# Internet Appendix for
# "Specialization in Bank Lending: Evidence from Exporting Firms"

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**ABSTRACT**

This Internet Appendix serves as a companion to the paper "Specialization in Bank Lending: Evidence from Exporting Firms." It contains supplementary material, tables, and figure not included in the main text in order to conserve space.

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## IA.A. Model extension

The exposition in subsection II.B in the main text focuses on the firm's optimal choice of bank per activity, which is our object of interest. It purposely simplifies the problem of the firm to cost minimization for any given level of output, in each activity $c$. This problem could be understood as a step within a more complete profit maximization, where output level and total variable cost are endogenous optimal outcomes.

Consider the case of CES demand structure, with activity-wide demand shifter $Q^c$ (i.e., $Q^c$ recovers market size, competition prices, and other market-wide variables exogenous to the firm) and elasticity of substitution $\sigma > 1$ (an application mentioned in the body of the paper). Firm $i$ faces the following demand function for activity $c$:

$$q_i^c = Q^c(p_i^c)^{-\sigma}.$$

As in the body of the paper, the production function incorporates the bank-activity lending advantage and the firm idiosyncratic factor: $q_i^c = \gamma_b^c L_{ib}^c \exp\{\mu\epsilon_{ib}^c\}$, provided that bank $b$ is chosen to fund activity $c$.

The firm chooses the level of output $q_i^c$ and the bank $b$ that maximizes profits for activity $c$. Replacing with the demand and production functions, the problem can be rewritten as:

$$\max_{q,b} \quad (Q^c)^{\frac{1}{\sigma}}(q_i^c)^{\frac{\sigma-1}{\sigma}} - \frac{r_b}{\gamma_b^c}\exp\{-\mu\epsilon_{ib}^c\}q_i^c.$$

The first and second terms correspond to revenues and total cost, respectively.

This problem can be solved in two steps. $MC_i^c = \frac{r_b}{\gamma_b^c}\exp\{-\mu\epsilon_{ib}^c\}$ is the marginal cost of production, given the yet-to-be-chosen bank $b$. Then, the profit maximization problem can be expressed as:

$$\max_{q} \quad (Q^c)^{\frac{1}{\sigma}}(q_i^c)^{\frac{\sigma-1}{\sigma}} - MC_i^c q_i^c.$$

The optimal output and price are:

$$
\begin{aligned}
q_i^c &= Q^c \left[ \frac{\sigma}{\sigma - 1} MC_i^c \right]^{-\sigma} \\
p_i^c &= \frac{\sigma}{\sigma - 1} MC_i^c.
\end{aligned}
$$

In the body of the paper, we pair activities with export destinations. Then, total cost of credit $r_b L_{ib}^c$ is proportional to exports towards $c$:

$$
r_b L_{ib}^c = MC_i^c q_i^c = \frac{\sigma - 1}{\sigma} p_i^c q_i^c = \frac{\sigma - 1}{\sigma} X_i^c,
$$

and lending towards activity $c$, provided $b$ is the chosen bank to fund this activity, is simply:

$$
L_{ib}^c = \frac{\sigma - 1}{\sigma} \frac{X_i^c}{r_b},
$$

Optimal profits depend negatively of the marginal cost of production $MC_i^c$:

$$
\Pi_i^c = \left( \frac{\sigma - 1}{\sigma} \right)^{\sigma - 1} Q^c (MC_i^c)^{-\sigma + 1}.
$$

Then, the maximization is complete with firm's choice of bank for each activity $c$, which is the step explained in the body of the paper:

$$
b = \arg\min_{b'} \quad \frac{r_{b'}}{\gamma_{b'}^c} \exp\{-\mu \epsilon_{ib'}^c\}.
$$

**Proxy for comparative lending advantage using observable data**

We do not observe $L_{ib}^c$ but only $L_{ib} = \sum_{k=1}^{C} L_{ib}^k$. Then, as explained in subsection II.B in the main text, we use $\sum_i L_{ib} X_i^c$, as a proxy for $\sum_i L_{ib}^c$, to recover our object of interest, $\widetilde{\gamma}_b^c$, that is, the pattern of banks' comparative advantage by export destination.

