transmission of disturbances. At the same time, this bank-specific market friction creates a separate channel of shock propagation, a function of bank shareholder and manager incentives. It can even happen that the impact of an exogenous shock on credit has a different sign in the “relationship” as opposed to the “arm’s-length” banking environment. This phenomenon, caused by the marginal effect of the human-capital management in the bank operation, is present in those bank branches with relatively small loan volumes. When the loan volume is large, the direction of the reaction of the manager-auditing bank to shocks abroad is the same as that of an arm’s-length lender.

**Keywords:** multinational bank, managerial effort, audit, credit, foreign shock

**JEL Classification:** F37, G21, G28, G31

**1. Introduction**

Are the consequences of a shock in one country on the development of another different in economies with a high degree of foreign-bank penetration when international banks provide an additional transmission medium beyond the standard financial markets? Should this be an area of concern for bank regulators, suggesting an approach with particularly beneficial effects in turbulent times? Both questions, beside the associated theoretical challenge, are of great practical importance for economies that are financially integrated with larger, external ones.

Standard portfolio-optimization theory derives wealth allocation across assets and their pricing from statistics of exogenous random factors. If a structural-uncertainty parameter of an economy changes, investor portfolios are shifted to reflect the new equilibrium prices of risk. Thus, if an international investor decides between assets in two different countries, an adverse shock to the asset-return pattern in one country usually calls for wealth reallocation toward the other. Naturally, the theoretical foundation of this result erodes quickly as one departs from the frictionless-market paradigm. More often than not, cross-subsidizing within a multinational

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bank is the only visible reaction to the mentioned asymmetric development of national asset returns. Formalization of the rational reasons behind the observed responses to shocks can be addressed with a toolkit provided by financial intermediation microeconomics. Such is the general objective of this paper.

### 1.1 Background

The banking sectors of the new EU member states from central and eastern Europe (CEE) are all characterized by a high degree of foreign penetration. The cases range from the near-100 percent dominance of foreign-owned banks in the domestic sector (Czech Republic, Estonia, Lithuania, Slovakia, Hungary) to a substantial presence (Latvia, Poland). This is untypical for the rest of the European Union (EU). Even small open economies outside the CEE region do not usually show excessive foreign-bank presence targeted at servicing the local economy as such. That is, most of them either have a tradition of international banking activities of their own (the Benelux countries or Greece) or of providing offshore financial services (Cyprus and Malta). We are left with two exceptions, Denmark and Portugal, which host a significant share of banking-service providers from abroad with the conventional objective of credit provision to the domestic market. Both are small open economies without international financial center or tax-haven ambitions. Their foreign-bank penetration is mainly due to bigger neighboring economies: Scandinavian in the case of Denmark, Spanish in the case of Portugal. The exact reasons (historical, cultural, and geographical, in addition to purely commercial) for the cross-border expansion of bank activities are immaterial for the present study. Our main point here is that for small open economies neighboring a bigger economic area, foreign-bank operations can constitute a significant source of exogenous uncertainty on the domestic market. This reality has less to do with the immediate transitional-economy history than with economic size and relative surroundings factor.

*Figure 1* compares seven relevant new EU member states from the CEE region (Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, and Slovakia), Denmark, and Portugal in terms of the weight of foreign banks in their respective economies.<sup>1</sup> We use four indicators – total banking-sector assets, total assets of foreign-bank branches, total bank loans, and loans granted by foreign-bank subsidiaries – all relative to nominal gross domestic product (GDP). To get an idea of the extent of foreign-bank penetration, one can compare the said indicators in pairs for each country. All data are for year-end 2003. When defining the banking sectors, we have excluded central banks and special-purpose institutions such as mortgage banks, building societies, and foreign trade-credit agencies. When selecting banks under foreign control, we choose only those in which the parent company (the majority shareholder or the ultimate owner) is itself a bank. All data are from BankScope.

Although BankScope does not provide distinct information on foreign branches, the conclusions one can draw from the data for subsidiaries cannot be but reinforced since their qualitative role is hardly different.<sup>2</sup> For the purposes of quantitative assessment, it may be useful to keep in mind the relative weights of foreign-bank branches. For instance, foreign-bank branches active in the Czech Republic in the first two quarters of 2004 accounted for more than 9 percent of the commercial banking sector's total assets and 11 percent of the loans. One would expect similar figures for Slovakia, somewhat higher for Hungary, and lower for Poland and the Baltic states. Exact measurement is not important to what we do in this paper.

The well-known discrepancy of financial depth between old and new EU members is indeed reflected in *Figure 1*. Therefore, the same absolute level of foreign-bank penetration (e.g., the foreign-subsidiary loan-size/GDP ratio, approximately equal to 0.22 both for Denmark and Slovakia) can correspond to anything from the substantial, although still minority, market

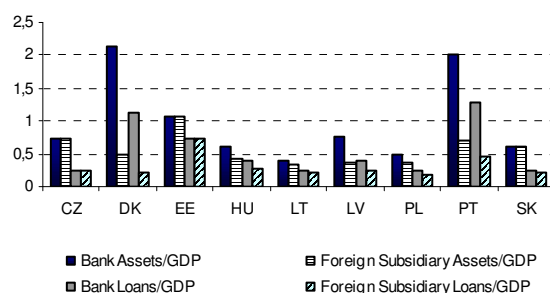
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<sup>1</sup> Slovenia was not included since its government has not yet carried out major bank privatization.

<sup>2</sup> See also (de Haas, van Lelyveld, 2002), who have established that cross-border credit (by branches) and credit by subsidiaries in CEE countries expanded simultaneously.

positions of foreign banks to nearly 100 percent foreign dominance. Accordingly, given the difference of the degree of financial depth in the old and the new European Union, our indicators confirm the high degree of foreign-bank penetration in the selected countries. It is important to note that foreign-bank total assets and loan figures relative to GDP are surprisingly similar across the sample (with the exception of Estonia, a very small economy providing an example of nearly perfect regionalization, not just integration, in terms of banking services). An immediate interpretation is that the role of bank credit in new member state economies is modest compared to old EU economies. However, the most advanced parts of such new EU economies, namely, the ones whose ownership, financing, and production structures are integrated with other industrialized countries, make use of bank credit to the same extent as their counterparts.

FIGURE 1 Bank-sector Depth and Foreign-bank Penetration in Small EU Economies (year-end 2003)



Data: BankScope

In view of the above, it is reasonable to consider the impulses, both positive and negative, coming to CEE economies through foreign-bank presence as a highly significant factor, one that influences their economic well being. We take this as a sufficient justification for a detailed theoretical analysis of foreign-bank activities inside any small open economy.

In the new member states, foreign bank penetration took place before EU accession, that is, before the EU-unified bank-licensing system. Penetration took the form of both local bank acquisition and the establishment of branches. The distinction between the two forms of foreign presence is not critical to our analysis, mainly given the relatively big size of the parent banks compared with their foreign units. Given this circumstance, two particular observations come as no surprise: capital constraints are slack for CEE banks under foreign control, so that own capital or lack thereof has little impact on activities in the host countries; and the financial control of parent company's over foreign-unit operations is usually quite tight, regardless of the representation form.<sup>3</sup>

Due to the almost complete foreign-bank dominance over the banking sectors of the new EU member states, the pace and form of the financial integration of the latter has become an endogenous process. Given the slow growth of CEE capital markets, multinational banks are responsible for the most significant component of the region's financial-integration process as a whole. The forces behind their lending and deposit-taking behavior thus become a major macroeconomic concern. Specifically, governance issues within multinational banks put to the fore-

<sup>3</sup> Actually, there may even exist some hybrid forms. For instance, from the legal point of view, cooperative and savings banks of the Raiffeisen variety are loose conglomerates of individual local banks regardless of the country of incorporation, whereas, in practice, the headquarters has a powerful say in the operation of each unit of the conglomerate. More generally, at the moment there might exist a certain migration trend from the subsidiary to the branch structure with regard to multinational bank operations in the CEE region.

ground the question of managerial performance and accountability in individual country units. We intend to demonstrate that managerial human capital and incentives are factors to be taken very seriously when assessing the possible channels of cross-border shock via a multinational bank.

Our arguments are applicable to both standard organizational forms of foreign-bank presence, branches and subsidiaries. Nevertheless, for our purposes it is easier to think of the foreign-bank operation in a small economy along the branch form, that is, without separate capital requirements and with a centralized alternative to localized management. We try to react to the two cited stylized facts visible in foreign-owned bank activities in CEE economies: over-capitalization (i.e., slack regulatory capital constraints) and the gradually increasing weight of branch-based presence. Both observations indicate that the legal structure may not be the prime factor of relevance and that the role of banking supervision has to be understood less conventionally in such economies. Accordingly, our analysis can be considered as complementary to those papers directly addressing the organizational-form aspects of bank risks (Calzolari, Lóránth, 2004), (Dermine, 2003), (Lóránth, Morrison, 2003).

## 1.2 Highlights of the Analysis

The multinational bank that we model faces fundamental market imperfections caused by the fact that it is a bank and not a textbook international investor. What makes it different is the presence of the twin principle-agent phenomena (bank shareholders vs. managers, managers vs. borrowers) that are at the core of the banking business according to the theory developed by Diamond (1984) and Diamond and Rajan (2000, 2001).

We construct an environment in which banks exist for the reason exemplified in Diamond and Rajan (2000, 2001). Namely, banks grant loans because their managers possess specific, non-transferable human capital that allows them to collect debt better than an outside creditor. The extent to which this managerial human capital is being employed corresponds to the degree to which relationship-banking features prevail in the economy. At the same time, a bank is able to attract deposits – and therewith extend the scale of its operation outside the limits of own available funds – only because the rents from improved debt collection are not entirely appropriated by the managers themselves. Part is being turned over to the shareholders and depositors, since the former have the ability to audit the manager-run bank, reducing the manager's exclusive control over the proceeds from the loan portfolio. At the same time, the depositors' position allows them to threaten the shareholders and managers with a run on the bank if an audit is not carried out and the human capital not supplied, as such would imply that the resulting revenues are insufficient to repay depositors' claims. Thus, the underlying mechanism of the bank function in our model, as per Diamond-Rajan, involves the two principal-agent relationships. One is between the bank manager and the borrower, in which the manager is the principal; the other is between the shareholder and the manager, in which the manager is the agent. We formulate a "reduced-form" model of an international bank along these lines, meaning that the game-theoretic elements of manager-shareholder and manager-borrower interactions are present backstage. A common multinational shareholder employs two managers of national branches, each doing the loan-deposit business within the respective national borders. The shareholder audits the managers (at a cost) and the managers exercise their borrower-monitoring effort (also at a cost). Under these conditions, deposits are collected and credit granted in non-zero amounts. Then we ask what happens to the provision of credit by the bank branch in one country if an exogenous disturbance to real economic activity occurs in the other. Specifically, we are interested in the difference of behavior compared with a multinational investor who is not a bank in the Diamond-Rajan sense but an international portfolio optimizer handling all assets at arm's length.

The analysis confirms the existence of both qualitative and quantitative differences between responses to shocks abroad by the bank dependent on manager human capital and the arm's-length lender. Our main findings are as follows.

1. Relationship-based (i.e., dependent on manager human capital) and arm's-length multinational banks differ in their reactions to parent-bank home-country disturbances, the difference in a foreign-unit behavior being related to the volume of its lending in the host country.
2. Spillovers of the home-country shocks to the host-country credit are most likely to happen through relatively small branches, whereas in big branches spillovers are efficiently blocked by local-manager incentives .
3. If the branch credit volume is big enough, then an exogenous reduction of the branch-manager audit costs by the bank shareholders leads to credit expansion.

Put differently, the most problematic in terms of shock spillovers are branches that manage small volumes of loans. That is, under these conditions, the marginal effect of the manager effort is particularly strong and the usual international portfolio-diversification motive is dominated by this specific manager input motive. Therefore, the loan volume granted by the branch is expanded in situations where a standard investor would contract it, and vice versa. On the contrary, relatively big lenders, even if the role of manager input therein is prominent, react similarly to the arm's-length investor, quantitative differences notwithstanding. The same is true for the shocks originating in a different country, that is, happening to a variable that does not enter the surplus definition for the manager in the country branch. To our knowledge, there are no other contributions to the literature on financial intermediation combining the Diamond-Rajan theory of banking with an analysis of cross-border shock propagation in the above sense.

### 1.3 Literature Review

The current economic thinking about the relations among bank organizational structure, management incentives, and credit policies is strongly influenced by the work of Dewatripont and Tirole (1993). These authors created a model that accommodated the roles of shareholder, depositor, and regulator. The principal conclusion is that regulation exists because small, dispersed claim holders on a bank (i.e., the depositors) are unable to coordinate their effort well enough to enforce adequate management decisions. However, the approach of Dewatripont and Tirole is not bank specific (i.e., it can be equally applied to any profit-seeking enterprise with decisions delegated to managers). The literature directly addressing the special role of banks exploits the information asymmetry between entrepreneur and investor. Thus, Diamond (1984) explains the existence of banks via their role as delegated monitors of risky investment. This idea was further developed to explain the necessity of financial intermediaries in the form of banks in an environment where not just entrepreneurial effort but also the effort given to its monitoring is partially unobservable (see (Diamond, Rajan, 2000)). Beside that, the systemic specificity of banks and other credit institutions from the macroeconomic point of view requires a structured analysis of bank financing and investment decisions. A widely recognized unified approach to capital budgeting by financial institutions was offered by Froot and Stein (1998).

The existing theory of bank risk management mostly relies on highly stylized models, usually in two or three periods, that investigate the role of different asymmetric-information effects on organizational form and asset-portfolio composition. The underlying property of the modeled entity is its tendency to generate a phenomenon called "capture" (see, e.g., (Dell'Araccia, Marquez, 2004)). This is an advanced form of information asymmetry in the capital market. Under "borrower capture" one understands the inability of finance-seeking entrepreneur to communicate the project-quality information credibly to anyone but the "house bank." Similarly, "intermediary capture" occurs if a bank seeking to attract depositors and outside equity providers is unable to credibly communicate the quality of its investment portfolio to anyone but the incumbent majority shareholder. Sometimes, the existence of capture in theoretical models leads to surprising results when the interplay with regulatory policies is considered. (For instance, bank-share ownership can become more risky as a result of capital requirements tightening, as in the model by Morrison and White (2004). This paper adds another element –

the regulator's own reputation and its significance for the equilibrium resource allocation in the financial-services market – to the discussion.) An important object of study is the probability of a depositor run or bank failure (more generally, the occurrences of financial crises) in a dynamic perspective. These models are concerned with the long-term sustainability of loan and deposit markets rather than the outcome of a single strategic encounter between financial-service providers and suppliers. In this vein, Repullo (2004) studies the existence of “prudent” versus “gambling” equilibria as a function of regulatory requirements and the impact on the credit conditions. Another recent contribution to this line of literature is (Monnet, Quintin, 2004), in which not just the current state but also the historical path of financial markets determines their size and structure in the next period.

The extension of the discussed framework to multinational banks, as in Külpmann (2000), involves deepening the analysis to the level of individual divisions (branches) and their managers' optimal choices within a multinational bank. Alternatively, Chan-Lau and Chen (2002) derive a dependence of the financial crisis (a reversal in the credit supply) in an open economy on the extent of frictions in the financial sector relative to the economic fundamentals. These and related papers subsume that international asset diversification is an important motive in multinational-bank decision making, which is long recognized in the literature on international finance (see, e.g., (Heston, Rouwenhorst, 1994)).

The specific topic of foreign-bank presence in the CEE region was covered by two empirical reports by de Haas and van Lelyveld (2002, 2003), which use Bank for International Settlements' and BankScope statistics ending in 2000. Developing on earlier empirical literature mainly concerned with Latin America, these reports distinguish between the “pull factor” and the “push factor” associated with foreign-bank penetration. The former corresponds to the reduction in credit by foreign banks in reaction to economic downturns and financial crises in the host country (and its expansion during booms), the latter deals with reaction to the home-country situation of the parent bank. There is a positive push effect when home-country disturbances result in a credit contraction by foreign units (the parent bank is concerned with balance-sheet repair). A negative push factor is present when home difficulties lead foreign units to lend more (the parent bank follows the standard portfolio-diversification logic). For the CEE, de Haas and van Lelyveld find that the pull factor is absent: foreign banks did not cut credit during host-country troubles. On the other hand, they do find a negative push effect: there is a significant negative relationship between home-country economic growth and host-country credit by foreign banks. This finding is supported by informal evidence from other sources. Given that the workings of the push factor have implications for both macroeconomic and financial stability, the model to be developed here will be primarily used to study the spillover of home-country shocks through dependent bank units in the host country.

Recently, international bank-regulation issues also received attention. Holthausen and Rønde (2004) study the impact of the home- and the host-country supervisor information exchange on bank-closure decisions. Lóránth and Morrison (2003) examine the role of national deposit insurance and evaluate its impact on the decision making of multinational banks. They also link the result about cross-border investment choices to the existence of a multinational bank channel for financial contagion. Calzolari and Lóránth (2004) extend the analysis to include a welfare-optimizing regulator and show how the regulatory stance is influenced by the chosen representative form (branch vs. subsidiary) of the foreign bank. Morrison and White (2004) endow the regulator with an additional ability (beside bank-licensing and capital-adequacy requirements), asset auditing, and examine the impact of this additional tool on the phenomena of adverse selection and moral hazard in the banking sector. Their model allows for multiple equilibria, some of which entail confidence crisis in the banking sector and a corresponding welfare-reducing decrease in project financing.

Although we do not model the regulator explicitly, the problems discussed in this last strain of literature have a direct bearing on this paper. By focusing on risk grouping in accordance with the country of origin, we are able to concentrate the analysis on international

financial intermediaries co-existing with national regulators. In our approach, the capture effect is studied as friction between entrepreneurs, banks, and investors of individual countries (in fact, we are thereby also able to address the question of home bias in the bank-loan markets with the twin capture effects). Given the focus of this paper on the credit-creation aspects of the banking industry, explicit coverage of bank failure and closure alternatives is not essential. Hence, there are no bankruptcies in our model. Otherwise, after a formal description of bank asset and liability transformation under bankruptcy, one would have to conduct the very same analysis of deposit collection and lending under new owners and managers. Therefore, we model banks and bank managers, whose preferences exclude a termination of activity for reason of a depositor run or a regulatory action (both are only present as latent threats). Regulation, in our understanding, is a set of legal norms that co-determine a bank's shareholder and managers' preference structures. Supervision, on the other hand, is understood as a way for policymakers to influence the parameters of banks' day-to-day operations, such as the opportunity cost of capital or sensitivity to liquidity fluctuations. One of the consequences of our model is a case for a regulatory policy that facilitates the bank portfolio audit for its shareholders and depositors. In this way, the domestic banking regulator may support an equilibrium with a high degree of specific manager human capital in multinational bank branches under his jurisdiction. Suppose there is a sudden reversal in the credit-creation process owing to a real or financial disturbance in the home country of the parent bank or banks. If, as is the case in the small open economies discussed earlier, too many host-country borrowers depend on loans from foreign-controlled bank, this reversal will have a macro-impact, with possible subsequent implications for the financial health of the real sector, that is, financial stability. The domestic regulator is not in the position to change the behavior of the incumbent foreign-controlled bank. However, a proper regulatory stance can encourage the entry of other banks able to provide the missing funds. In this respect, we suggest that one key criterion of the regulatory and supervisory policies is their ability to reduce bank managers' monitoring costs. This will reduce agency problems, particularly in foreign-bank branches that manage large loan volumes, that is, those with the highest degree of systemic significance. As a result, these branches will no longer act as transmitters of disturbances from the parent-bank countries to the domestic credit market.