We define $S_b^c$ as follows:

$$S_b^c = \frac{\sum_i^I L_{ib} X_i^c}{\sum_k^C \sum_i^I L_{ib} X_i^k}.$$

Notice that, from equation (2) in the body of the paper,

$$\sum_{i=1}^{I} L_{ib} X_i^c = \sum_{i=1}^{I} \left( \sum_{k=1}^{C} L_{ib}^k \right) X_i^c = \sum_{i=1}^{I} \left( \frac{1}{r_b} \sum_{k}^{C} \mathbb{I}_{ib}^k X_i^k \right) X_i^c,$$

where $\mathbb{I}_b^k$ is an indicator function that signals whether bank $b$ is chosen by firm $i$ to fund activity $k$. Since the idiosyncratic motive $\{\epsilon_{ib}^c\}$ is assumed to be i.i.d across firms, we get (for a large number of firms):

$$\begin{aligned} \sum_{i=1}^{I} L_{ib} X_i^c &= \frac{1}{r_b} \sum_{k'=1}^{C} Pr_b^{k'} \sum_{i=1}^{I} (X_i^{k'} X_i^c) \\ \sum_{k=1}^{C} \sum_{i=1}^{I} L_{ib} X_i^k &= \frac{1}{r_b} \sum_{k'=1}^{C} Pr_b^{k'} \sum_{k=1}^{C} \sum_{i=1}^{I} (X_i^{k'} X_i^k). \end{aligned}$$

Then, we can express the observable object $S_b^c$ in terms of the parameters of interest in our model, $\{\widetilde{\gamma}_b^k\}$:

$$S_b^c = \upsilon \sum_{k=1}^{C} \left\{ \widetilde{\gamma}_b^k \sum_{i=1}^{I} (X_i^k X_i^c) \right\} \qquad \widetilde{\gamma}_b^k \equiv \frac{Pr_b^k}{\sum_{k'=1}^{C} Pr_b^{k'}},$$

where, using the assumption of independence of $\{\widetilde{\gamma}_b^c\}$ and $\sum_{k=1}^{C} \widetilde{\gamma}_b^k = 1$, we get that (for a large number of banks) $\upsilon > 0$ is constant across all banks:

$$\upsilon^{-1} = \sum_{k=1}^{C} \left\{ \widetilde{\gamma}_b^k \sum_{k'=1}^{C} \sum_{i=1}^{I} (X_i^k X_i^{k'}) \right\} = \sum_{k=1}^{C} \sum_{k'=1}^{C} \sum_{i=1}^{I} (X_i^k X_i^{k'}).$$

We now show the conditions under which $S_b^c$ is a good proxy for our object of interest

$\widetilde{\gamma}_b^c$, for any given destination $c$. In particular, the conditions on the correlation between destinations in the distribution of firm exports and the correlation between destination in the bank lending advantages, so that the covariance between these two objects is positive for any country $c$ (i.e., $\mathrm{cov}_c(\widetilde{\gamma}_b^c, S_b^c) > 0$):

$$\begin{aligned} \mathrm{cov}_c(\widetilde{\gamma}_b^c; S_b^c) &= B^{-1}\sum_{b=1}^{B}\{\widetilde{\gamma}_b^c \cdot S_b^c\} - \left\{B^{-1}\sum_{b=1}^{B}\widetilde{\gamma}_b^c\right\} \cdot \left\{B^{-1}\sum_{b=1}^{B} S_b^c\right\} \qquad \text{(IA.1)} \\ &= \upsilon B^{-1}\sum_{b=1}^{B}\left\{[\widetilde{\gamma}_b^c - \overline{\gamma}^c] \cdot \sum_{k=1}^{C}\left[\widetilde{\gamma}_b^k \sum_{i=1}^{I}(X_i^c X_i^k)\right]\right\} \\ &= \upsilon \cdot \left\{B^{-1}\sum_{b=1}^{B}\sum_{k=1}^{C}[\widetilde{\gamma}_b^c - \overline{\gamma}^c]\,\widetilde{\gamma}_b^k\right\} \cdot \left\{\sum_{k=1}^{C}\sum_{i=1}^{I}(X_i^c X_i^k)\right\}, \end{aligned}$$

where we use the overline for averages, that is, $\overline{\gamma}^c \equiv B^{-1}\sum_b \widetilde{\gamma}_b^c$. Moreover, we refer to export aggregates as $\sum_i X_i^c \equiv X^c$ and the covariance between export destinations as $\sigma_{ck}$, so that $\sum_i (X_i^c X_i^k) = X^c X^k + \sigma_{ck}$. Correspondingly, and $\mathrm{cov}_b(\widetilde{\gamma}_b^c; \widetilde{\gamma}_b^k) = \rho_{ck}$ for $c \neq k$. Then:

$$\mathrm{cov}_c(\widetilde{\gamma}_b^c; S_b^c) = \upsilon \sum_{k=1}^{C}\left\{(X^c X^k + \sigma_{ck}) \cdot \rho_{ck}\right\}.$$

If the covariances between destinations in exports and lending advantages are zero (i.e., $\sigma_{ck} = \rho_{ck} = 0$ for all $c \neq k$), then the expression above is simplified to (the case considered in the body of the paper):

$$\mathrm{cov}_c(\widetilde{\gamma}_b^c; S_b^c) = \upsilon \sum_{i=1}^{I}(X_i^c)^2 \; B^{-1}\sum_{b=1}^{B}(\widetilde{\gamma}_b^c - \overline{\gamma}^c)^2 > 0.$$