The rest of this paper is organized as follows. Section 2 introduces the model. Section 3 presents the main results concerning the reaction of foreign branches to international shocks. Section 4 indicates possible extension of the analysis to the problems of regulatory policies and exchange rate risks. Section 5 concludes. Proofs of the technical statements are collected in the Appendix.

## 2. The Model

There are two countries in our model, each offering one general investment opportunity and another opportunity to grant non-traded loans. There is also a risk-free money-market deposit opportunity. An international financial institution is owned by a representative shareholder. She operates branches in both countries and can, in addition to investing her own funds in either of these assets, collect deposits from the public. Each branch faces a supply of deposits within the country, which is an upward-sloping function of the deposit rate that it offers. Some deposits may be withdrawn upon the payment of interest due to an unspecified liquidity shock.

To perform the loan and deposit business, the shareholder usually hires a manager for the bank branch. The branch manager possesses an endowment of non-transferable human capital, allowing him to collect a rate of return on the loans in excess of the baseline arm's-length rate that can be extracted from the same borrowers by an outside investor in the market. He is remunerated by a fee paid out of the branch's proceeds.

There are two dates, the first when the capital allocation, deposit collection, and lending takes place, and the second when returns are realized and interest and fees paid. The shareholder and the managers are risk-averse expected-utility maximizers. The uncertainties at date 0 exist with regard to six variables (three in each country): return on loans, return on outside assets, and deposit/withdrawal rate.

## 2.1 Bank Balance Sheet and Cash Flows

The general notational convention to be employed throughout the paper is the use of uppercased letters for the home-country variables and lowercased letters for foreign-country ones.

Let  $C$ ,  $D$ ,  $X^0$ , and  $X$  be, respectively, shareholder own funds (capital), deposits, cash holdings, and granted loans, for the home-country branch. There are opportunity costs of capital equal to the rate of return,  $R^C$ , on domestic outside assets. The interest rate on deposits is  $R^D$ , and the random deposit/withdrawal rate at date 1 is  $\Xi$ . Cash earns the risk-free money-market rate of return,  $R^0$ , whereas the loans earn a risky rate of return  $R$ . This means that the date-1 domestic wealth of the bank shareholder is equal to:

$$W = X^0(1 + R^0) + X(1 + R) - D(R^D + \Xi) - C(1 + R^C)$$

Let  $Y = R - R^0$ ,  $Y^D = 1 + R^0 - R^D - \Xi$ ,  $Y^C = R^C - R^0$  be the excess returns on loans, deposits, and outside assets over the risk-free rate.<sup>4</sup> Given the bank branch balance-sheet identity  $C + D = X^0 + X$ , the expression for domestic wealth can be rewritten as:

$$W = XY + DY^D - CY^C \quad (1)$$

Analogously, the cash wealth of the foreign branch at date 1 is:

$$w = xy + dy^d - cy^c \quad (2)$$

To keep the model complexity under control, we do not model exchange-rate risks separately, but offer a few comments concerning their role in Section 4. For the moment, the shareholder gross cash wealth at date 1 coming from both bank branches is simply  $W^S = W + w$ . From this, one shall subtract the manager fees and the costs of the manager audit. The formation mechanism of both is described next.

## 2.2 Shareholder-Manager Interaction

For definiteness, we describe the manager fees and audit costs for the home-country branch; the foreign-branch results are obtainable by a simple change in notation.

If the loan portfolio represented by  $X$  were held by an outside investor without any particular knowledge of, or relationship with, the involved borrowers, the date 1-excess return on it would be a constant mean  $V$  plus a zero-mean normal noise. The branch manager can do better than that, provided he puts to work his human capital by exercising the amount of effort  $H > 0$ . Then, the return becomes:

$$Y = F(H) + \varepsilon^X$$

where the disturbance  $\varepsilon^X$  is normal, with zero mean and standard deviation  $\sigma_X$ . Here,  $F$  is a strictly increasing and strictly concave function, with  $F(0) = V$  and the limit at infinity equal to  $V^H > V$ .<sup>5</sup> The managerial effort is costly, the cost function,  $H \mapsto \Phi(H)$ , being strictly increasing and convex, with  $\Phi(0) = 0$ . Thus, the attainable mean return on the loan portfolio varies with the manager's effort between  $V$  and  $V^H$ , the maximum value being possible only at infinite cost.

<sup>4</sup> If all deposits were claimed back at date 1, we would have  $\Xi = 1$  and  $Y^D = R^0 - R^D$ . However, we should think of a typical case when only a fraction of deposits is withdrawn and, accordingly,  $\Xi$  is a random variable distributed around a mean value substantially below unity.

<sup>5</sup> One can think of the "true" potential return on  $X$  as an unobservable value. By employing his human capital, the branch manager obtains a noisy signal about the potential return. The signal is downward biased, but the bias decreases with  $H$ . Note the difference of this interpretation and the one-in-many microfinance models, where the signals are unbiased and only their precision varies. Our understanding is closer to the discrete version of Girsanov's probability: better signals mean a more precise knowledge of the drift, whereas the diffusion magnitude stays the same.



If the shareholder's control over the branch were at the outside-investor level, she would consider  $Y$  a random variable with the low mean  $V$ :  $Y = V + \varepsilon^X + \varepsilon^S$ . The additional (compared with the manager) noise  $\varepsilon^S$  is assumed zero-mean normal with variance  $\sigma_s$ , independent of  $\varepsilon^X$  and all other sources of uncertainty. The shareholder can spend the amount of pecuniary and non-pecuniary resources  $B$  in order to audit the manager's activities in the branch. One effect of the audit is the shareholder's ability to reduce her bias in the knowledge of  $Y$ , similarly to the manager. The other effect is her enhanced ability to collect on risky loans in the event she dismisses the manager and runs the branch directly. The enhanced collection ability is a function of the audit resources per unit of loan,  $A = B/X$ . If the manager is fired, the shareholder, by her direct engagement with the branch, can achieve the return equal to:

$$Z = G\left(\frac{B}{X}\right) + \varepsilon^X + \varepsilon^S$$

with  $G$  being a strictly increasing and strictly concave function, with  $G(0) = V$  and the limit at infinity equal to  $V^S \in (V, V^H)$ . The shareholder revenue must be subsequently reduced by the audit cost, which is assumed to be a strictly increasing convex function  $K$  of  $B$ , with  $K(0) = 0$ . Of course, the balance-sheet decisions  $\tilde{X}$  and  $\tilde{D}$ , taken by the shareholder acting alone, as well as domestic-branch cash wealth so attained,  $\tilde{W}$ , would be different from the ones following from the manager's decisions (plain symbols with no tildas; the difference will be characterized shortly). We shall call the hypothetical values  $\tilde{X}$  and  $\tilde{D}$  (and the two corresponding values for the foreign-country branch) the shareholder's *substitute* portfolio choices. Note that the manager has no authority over the shareholder's own funds allocated to the branch. Therefore, we can think about the  $C$  variable as being set by the shareholder in advance of the manager-shareholder negotiations over recompense and thus not entering the bargaining process. The shareholder decides rationally upon the  $C$ -value in anticipation of the negotiation outcome (see also Section 2.3).

The shareholder's inability to fully replace the manager is expressed, first, by the inequality  $V^S < V^H$ , and, second, by the presence of additional noise,  $\varepsilon^S$ , in the return. Nevertheless, the possibility to audit allows the shareholder to threaten the manager with dismissal should he decide to claim the whole rent on the debt-collection ability for himself, cutting out the bank owner. With the audit, a part of the rent is turned over to the shareholder and another part to the depositors. The latter effect arises since the depositors are offered a rate of interest sufficient to attract them to the bank.

We assume that in the course of mutual negotiations, the shareholder makes known to the manager the resources,  $B$ , to be allocated to audit. The manager then selects his fee,  $M$ , so that the shareholder is indifferent to keeping or dismissing the manager:

$$W - K(B) - M = \tilde{W} - K(B)$$

which is equivalent to requiring the fee, which is lower by one cent lower than

$$M = W - \tilde{W} \tag{3}$$

Any fee higher than the left-hand side of equation (3) would see the manager dismissed, since the shareholder would do better acting in his place herself. A lower fee would be suboptimal for the manager unless he was exposed to competition from others with human capital linked to the same loan portfolio, which is highly improbable. Namely, we associate the manager's special skills with his knowledge about the repayment ability of the set of borrowers that comprise the loan portfolio of the branch. In other words, managers have an enhanced ability to collect on debt because they act in a relationship-banking environment. Altogether, equation (3) is just one of the many existing ways to describe the shareholder-manager negotiation outcome, which was chosen for its computational tractability.<sup>6</sup>

<sup>6</sup> For instance, in (Diamond, Rajan, 2000) the bargaining power is split at random between the shareholder and the manager, each of them given, with a 1/2-probability, the right to make a take-it-or-leave-it

The agreed managerial fees are inputs into the optimization programs solved by the two managers and the shareholder.

### 2.3 Optimal Investment, Audit, and Managerial Effort

We shall consider the case when the shareholder maximizes the expected negative exponential utility with risk-aversion parameter  $\gamma$  of the date-1 cash wealth,  $W^S = W + w$ , net of manager fees and audit costs:

$$E \left[ -\exp \left\{ -\gamma (W + w - M - m - K(B) - k(b)) \right\} \right]$$

Each manager maximizes his own expected negative exponential utility of the fee, net of the effort costs, that is,

$$E \left[ -\exp \left\{ -\gamma^M (W - \tilde{W} - \Phi(H)) \right\} \right]$$

and

$$E \left[ -\exp \left\{ -\gamma^m (w - \tilde{w} - \phi(h)) \right\} \right]$$

or the home- and the foreign-branch manager, respectively. The three risk-aversion parameters  $\gamma$ ,  $\gamma^M$ , and  $\gamma^m$  need not be equal to one another.

The risk-aversion assumption for all agents in the model is used to generate non-trivial demands for different assets and allows one to analyze portfolio shifts in response to shocks. For the same reason, the asset returns contain random noises even though the latter are unaffected by the relationship-banking degree, that is, they are seemingly unrelated to the central object of our interest. As mentioned before, our concept of informational frictions in the loan market utilizes the effect of *biased* information (errors in the perceived mean values) rather than *imprecise* information (higher than efficient variances). All the same, non-zero variances are needed in the present setting to prevent the problem from becoming vacuous.

Negative exponential utility has been selected for the sake of explicitness and ease of computation, although qualitatively similar results – albeit with a messier algebra – are obtainable for more general forms of the utility function.

#### 2.3.1 Manager's Choices

For definiteness, we formulate below the result for the foreign-branch manager, the domestic-manager results being recoverable by change of notation.

The manager's choice variables are effort  $h$ , credit volume  $x$ , and the deposit rate  $r^d$ . Let  $r^d \mapsto \pi(r^d)$  be the public supply of deposits as a strictly increasing function of the deposit rate, and  $d \mapsto t(d)$  its inverse. Formally, optimizing with respect to  $r^d$  and  $d$  by the manager is equivalent. The manager and the shareholder will be assumed to optimize the deposit volume as monopolists, taking the inverse deposit-supply function  $t$  into account. The choice-theoretic background of the bank-depositor interaction is not central to the subject of this paper and is left outside its scope.

Recall that the manager takes the capital allocated to the branch,  $c$ , as well as the “tilda variables” (the values of  $\tilde{d}$  and  $\tilde{x}$  that would be set by the shareholder if she decided to act without the manager) as given. Let  $y^d = n^d + \varepsilon^d$ ,  $\text{Var}[\varepsilon^d] = \sigma_d^2$ , and analogously for the excess return on the outside investment (or the shareholder's effective opportunity cost of capital in the foreign country),  $y^c$ . The correlation coefficient between  $\varepsilon^x$  and  $\varepsilon^d$  will be denoted  $\rho_{dx}$ . Then, the manager's optimal choices of  $x$ ,  $d$ , and  $h$  can be characterized as follows:

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offer to the other. In this paper, we renounce the possibility to explore the available game-theoretic ramifications of the manager-shareholder relation.

$$\sigma_x^2 (x - \tilde{x}) + \sigma_d \sigma_x \rho_{dx} (d - \tilde{d}) = \frac{f(h)}{\gamma^m} \quad (4a)$$

$$\sigma_d \sigma_x \rho_{dx} (x - \tilde{x}) + \sigma_d^2 (d - \tilde{d}) = \frac{n^d - (d - \tilde{d})t'(d)}{\gamma^m} \quad (4b)$$

$$xf'(h) = \phi'(h) \quad (4c)$$

This fact is an immediate consequence of the standard negative exponential utility maximization results.

Two observations can be made immediately by inspecting the first-order condition (FOC) of optimality (equations 4a–4c).

First, looking at equation (4c), which is valid for effort levels  $h \geq 0$ , one can infer the minimal level of loans justifying the manager human-capital involvement in the branch, namely,  $\underline{x} = f'(0) / \phi'(0)$ . That is, the relationship banking will be entertained by the foreign branch only for  $x > \underline{x}$  (a similar threshold value exists for the domestic branch as well).

Second, equations (4a) and (4b) demonstrate that the branch balance sheet, characterized by the triplet  $(c, d, x)$  or  $(c, \tilde{d}, \tilde{x})$ , looks different with and without manager participation, even if the shareholder's benefit is the same in both cases. Specifically, the difference between the levels of granted credit is:

$$x - \tilde{x} = \frac{1}{\gamma^m \sigma_x^2 (1 - \rho_{dx}^2)} \left( f(h) - \frac{\sigma_x \rho_{dx}}{\sigma_d} (n^d - (d - \tilde{d})t'(d)) \right) \quad (5)$$

One should think of the right-hand side of equation (5) as a typically positive value that shows by how much the manager must increase the size of the branch loan portfolio, compared with the hypothetical shareholder-management situation, in order to earn a positive fee.

### 2.3.2 Shareholder's Choices

Because the shareholder knows the rules as per equation (3), according to which the manager fees in both branches is set, she is faced with the objective of selecting the variables  $C$ ,  $\tilde{R}^D$ ,  $\tilde{X}$ ,  $c$ ,  $\tilde{r}^d$ ,  $\tilde{x}$ ,  $B$ , and  $b$  to maximize the expected negative exponential utility of the random variable:

$$\tilde{W}^S - K(B) - k(b) = -CY^C + \tilde{D}Y^D + \tilde{X}Z - cy^c + \tilde{d}y^d + \tilde{x}z - K(B) - k(b)$$

The latter expression is the cash wealth of the bank at date 1 less the audit expenditures in both branches. Recall that the  $\tilde{D}$ -,  $\tilde{X}$ -,  $\tilde{d}$ -, and  $\tilde{x}$ -values that the shareholder optimizes are substitute, that is, they are not applied as long as the managers retain their jobs. On the contrary, the capital values  $C$  and  $c$ , as well as the audit expenditures  $B$  and  $b$ , in the shareholder's program are the ones to be actually implemented, as they are not co-determined by managers.

The shareholder's program can be equivalently solved for audit-per-unit-of-credit expenditures  $A = B / \tilde{X}$ ,  $a = b / \tilde{x}$  instead of  $B$  and  $b$ . We will employ the following convention for notational simplicity:

$$\text{Define the parameters } \eta_D = \frac{R\Pi'(R)}{\Pi(R)} = \frac{T(D)}{DT'(D)}, \quad \eta_d = \frac{r\pi'(r)}{\pi(r)} = \frac{t(d)}{dt'(d)}$$

– interest-rate elasticities of deposit supply by the public in the home and the foreign country. Further, let us denote by  $L$  the following column vector:

$$L = \left[ -N^C, N^D - \frac{\tilde{R}^D}{\eta_D(\tilde{R}^D)}, G(A) - AG'(A), -n^c, n^d - \frac{\tilde{r}^d}{\eta_d(\tilde{r}^d)}, g(a) - ag'(a) \right]^T$$

Its components are mean excess returns of assets from the shareholder's perspective, adjusted for supply-elasticity effect in the case of deposits and for the marginal effect of auditing the managers in the case of loans. Also, let  $\Omega$  be the covariance matrix of the random vector  $[-\varepsilon^C, \varepsilon^D, \varepsilon^X + \varepsilon^S, -\varepsilon^c, \varepsilon^d, \varepsilon^x + \varepsilon^s]$ . Finally, denote by  $\tilde{J}$  the column vector of the shareholder's asset choices:  $\tilde{J} = [C, \tilde{D}, \tilde{X}, c, \tilde{d}, \tilde{x}]^T$ .

Then the following necessary and sufficient first-order conditions of optimality can be easily derived from standard results on expected negative exponential utility maximization:

$$\Omega \cdot \tilde{J} = \frac{1}{\gamma} L \quad (6a)$$

$$G'(A) = K'(\tilde{X}A) \quad (6b)$$

$$g'(a) = k'(\tilde{x}a) \quad (6c)$$

In the absence of an audit, equation (6a) would be a standard portfolio-optimization result for a risk-averse investor with negative exponential utility of wealth. That is, a banker who operates both branches as an arm's-length deposit-and-loan businesses, sets own capital, deposit, and loan volumes on the basis of excess return statistics of the six existing risky assets: their means and the covariance structure.<sup>7</sup> In Section 3 we analyze the difference that the twin market imperfections of the banking business makes in terms of lending decisions. In particular, we are interested in the different reactions of the multinational bank to external shocks compared with the arm's-length benchmark.

### 3. External Shocks and Credit Creation

As the results of Sections 2.2 and 2.3 indicate, the international bank reaction to exogenous disturbances in our model can be decomposed in two elements. First, manager-operated bank branches take deposits and provide credit differently than do shareholder-operated branches (equations [4a], [4b]). Second, the shareholder substitute decisions on deposits and loans are affected by shareholder-manager interactions (equation [6a]).

As this paper is concerned with the transmission of shocks across national borders, we focus on the impact of the home-country asset parameters, such as  $N^D$ ,  $\sigma_D$ ,  $N^C$ ,  $\sigma_C$ , and so forth, on the foreign-country bank-credit creation,  $x$ . Analyzing the consequence of the mean return parameters,  $N^C$  and  $N^D$ , turns out to be the most straightforward. Of these two,  $N^D$ , the average return on deposits, allows for quite a direct interpretation: its decrease corresponds to an increased rate of deposit/withdrawal in the domestic economy (something like an adverse liquidity shock experienced by home depositors, as modeled in Diamond and Rajan [2001]). Interpretation of the mean return  $N^C$  can be based on the capital-adequacy policy of the regulator. Indeed, tightening the capital-adequacy ratio can be mirror-imaged in our model as a reduction in the opportunity costs of capital.