More generally, a sufficient condition for this covariance to be positive is $\frac{d\rho_{ck}}{d\sigma_{ck}} \geq 0$. This condition has an intuitive interpretation. Some export markets share common attributes (for example, EU countries have common administrative rules), which may result in positive correlation in the expertise of both firms and banks towards those markets. This condition states that some of those shared attributes are common for banks and firms, so that the correlation between destinations in the pattern of banks' lending advantage, $\sigma_{ck}$, and in the pattern of firms' export, $\rho_{ck}$, satisfy $d\rho_{ck}/d\sigma_{ck} > 0$.

Under those conditions, country-$c$ specific ranking of $\{S_b^c\}_{b\in B}$ is a good instrument for the unobservable ranking of $\{\widetilde{\gamma}_b^c\}_{b\in B}$ across banks, for any destination $c$.

## IA.B. Empirical Identification of Credit Supply Shocks

We present a simple model based on Khwaja and Mian (2008) (henceforth "KM") to explain why firm-time fixed effects cannot fully account for changes in firm credit demand when banks are specialized. We start with the model described in KM and derive the identification assumption in their setting. Next, we consider an extension of the KM model in which banks specialize and discuss how it affects the identification assumption.

KM assumes that each bank makes a single loan. We follow KM's notation and denote the loan made by bank $i$ to firm $j$ at time $t$ as $L_{ij}^t$. Banks can finance the loan with deposits or bonds. The following balance sheet identity holds:

$$L_{ij}^t = D_i^t + B_i^t,$$

where $D_i^t$ is deposit financing and $B_i^t$ is bond financing.

KM assumes that deposit funding is insured and available up to an exogenous amount denoted by $\bar{D}_i^t$. Because of deposit insurance, banks strictly prefer deposit financing over bond financing. To make the problem interesting, KM assumes that deposit funding is scarce such that $L_{ij}^t > \bar{D}_i^t$. It follows that banks need to issue bonds to finance the loan.

KM assumes that bond financing has a *marginal* cost of $\alpha_B B_i^t$. It is straightforward to see that the marginal cost of bond financing is increasing in the amount of bond financing, $B_i^t$. This can be interpreted as a reduced form way of capturing informational frictions in bank financing (e.g., Stein (1998)).

KM assumes that the marginal return to a loan is given by $\bar{r} - \alpha_L \times L_{ij}^t$. It is straightforward to see the marginal return on loan $L_{ij}^t$ is decreasing in loan size.

KM assumes that there are shocks to the supply of deposit funding. The supply shock is modeled as a shock to the total availability of deposit funding. Total deposit funding is given by $\bar{D_i^{t+1}} = \bar{D_i^t} + \bar{\delta_t} + \delta_{it}$ where $\bar{\delta_t}$ is an aggregate deposit shock and $\delta_{it}$ is an idiosyncratic shock to bank $i$ at time $t$.

KM assumes that there are shocks to the demand for credit. The demand shock is modeled as a shock to the return on lending. It can be interpreted as a productivity shock. The return to lending is given by $\bar{r} - \alpha_r \times L_{ij}^t + \bar{\eta_t} + \eta_{jt}$ where $\bar{\eta_t}$ is the aggregate demand shock and $\eta_{it}$ is an idiosyncratic shock to firm $i$ at time $t$.

KM solves this model for a two-period setup. KM drops subscript $t$ when examining the two period setup. They use the FOCs for each period combined with the balance sheet identity to solve for loan growth, denoted as $\Delta L_{ij}$, in terms of the exogenous demand and supply shocks and the cost parameters:

$$\Delta L_{ij} = \frac{\alpha_B}{\alpha_L + \alpha_B}(\bar{\delta} + \delta_i) + \frac{1}{\alpha_L + \alpha_B}(\bar{\eta} + \eta_j).$$

This equation can be rewritten in terms of exposure to an aggregate shock and idiosyncratic shocks:

$$\Delta L_{ij} = \frac{1}{\alpha_L + \alpha_B}(\bar{\eta} + \alpha_B \bar{\delta}) + \frac{1}{\alpha_L + \alpha_B}\ \eta_j + \frac{\alpha_B}{\alpha_L + \alpha_B}\ \delta_i. \tag{IA.2}$$

KM suggests estimating this equation using the following OLS regression:

$$\Delta L_{ij} = \beta_0 + \beta_1 D_i + \gamma_j + \varepsilon_{ij},$$

where $D_i = \delta_i$ captures a bank-specific deposit shock.