Certain properties of the bank's balance-sheet reaction to shocks in  $N^C$  and  $N^D$  can be formulated in a uniformed fashion. Namely, let  $p$  be either  $N^C$  or  $N^D$ . The impact of a small change in  $p$ , in accordance with the results of Section 2, is naturally decomposed into the impact on substitute balance-sheet variables,  $\tilde{J}$ , and the impact on the difference between the actual

<sup>7</sup> Of course, the deposit volume is set indirectly through the deposit rate. However, in this paper neither depositor behavior nor depositor links with other strategic interactions in the economy is explicitly modeled.

and the substitute variables ( $D-\tilde{D}$ ,  $X-\tilde{X}$ ,  $d-\tilde{d}$ ,  $x-\tilde{x}$ ). We start with the former, meaning that the shareholder-optimality conditions will have to be differentiated with respect to  $p$ .

More notations will be needed to formulate the results. Thus:

$$\alpha_s^2 = -\frac{1}{\gamma} \frac{\tilde{A}^2 G''(\tilde{A}) K''(\tilde{X}\tilde{A})}{\tilde{X} K''(\tilde{X}\tilde{A}) - G''(\tilde{A})}, \quad \alpha_s^2 = -\frac{1}{\gamma} \frac{\tilde{a}^2 g''(\tilde{a}) k''(\tilde{x}\tilde{a})}{\tilde{x} k''(\tilde{x}\tilde{a}) - g''(\tilde{a})}$$

where tildas indicate the optimal choice of the corresponding variables by the shareholder, as characterized by equation (6). Further, we split vector  $L$  of the adjusted mean of asset returns as follows:

$$L = L^0 + L^S = \begin{bmatrix} -N^C \\ N^D - \frac{\tilde{R}^D}{\tilde{\eta}_D} \\ V \\ -n^c \\ n^d - \frac{\tilde{r}^d}{\tilde{\eta}_d} \\ v \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ G(\tilde{A}) - V - \tilde{A}G'(\tilde{A}) \\ 0 \\ 0 \\ g(\tilde{a}) - v - \tilde{a}g'(\tilde{a}) \end{bmatrix}$$

to separate the usual portfolio-optimizing source of response to parameter change (i.e.,  $L^0$ ) from the bank-specific audit-optimizing source,  $L^S$ . (Note that the arm's-length banker's choice of

portfolio is  $J = \frac{1}{\gamma} \Omega(\rho)^{-1} L^0$ .)

Next, to avoid unnecessary exploration of the second-order impact of  $p$  on the second component of  $L$  (and  $L^0$ ) through the term  $\frac{\tilde{R}^D}{\tilde{\eta}_D}$ , and on the fifth component – through the term

$\frac{\tilde{r}^d}{\tilde{\eta}_d}$ , we identify a small shift in  $p$  with a small shift of the second component of  $L^0$  as such.

Indeed, although the reaction channeled through deposit demand elasticity may be important in its own right, this reaction is qualitatively the same for manager-auditing banks and arm's-length investors.<sup>8</sup> Our goal here, however, is the examination of specific effects that appear in shareholder-manager frictions.

In short, using subscripts to denote partial differentiation, we can say that the  $p$ -impact on the right-hand side of the shareholder-optimality conditions in equation (6), represented by

<sup>8</sup> For instance, if the deposit supply is a linear function of the interest rate in the relevant equilibrium values domain (see more to this case in Parametric Example 2), that is, one can write  $T(D) = T_0 D$ ,  $t(d) = t_0 d$ , then the elastic deposit-supply effect can be accommodated by replacing the variances  $\sigma_D^2$ ,

$\sigma_d^2$  in matrix  $\Omega$  in equation (6a) by the expressions  $\sigma_D^2 + \frac{T_0}{\gamma}$ ,  $\sigma_d^2 + \frac{t_0}{\gamma}$ . This would mean a change in

the correlation structure of matrix  $\Omega$ , although a change that is independent of the role of manager human capital in the bank.

$L_p$ , is a sum of the standard portfolio-diversification impact  $L_p^0$  and the specific impact  $L_p^S$  coming from the shareholder-manager friction.

Let  $\rho$  be the set of correlations for the asset-return noise vector  $[-\varepsilon^C, \varepsilon^D, \varepsilon^X, -\varepsilon^S, \varepsilon^d, \varepsilon^x]$ . Keeping the variance structure  $\sigma_C, \sigma_D, \sigma_X, \sigma_C, \sigma_d, \sigma_x$  fixed, we will denote the covariance matrix for the same asset-return noise vector by  $\Omega(\rho)$ . Recall that this is the matrix that determines, in a direct analogy to equation (6a) but with  $L$  replaced by  $L^0$ , the asset demands of an arm's-length international investor. Obviously, for such an investor the balance-sheet reaction to a  $p$ -shock is characterized by the equation system:

$$\Omega(\rho) \cdot J_p = -\frac{1}{\gamma} L_p^0 \quad (7)$$

Accordingly, if  $I(\rho)$  is the inverse of  $\Omega(\rho)$ , then the sensitivity of the lending volume in the foreign country to a small change in  $N^D$  is proportional to the second element in the sixth row of  $I(\rho)$ , whereas its sensitivity to a small change in  $N^C$  – to minus the first element in the sixth row of  $I(\rho)$ :

$$\frac{\partial x}{\partial N^D} \approx \frac{1}{\gamma} I(\rho)_{62}, \quad \frac{\partial x}{\partial N^C} = -\frac{1}{\gamma} I(\rho)_{61} \quad (8)$$

The substitute asset demands in a manager-monitoring multinational bank react differently. Denote by  $\tilde{\Omega}$  the covariance matrix  $\Omega(\rho)$ , in which the third element on the main diagonal is replaced by  $\tilde{\sigma}_x^2 = \sigma_x^2 + \sigma_s^2 + \alpha_s^2$ , and the sixth element on the main diagonal – by

$$\tilde{\sigma}_x^2 = \sigma_x^2 + \sigma_s^2 + \alpha_s^2. \quad \text{Further, put } \tilde{\rho}_{CD} = \rho_{CD}, \quad \tilde{\rho}_{CX} = \frac{\sigma_x}{\tilde{\sigma}_x} \rho_{CX}, \quad \tilde{\rho}_{DX} = \frac{\sigma_x}{\tilde{\sigma}_x} \rho_{DX},$$

$$\tilde{\rho}_{Xx} = \frac{\sigma_x \sigma_x}{\tilde{\sigma}_x \tilde{\sigma}_x} \rho_{Xx}, \text{ and so forth, by obvious analogy. The result, generalizing equations (7) and (8)}$$

for the manager-monitoring bank shareholder, can then be stated as the following proposition, proved in the *Appendix*.

**Proposition 1** *If  $p$  is either the home country outside the investment-return mean,  $N^C$ , or the mean (net of deposit interest rate and withdrawal rate) return on domestic deposits,  $N^D$ , then the bank-shareholder substitute balance-sheet reaction to a  $p$ -shock is characterized by:*

$$\tilde{\Omega} \cdot \tilde{J}_p = -\frac{1}{\gamma} L_p^0 \quad (9)$$

*In particular, the sensitivity of the substitute lending volume in the foreign country to a small change in  $N^C$  and  $N^D$  can be characterized by:*

$$\frac{\partial x}{\partial N^C} = -\frac{1}{\gamma} \frac{\sigma_x}{\tilde{\sigma}_x} I(\tilde{\rho})_{61}, \quad \frac{\partial x}{\partial N^D} \approx \frac{1}{\gamma} \frac{\sigma_x}{\tilde{\sigma}_x} I(\tilde{\rho})_{62} \quad (10)$$

The above proposition states that the manager-monitoring shareholder reacts to external shocks as if she were an arm's-length investor with a distorted covariance structure of asset returns. First, the variance of returns on loans (both at home and abroad) is expanded to include the shareholder audit noises  $\varepsilon^S$  and  $\varepsilon^d$ . It is also increased, respectively, by the value of  $\alpha_s^2$  and

$\alpha_s^2$ , as if these parameters were variances of further error terms. Because  $\frac{\sigma_x}{\tilde{\sigma}_x} < 1$ ,  $\frac{\sigma_x}{\tilde{\sigma}_x} < 1$ , the

correlation parameters in  $\tilde{\Omega}$  are smaller than  $\rho$ . For the same reason, the factors  $\frac{\sigma_x}{\tilde{\sigma}_x}$  and  $\frac{\sigma_x}{\tilde{\sigma}_x}$  reduce the magnitudes on the right-hand side of equation (10) compared to equation (8), even if one ignores the transition from  $\rho$  to  $\tilde{\rho}$  in  $I(\rho)$ . In short, the ‘‘covariance effects’’ play a weaker role when the bank conducts *substitute* asset diversification than when the same manager-monitoring bank conducts *actual* asset diversification under an arm’s-length approach.

### Parametric Example 1: Linear-quadratic Audit Costs

To get a parametric representation of the shareholder’s audit role in her substitute decision making, consider a pair of linear-quadratic audit-cost functions

$$K(B) = \frac{K_0(1 + \mu_H B)^2 - K_0}{2}, \quad k(b) = \frac{k_0(1 + \mu_f b)^2 - k_0}{2}$$

for a set of positive constants,  $K_0, k_0, \mu_H, \mu_f$ . We will also select a special form of the substitute mean loan returns  $G$  and  $g$ :  $g(a) = v + \frac{v^a a}{1+a}$ , and similarly for  $G$ . Under these assumptions,

the first-order condition of equation (6c) is equivalent to  $(1+a)^2(1 + \mu_f \tilde{x}a) = \frac{v^a}{k_0 \mu_f}$ , and

similarly for equation (6b). It can then be shown that optimal  $a$  is a decreasing function of  $\tilde{x}$ , similarly for  $A$ . In particular, the range of possible audit-expenditure realizations ( $a, A$ ) is bounded. From the same first-order conditions, we also derive that for  $V^A > K_0 \mu_H$ ,  $v^a > k_0 \mu_f$ , the optimal audit expenditures are always positive.

More importantly, we are able to make the right-hand side of equation (6a) more explicit. Indeed, one immediately checks that  $g(\tilde{a}) - \tilde{a}g'(\tilde{a}) = v + k_0 \mu_f \tilde{a}^2 (1 + \mu_f \tilde{x} \tilde{a})$ , and similarly for the home-country parameters. By substituting the latter expression into equation (6a), we can transform it into:

$$\Omega^a \tilde{J} = \frac{1}{\gamma} L^a$$

with  $L^a = \begin{bmatrix} -N^C \\ N^D - \frac{\tilde{R}^D}{\tilde{\eta}_D} \\ V + K_0 \mu_H \tilde{A}^2 \\ -n^c \\ n^d - \frac{\tilde{r}^d}{\tilde{\eta}_d} \\ v + k_0 \mu_f \tilde{a}^2 \end{bmatrix}$  and  $\Omega^a$ , which differs from  $\Omega$  in equation (6a) by the elements

$\sigma_x^2 + \sigma_s^2 - \frac{K_0 \mu_H^2 \tilde{A}^3}{\gamma}$ ,  $\sigma_x^2 + \sigma_s^2 - \frac{k_0 \mu_f^2 \tilde{a}^3}{\gamma}$  instead of variances  $\sigma_x^2 + \sigma_s^2$ ,  $\sigma_x^2 + \sigma_s^2$  in the third and sixth position on the main diagonal. That is, the audit has changed the portfolio problem as perceived by the shareholder. It has increased the mean returns on loans from the arm's-length levels  $V$  and  $v$  to, respectively,  $V + K_0 \mu_H \tilde{A}^2$  and  $v + k_0 \mu_f \tilde{a}^2$ . It has also reduced the noise-return variances  $\sigma_s^2$ ,  $\sigma_s^2$  dealt by the shareholder in the course of her substitute management of the loan portfolio, to the extent proportional to the cube of the audit-expense per-credit unit. The latter effect cannot erase the variances completely since, as mentioned before, the optimal audit expenses are bounded. (By the proper choice of parameter values one can make the maximum feasible audit expenditures just offset the excess variances  $\sigma_s^2$  and  $\sigma_s^2$ .)

Altogether, in the context of the present example, the optimal reaction to parameter changes can be visualized a little easier than in the general case covered by Proposition 1.

The actual lending decisions are made by the branch manager and differ from the substituting shareholder decisions. Therefore, the total effect of a parameter change shall include the reaction of the manager. The latter is discussed next.

Define the auxiliary function  $q$  as  $q(x) = \frac{\phi'(h)^2}{x^2 [\phi''(h) - x f''(h)]}$ , with  $h = \chi(x)$  being the optimal manager effort as a function of loan volume, as characterized by the optimality condition in equation (4c). Introduce the auxiliary variables  $\hat{\sigma}_d^2 = \sigma_d^2 + \frac{2t'(d) + (d - \tilde{d})t''(d)}{\gamma^m}$

and  $\delta = \gamma^m \sigma_x^2 \left( 1 - \frac{\sigma_d^2}{\hat{\sigma}_d^2} \rho_{dx}^2 \right)$ . The relative impact of the same parameters  $N^C$  and  $N^D$  as in

Proposition 1, on the actual and the substitute loan volumes is described in the following proposition.

**Proposition 2** *If  $p$  is either the home country outside the investment return mean,  $N^C$ , or the mean return on domestic deposits,  $N^D$ , then the reaction of the foreign-branch-manager-determined loan volume,  $\hat{x}$ , and the substitute loan volume,  $\tilde{x}$ , to a  $p$ -shock are linked by the equation:*

$$(\delta - q(\hat{x})) \hat{x}_p = \delta \tilde{x}_p + \frac{\sigma_d \sigma_x \rho_{dx}}{\hat{\sigma}_d^2} [t'(\hat{d}) + (\hat{d} - \tilde{d})t''(\hat{d})] \tilde{d}_p \quad (11)$$

In equation (11),  $\hat{d}$  is the manager-determined deposit volume. (See the Appendix for the proof.)

Equation (11) can help us distinguish two modes of the actual and the substitute loan-volume reaction to a  $p$ -shock. Namely, function  $q$  in equation (11) is typically strictly decreasing. The exact result, proved in the Appendix, is as follows.

**Lemma 1** *If the marginal manager-effort cost function  $\phi'$  is convex, that is,  $\phi''' \geq 0$  everywhere, then  $q$  is strictly decreasing.*



Lemma 1 allows us to define the critical loan volume level  $x^*$  by  $q(x^*) = \delta$ . For equilibrium values  $\hat{x} < x^*$ ,  $\delta - q(\hat{x}) < 0$ , and the substitute loan-volume marginal reaction to a disturbance,  $\tilde{x}_p$ , goes in the opposite direction from  $\hat{x}_p$  (we consider the impact of the second term on the right-hand side of equation [11] to be small). For  $\hat{x} > x^*$ , both reactions go in parallel to each other.

**Parametric Example 2: Linear Manager-effort Costs, Linear Deposit Demand**

Let us consider a simple version of the above model with manager-effort costs dependent linearly on his effort:  $\phi(h) = \tau h$ , with  $\tau$  a positive constant. (Recall that the results obtained so far did not require strict convexity of the cost function  $\phi$ .) To simplify things further, assume that the deposit demand by the public in the foreign country can be approximated by a linear function, at least in the range of  $d$ - and  $r^d$ -values that contain the equilibrium. Therefore, we take  $t(d) = t_0 d$ . This assumption makes variables  $\hat{\sigma}_d$  and  $\delta$  constants. To complete the parameterization of this example, we fix the functional form of the foreign-manager average loan-

return dependence on effort  $f(h) = v + \frac{v^h h}{1+h}$ . Function  $q$  then becomes:

$$q(x) = \frac{\tau}{2v^h} \frac{(1+h)^3}{x^3}$$

The first-order condition of equation (4c), characterizing the optimal manager effort, can be used to express the latter as a function of optimal loan volume  $\hat{x}$ :

$$1 + \hat{h} = \left( \frac{v^h \hat{x}}{\tau} \right)^{1/2}$$

which further simplifies the expression for  $q(\hat{x})$ :  $q(\hat{x}) = \frac{1}{2} \left( \frac{v^h}{\tau \hat{x}^3} \right)^{1/2}$ .

Equation (11) of Proposition 2 reduces to:

$$(\delta - q(\hat{x})) \hat{x}_p = \delta \tilde{x}_p + \frac{\sigma_d \sigma_x \rho_{dx} t_0}{\hat{\sigma}_d^2} \tilde{d}_p \tag{12}$$

Now, being a linear combination of  $\tilde{x}_p$  and  $\tilde{d}_p$  (the quantities characterized by equation (9) in Proposition 1), the right-hand side of equation (12) is generically different from zero. Therefore, the left-hand side must be non-zero as well. This imposes the restriction  $q(\hat{x}) \neq \delta$  on the equilibrium loan volume. In fact, the range of possible equilibria therewith becomes split into the region of “small loan volumes,”  $\hat{x} < x^*$ , and “large loan volumes,”  $\hat{x} > x^*$ . The critical value  $x^*$ ,

for which  $q(x^*) = \delta$  is now given by  $x^* = \frac{1}{2\delta} \left( \frac{v^h}{\tau} \right)^{1/2}$ .

Note that the minimal feasible loan volume,  $\underline{x}$ , for which the manager effort is justified, equals  $\frac{\tau}{v^h}$ .

Obviously, for the small-loan-volume equilibrium to be feasible, it is necessary to impose a technical condition,  $\underline{x} < x^*$ , equivalent to  $\underline{x} = \frac{\tau}{v^h} < (2\delta)^{-\frac{3}{2}}$ .

Small-loan volume equilibria correspond to the case when the coefficient  $\delta - q(\hat{x})$  on the left-hand side of equation (12) is negative. In such an equilibrium, the reactions of the actual and the substitute credit creation have opposite signs. (We are thinking of the situation when the deposit change effect  $\tilde{d}_p$  has a small weight compared to  $\delta$  for instance, for the reason of small correlation coefficient  $\rho_{dx}$  or the deposit supply coefficient  $t_0$ .) Therefore, when the relationship-banking sector in the foreign country is relatively small, external shocks make the multinational bank manager react in a direction opposite to that of an international portfolio maximizer. The reason is that, with small loan volumes, the manager's objective function responds very sensitively to his shifts of effort. Put differently, due to the marginal effect of effort (or credit volume) on the mean loan returns being a decreasing function, a credit contraction makes the manager look better in the shareholder's eyes. In the region where these marginal effects are high (because credit volumes are low), the said motive is stronger than the standard portfolio-optimization motive. Consequently, when conventional portfolio-diversification wisdom suggests expanding the loan volume, benefits from a revised human-capital involvement in the loan management point to the opposite, and vice versa.

Observe that this result is valid only for shocks *abroad*, that is, the variables that do not directly enter the manager's surplus definition. Otherwise, for example, when a domestic deposit/withdrawal-rate shock occurs, conventional arm's-length investment motives typically dominate.

The large-loan-volume equilibria (when  $q(\hat{x}) < \delta$ ), produce a co-movement of the external shock reaction between the actual and the substitute credit volumes. That is, the bank branch reacts qualitatively similar to what an arm's-length investor would do. Moreover, according to equation (12), the magnitude of this reaction is increased relatively to the substitute

loan-volume reaction (since the ratio  $\frac{\delta}{\delta - q(\hat{x})}$  is greater than 1). As was shown in Proposition 1,

the substitute loan volume, on the other hand, produces a dampened reaction to external shocks compared to the arm's-length benchmark. Therefore, the overall effect, when compared with the case of the conventional international investor, may be either stronger or weaker, depending on the parameters of the model. In any event, a manager-auditing foreign-bank branch with a large-loan-volume equilibrium would be difficult to empirically separate from an arm's-length lender based solely on its reaction to other-country disturbances.