Assume that the econometrician cannot observe $\gamma_j = \frac{1}{\alpha_L+\alpha_B}\eta_j$. It follows that the combined error term is $\gamma_j + \varepsilon_{ib}$. The OLS coefficient $\hat{\beta}_1$ identifies the lending channel if $Cov(D_i, \gamma_j + \varepsilon_{ij}) = 0$.

KM argues that it is unlikely that the condition $Cov(D_i, \gamma_j + \varepsilon_{ij}) = 0$ holds in most empirical settings. They argue that $\gamma_j$ is likely to be positively correlated with $D_i$. The reason is that firms experiencing a negative shock (low realization of firm-level shock $\gamma_j$) are likely to be matched to banks that experience a negative deposit shock (low realization of bank funding shock $\delta_i$). As discussed in KM, this implies that the coefficient $\hat{\beta}_1$ would be biased upwards.

To address this issue, KM propose to include firm fixed effects $FE_j$ in the OLS regression. The firm fixed effects control for firm-level shocks $\gamma_j$. Conditional on firm fixed effects, it is sufficient to assume that $Cov(D_i, \varepsilon_{ji}) = 0$. This is a weaker identification assumption. Under this assumption the OLS coefficient $\hat{\beta}_1$ identifies the lending channel. This is approach taken in KM.

KM points out this assumption could be violated. Specifically, they point out that this assumption does not hold if firm's loan demand is bank-specific and correlated with shocks to bank liquidity. KM state this "This can happen if, (a) nuclear shocks disproportionately affect export/import demand, (b) firms get "export/import related" loans from banks that specialize in the tradeable sector, or (c) these export/import intensive banks had more dollar deposits and thus suffered a larger liquidity crunch as well." They show that their results are robust to accounting for these concerns.

However, as discussed above, this is not the case in our study. We find evidence that firms' loan demand is bank-specific. To account for this evidence, we introduce bank specialization and show how bank specialization can create loan demand that is bank-specific and correlated with shocks to bank liquidity.

We add bank specialization to this framework as follows. Suppose firms engage in activities $k \in \{1, ..., K\}$. Given that KM assumes that each bank only makes one loan, each bank is specialized in one activity $k$. We assume that each firm engages in two different activities.

Assume that the marginal return to lending depends on the activity such that the firm are subject to activity-specific demand shocks, $\eta_{jt}^k$. In our setting, this is isomorphic to having a bank-specific loan demand shock. Intuitively, this can be interpreted as a positive net present value derived from services provided by specialized banks.[2] It follows that the marginal return to loan $L_{ij}^t$ is given by $\bar{r} - \alpha_r \times L_{ij}^t + \bar{\eta}_t + \eta_{jt}^k$ where $k$ denotes the specialization of bank $i$. Solving for the two-period setup, this yields the following equilibrium condition:

$$\Delta L_{ikt} = \frac{1}{\alpha_L + \alpha_B}(\bar{\eta} + \alpha_B \bar{\delta}) + \frac{1}{\alpha_L + \alpha_B}\ \eta_j^k + \frac{\alpha_B}{\alpha_L + \alpha_B}\ \delta_i. \tag{IA.3}$$

Note that the only difference between the equilibrium condition (IA.2) and (IA.3) is that we replaced $\eta_j$ with $\eta_j^k$.

Now suppose we estimate the following OLS regression:

$$\Delta L_{ij} = \beta_0 + \beta_1 D_i + \gamma_j^k + \varepsilon_{ij},$$

where $D_i = \delta_i t$ represents a bank-specific deposit shock. Assume the econometrician cannot observe $\gamma_j^k = \frac{1}{\alpha_L + \alpha_B}\eta_{jt}^k$. It follows that the combined error term is $\gamma_j^k + \varepsilon_{ij}$. The OLS coefficient $\hat{\beta}_1$ identifies the lending channel if $Cov(D_i, \gamma_j^k + \varepsilon_{ij}) = 0$. As discussed above, this assumption is unlikely to hold in many empirical settings.

Now consider adding a firm fixed effect $FE_j$ in the OLS regression. The firm fixed effect does not control for firm-level shocks because the shock varies across activities

[2]For example, a borrower expects a higher return when exporting to Argentina if the borrower takes out a loan from a bank that specializes in Argentina.

within the same firm. Hence, contrary to the KM setup, the condition $Cov(D_i, \varepsilon_{ji}) = 0$ is *not* sufficient for identification of the lending channel. This is the sense in which firm fixed effects do not solve the identification problem in the presence of bank specialization.

To summarize, if loan-demand is bank-specific then adding firm fixed effects alone does not solve the identification problem. To solve the problem, the firm-time fixed effects must be combined with an appropriate instrument for credit supply.

## REFERENCES

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