#### 4. Extensions: Regulation Heterogeneity, Exchange-Rate Risks

As long as foreign branches of a multinational bank have limited size, the home-country regulator of such a bank faces a more or less standard set of tasks. Our attention here will be given to the host country of a multinational bank branch. The available regulatory instruments in this case are limited compared to the standard. The capital-adequacy requirements are inapplicable, and the deposit-insurance arrangements are subject to international pressures toward harmonization. There remains some space for discretion with regard to solvency criteria and disclosure requirements. In terms of the model formulated in the previous sections, solvency criteria can be very loosely associated with the deposit/withdrawal rate  $\xi$ . The disclosure rules can be naturally associated with a parameter in the manager audit cost function  $k$ . Indeed, the branch remains solvent as long as its end-of-period cash wealth is able to absorb the withdrawal of deposits. In its decisions, the bank takes into account the statistics of the withdrawal rate  $\xi$ . Therefore, a supervisory tightening of the solvency criteria (e.g., more frequent on-site in-

spections, more strict enforcement of reporting obligations, etc.) can be represented by an increase in the mean value of  $\xi$ , or equivalently, by a fall in the mean deposit return rate  $n^d$ . The audit-cost reduction is linked to disclosure standards in an even more obvious way: the more the public (and hence the shareholder) is entitled to know about the loan quality via mandatory information channels, the less will have to be extracted by an effort-consuming auditing procedure.

Below, we give some formal observations on the host-country regulator possibilities offered by the two policy instruments mentioned above.

#### 4.1 Branch Solvency Requirements

As explained before, the adjustment of these requirements by the regulator can be formally accommodated as an exogenous shift in the value of parameter  $n^d$ . Suppose that the welfare criterion pursued by the policymaker is in a one-to-one correspondence with some function  $\omega$  of the deposit and credit volumes  $d$  and  $x$ . In reaction to a shock of a given size to a foreign variable (i.e., one of those discussed in the previous section), the regulator is able to adjust the average rate of the deposit return  $n^d$  by a multiple  $\theta$  of this shock size. Parameter  $\theta$  can be both positive and negative, depending on the direction of the policy response. From the results of Sections 2 and 3 it follows that there should always be a value of  $\theta$  that improves the welfare of the host country.

To see this, let  $p$ , as above, be the foreign variable subject to shock.<sup>9</sup> According to our assumption, and in the notation of Section 3, the marginal change in welfare is equal to

$$\omega_d \hat{d}_p + \omega_x \hat{x}_p$$

In other words, the host-country welfare will be improved if

$$\frac{\hat{x}_p}{\hat{d}_p} > -\frac{\omega_d}{\omega_x} \quad (13)$$

To find out for which values of the policy-response parameter  $\theta$  (equation (13)) are satisfied, one needs to go through the derivations that have led to the results of Propositions 1 and 2 and trace the impact of  $\theta$ . Compared with Section 3, the following adjustments must be made in the calculations. First, equation (4b) shall be corrected to include the explicit dependence on  $p$  due to the policy response:

$$\sigma_d \sigma_x \rho_{dx} (\hat{x} - \tilde{x}) + \sigma_d^2 (\hat{d} - \tilde{d}) = \frac{n^d + \theta p - (\hat{d} - \tilde{d}) t'(\hat{d})}{\gamma^m}$$

This equation must be then differentiated wrt  $p$  in the same way as in the proof of Proposition 2 in the Appendix. This will produce the  $\theta$ -corrected relation between  $(\hat{d}_p, \hat{x}_p)$  and  $(\tilde{d}_p, \tilde{x}_p)$ . Second,  $n^d$  must be replaced by  $n^d + \theta p$  in the definition of vector  $L^0$  preceding equation (9) of Proposition 1. Accordingly, the fifth component of the partial derivative  $L_p^0$  of  $L^0$  will be increased by  $\theta$  in the modified version of equation (9). This equation will generate the  $\theta$ -corrected values of  $(\tilde{d}_p, \tilde{x}_p)$ .

Combining the two described adjustments, it is possible to obtain the ratio on the left-hand side of equation (13) as a function of  $\theta$ . And, given the linear nature of the involved  $\theta$ -dependences in  $(\hat{d}_p, \hat{x}_p)$ , it is always possible to find values of this policy parameter that improve

<sup>9</sup> More precisely,  $p$  is a deviation of the parameter under consideration from the initial value.

welfare. Consequently, there is always place for welfare-improving national-policy reactions in the solvency standard area, in the sense that national discretion dominates international harmonization.

#### 4.2 Transparency and Audit Costs

One possible way of representing the transparency-requirement effect on audit costs is to associate a policy parameter with the audit-noise variance  $\sigma_s^2$ . Another is to assume that there is a policy parameter  $P$  that appears as a multiplicative factor by the audit-effort variable  $a$  in the cost function  $k$ . Since the workings of the latter alternative are easier to describe in terms of space and notation, we chose it.

The presence of the multiplicative audit cost-reducing policy parameter  $P$  means that the cost function  $k$  has the form  $k(b) = k_n(Pb)$ , where  $k_n$  is another strictly increasing and strictly convex function with  $k_n(0) = 0$ . The welfare consequences of the  $P$  adjustment can be analyzed in the same way as in the solvency-requirements case above, that is, with the help of equation (13), with  $p$  replaced by  $P$ . Calculation of the  $P$  impact on deposit and loan volumes can proceed as before. Because audit costs do not enter the manager's surplus definition, the  $P$  dependence of equations (4) is the same as stated in Section 3 and the proof of Proposition 2 in the Appendix. The difference comes up only in the response of substitute asset holdings, chosen by the shareholder. Namely, the last component of vector  $L^S$  has a special dependence on  $P$ . By using equation (6) and the implicit function theorem, one obtains the following analogue of equation (9):

$$\tilde{\Omega} \cdot \tilde{J}_p = \frac{1}{P} L^n \quad (14)$$

with vector  $L^n$  defined as  $L^n = \left[ 0, 0, 0, 0, 0, \frac{\gamma \tilde{a} g''(\tilde{a}) k'(\tilde{x}\tilde{a})}{\tilde{x} k''(\tilde{x}\tilde{a}) - g''(\tilde{a})} - \alpha_s^2 \tilde{x} \right]^T$ . The remaining variables

are the same as in Section 3.

Now observe that the last component of  $L^n$  is a negative quantity, so that the impact of  $P$  reduction (i.e., higher transparency requirements) on  $\tilde{x}$  is always positive. The overall impact on the actual loan volume  $\hat{x}$  is as stated in Proposition 2, that is, ambiguous. For instance, in the "small-loan-volume equilibrium" from Parametric Example 2 (Section 3), higher transparency reduces the audit costs and increases the substitute loan volume, but the actual credit may go down (unless the impact on the substitute deposit level reverts the overall outcome). This happens because a cheaper audit is exploited by the shareholder in the "income-effect" mode, so that the audit effort is not increased sufficiently. On the manager side, effort is an increasing function of current loan volume, whereas the marginal effect of managerial effort,  $f'$ , decreases in effort. Therefore, when the loan volume is small, the manager is trapped in the region of decision variables with "perverse" incentives: under any exogenous disturbance, he would prefer to be in a state with a reduced need for effort and a lower loan volume.

On the contrary, in the "large-loan-volume equilibrium," cheaper audit policies always result in credit expansion because the manager-set and the substitute credit volumes move in the same direction in response to shocks.

#### 4.3 Exchange-Rate Volatility

The formal setting with normal excess returns and negative exponential utility used in this paper is not particularly suitable for an explicit analysis of exchange-rate effects on international investment. The problem is that a normally distributed excess-foreign-asset return, accounted in foreign currency, after being multiplied by the exchange-rate variable, should

remain normal to allow the certainty-equivalence procedure to go through. However, a ratio of two normal variables does not possess a convenient parametric distribution, let alone such that would be appropriate to associate with the exchange rate. Therefore, one does not have the advantage provided by the expected value maximization for a lognormally-distributed wealth, and calculations become complicated. Here, while ignoring this unpleasant complication, we offer only a few general comments, based on understanding the foreign asset returns as random variables distorted by an exchange-rate risk with unspecified statistical properties.

From the multinational-bank shareholder point of view, the presence of exchange-rate risk means that the statistics of returns on assets that are foreign to her, that is,  $c$ ,  $d$ , and  $x$ , have a more specialized form compared with the one posited in Section 2. Namely, if  $S = S_0(1 + s)$  is the uncertain nominal price of a foreign-currency unit in domestic-currency terms on date 1 (and  $S_0$  is its known value at date 0), then the foreign-asset returns have the form  $1 + r^0 = (1 + s)(1 + r^{*0})$ ,  $1 + r^c = (1 + s)(1 + r^{*c})$ ,  $1 + r^d = (1 + s)(1 + r^{*d})$ ,  $1 + r^x = (1 + s)(1 + r^{*x})$ , with asterisks denoting the foreign-currency-denominated returns. If the foreign-branch manager is also a local resident, he would calculate his fee in foreign currency, while using the return rates  $r^{*0}$ ,  $r^{*c}$ ,  $r^{*d}$ , and  $r^{*x}$  in his decision problem. On the other hand, the shareholder would use the rates  $r^0$ ,  $r^c$ ,  $r^d$ , and  $r^x$  accounted in the currency of her country of incorporation. As a result, even if we ignore the non-normality of, at least, some random factors appearing in the agents' optimization problems in this new setting, the covariance structures appearing in the shareholder's and the foreign-branch manager's problems will be different. Due to the exchange-rate risk, one should typically expect a higher level of all the covariances involving foreign uncertainties than those involving domestic uncertainties only in the shareholder's problem. This will have an impact on the substitute asset-value choice by the shareholder. However, this effect, which is not at all relationship-banking specific, will combine with the usual manager decisions, as described in Section 2.3, making the overall picture more involved.

For instance, one could try to assess the impact of an increased exchange-rate volatility on the foreign-country-manager decisions, the credit creation in particular. For the local-resident manager, the exchange-rate parameters do not enter the definition of his surplus. Therefore, the result of Proposition 2, namely an analogue of equation (11), shall be valid, with  $p$  replaced by the exchange-rate volatility parameter. This gives us, as usual, a characterization of the credit-volume  $\hat{x}$  response *relative to* the response of the substitute value  $\tilde{x}$ . To analyze the latter, one must posit some parametric form of the covariance matrix  $\Omega$ -dependence on exchange-rate volatility. Let this be done in some unspecified way, denote the said volatility measure by  $\zeta$  and by  $\Omega_\zeta$  – the partial derivative of  $\Omega$  with respect to this variable. Note that matrix  $\Omega_\zeta$  shall have zeros in the left-upper quarter. Then, by proceeding similarly to Proposition 1, including the definitions of  $\alpha_s^2$ ,  $\alpha_x^2$ , and  $\tilde{\Omega}$ , one can arrive at the following formula, a counterpart to equation (9):

$$\tilde{\Omega} \cdot \tilde{J}_\zeta = -\Omega_\zeta \cdot \tilde{J}$$

This equation would be valid for an arm's-length international investor as well, with  $\tilde{\Omega}$  replaced by the original  $\Omega$ . That is, once again, one obtains a comparison of the reaction of the manager-dependent and the arm's-length bank to a shock, with the presence of managers resulting in a downshift of the correlation structure in the bank's stochastic investment-opportunity set. The subsequent interposition of this substitute shareholder behavior with the actual behavior of the manager is subject to the same "large- vs. small-loan-volume case" distinction as described above.

## 5. Conclusion

The paper introduced a model of a multinational bank dependent on the specific human capital of the branch management. The results utilize an understanding of commercial banking as a business whose *raison-d'être* is provided by the involvement of non-transferable manager

skills. The bank shareholders motivate the managers to employ their human capital by means of their own, manager-auditing effort. This twin agency-cost paradigm is applied to a risk-averse bank shareholder operating branches and employing managers in two countries. We have investigated the reaction of one country branch to a shock happening to asset returns in another country, and compared it to the reaction to the same shock of a bank acting as an arm's-length investor. The key notion that we found our analysis upon is the hypothetical substitute decision making of a bank shareholder in case she decides to do without the manager skills and save on his fees. The substitute portfolio decisions are different from both the decisions of an arm's-length bank and the actual decisions of the audited manager. The latter bases the effort and the loan-deposit choices on the intention to stay marginally more attractive to the shareholder than her own substitute management of the branch.

Quantitative differences in the shock response in an international portfolio-optimizing environment with and without the agency problems have been found, as expected. More importantly, we have found that there might also be qualitative differences. That is, if the country is foreign to the shock, the latter can have opposite impacts on the credit creation by a manager-skill-dependent and an arm's-length bank. In the model, this happens only on condition of small loan volumes, and the factor responsible for this phenomenon is manager sensitivity to effort costs.

We also comment upon the choices of a national regulator in the constructed environment. Although domestic credit growth is not the concern of the financial-services regulator, a sudden reversal of credit to the non-bank private sector by banks under foreign control is likely to threaten the financial situation of many bank-dependent firms and households. In a small economy with an overwhelming dominance of a few big foreign lenders, this can mean a secondary impact on financial stability. Therefore, it is in the interest of the regulator to support a banking-service market with a possibly stable credit supply. This is an additional challenge beside the well-known problem of the pro-cyclic nature of risk-based capital requirements with respect to domestic banks. Moreover, in a banking sector mostly populated by either foreign-bank branches or their overcapitalized subsidiaries, the regulator lacks the possibility to act through capital-adequacy requirements. However, there appears to exist some space for extra welfare-improving solvency criteria and transparency-requirement policy measures on the national level. This means that the "level-playing-ground" regulation in terms of transparency might encounter opposition in countries with a high degree of foreign-bank penetration.

A frequently posed question is the influence of the exchange-rate noise on the foreign-bank operation. The issue is not considered in full detail, but the model suggests that bank branches managing large loan volumes may react differently from branches that manage small loan volumes, to exchange-rate volatility as to any other external shock. Once again we find that, whereas the shareholder substitute decisions are similar to the ones of any other international portfolio optimizer, although with a reduced role for the asset-return correlations, the manager's choices are subject to a qualitative difference if the loan volume under his control is sufficiently small.

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## Appendix: Proofs

### PROOF OF PROPOSITION 1

To prove equation (9), one needs to differentiate equation (6a) with respect to  $p$ . The derivative of the left-hand side is equal to  $\Omega \tilde{J}_p$ . The right-hand side is  $L_p^0 + L_p^S$ , and one needs to calculate  $L_p^S$ . Clearly,

$$\frac{\partial [G(\tilde{A}) - \tilde{A}G'(\tilde{A})]}{\partial p} = -\tilde{A}G''(\tilde{A})\tilde{A}_p$$

and a similar equality is valid for the last component of  $L_p^S$ . Now we need to calculate the optimal audit reaction to a  $p$ -change. This is done in the following lemma for the foreign-branch audit; the home-branch result is obtained by change of notation.

**Lemma A1:** *For any model parameter  $p$ , the partial derivatives of the shareholder's optimal audit-per-loan-unit expenditure  $\tilde{a}$  and the optimal substitute loan volume  $\tilde{x}$  with respect to  $p$  are linked by:*

$$\tilde{a}_p = -\frac{\tilde{a}k''(\tilde{x}\tilde{a})}{\tilde{x}k''(\tilde{x}\tilde{a}) - g''(\tilde{a})} \tilde{x}_p$$

PROOF: This is a direct consequence of equation (6c) and the implicit-function theorem. The latter is applicable since the audit-cost function  $k$  is convex, function  $g$  is strictly concave, and, therefore, the expression  $\tilde{x}k''(\tilde{x}\tilde{a}) - g''(\tilde{a})$  is strictly positive.

Recalling the definitions of  $\alpha_s^2$ ,  $\alpha_x^2$ , and  $\tilde{\Omega}$ , we see that the result of  $p$ -differentiation of equation (6a) can be written as equation (9).

To obtain equation (10), introduce the auxiliary diagonal matrix  $l = \text{diag} \left\{ 1, 1, \frac{\tilde{\sigma}_x}{\sigma_x}, 1, 1, \frac{\tilde{\sigma}_x}{\sigma_x} \right\}$

and observe that, in the notations of Section 3,  $\tilde{\Omega} = l \cdot \Omega(\tilde{\rho}) \cdot l$ . So, by multiplying both sides of equation (9) by  $\tilde{\Omega}^{-1}$ , we get:  $\tilde{J}_p = \frac{1}{\gamma} l^{-1} \cdot \mathbf{I}(\tilde{\rho}) \cdot l^{-1} \cdot L_p^0$ , from which equation (10) follows by inspection of the corresponding matrix elements.

### PROOF OF PROPOSITION 2

The starting step of the proof is the  $p$ -differentiation of equation (4). Having conducted it, we get, recalling the definition of  $\hat{\sigma}_d^2$  and rearranging, the pair of equations:

$$\begin{aligned} \sigma_x^2 (\hat{x}_p - \tilde{x}_p) + \sigma_d \sigma_x \rho_{dx} \hat{d}_p &= \sigma_d \sigma_x \rho_{dx} \tilde{d}_p + \frac{f'(\hat{h}) \hat{h}_p}{\gamma^m} \\ \sigma_d \sigma_x \rho_{dx} (\hat{x}_p - \tilde{x}_p) + \hat{\sigma}_d^2 \hat{d}_p &= \left( \sigma_d^2 + \frac{t'(\hat{d})}{\gamma^m} \right) \tilde{d}_p \end{aligned}$$



To reduce the right-hand side of the first one to known quantities, we need to calculate the optimal manager-effort reaction to a  $p$ -change. This is done in Lemma A2.

**Lemma A2:** For any model parameter  $p$ , the partial derivatives of the manager's optimal effort level  $\hat{h}$  and the optimal loan volume  $\hat{x}$  with respect to  $p$  are linked by:

$$\hat{h}_p = \frac{f'(\hat{h})}{\phi''(\hat{h}) - \hat{x}f''(\hat{h})} \hat{x}_p$$

PROOF: This is a direct consequence of equation (4c) and the implicit-function theorem. The latter is applicable since the effort-cost function  $\phi$  is convex, function  $f$  is strictly concave, and, therefore, the expression  $\phi''(\hat{h}) - \hat{x}f''(\hat{h})$  is strictly positive.

The result of equation (11) in Proposition 2 is now obtained by routine algebra, given the definition of  $q$  and equation (4c).

PROOF OF LEMMA 1

By definition of  $q$  and  $\chi$ ,  $q(x) = f'(\chi(x))\chi'(x)$ . Then  $q' = f''(\chi')^2 + f'\chi''$ . The first derivative of  $\chi$  was obtained in Lemma A2. Differentiating equation (4c) twice, we get the following for the second derivative of  $\chi$ :

$$\chi'' = \frac{2f''\chi' + (xf''' - \phi''')(\chi')^2}{\phi'' - xf''}$$

Substituting the latter expression in that for  $q'$ , we see that it has the same sign as:

$$(\chi')^2 \left[ \phi'' f'' - x(f''')^2 - xf'f'' - xf'\phi''' \right] + 2ff''\chi'$$

Therefore, the condition  $\phi''' \geq 0$  is sufficient for the whole of the latter expression to be strictly negative.