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Abstract

In this paper, we explore how informational frictions in credit markets directly affect U.S. manufacturing fluctuations. Within the context of a dynamic industry model, we propose a strategy for identifying intermediation costs related to informational asymmetries between lenders and borrowers. The analysis suggests that these costs have been steadily falling over the post-war period. We also present evidence that changes in the cost of intermediation should directly affect output, as opposed to just propagating the effects of other shocks. Finally, we find that the relative share of output fluctations explained by financial innovations increases monotonically over time. Therefore, policy changes that reduce financial frictions, and thereby increase output, are likely to be most effective in the long run.

JEL Classification: E32, E44

Keywords: Intermediation, Informational Frictions, Economic Fluctuations

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1 Introduction

Recent theoretical work suggests that intermediation costs which arise from frictions considerably amplify economic fluctuations (see Bernanke and Gertler 1989, as well as Carlstrom and Fuerst 1997 among others). Empirically, Gertler and Gilchrist (1994), as well as Balke (2000), find support for this hypothesis whether fluctuations emanate from demand or supply shocks. In earlier work, however, Bernanke (1983) argued that changes in the cost of intermediation could also act as a direct source of economic fluctuations. The idea is that the resource costs associated with intermediation directly affect firms' borrowing decisions and, consequently, their investment behavior. Much less work has been carried out regarding the latter observation, mainly because the concept of intermediation costs is one that has been difficult to capture empirically. According to Bernanke (1983), "it would be useful to have a direct measure of the cost of credit intermediation; unfortunately, no really satisfactory empirical representation of this concept is available."[1]

In this paper, we identify an important component of intermediation costs which stems from informational frictions, namely bank lending costs. In doing so, our strategy relies on a dynamic industry model where lenders and borrowers have asymmetric information. In such an environment, Diamond (1984), as well as Gale and Hellwig (1985), show that intermediaries naturally emerge as a means of economizing on the costs associated with the monitoring of firms. Because these financial intermediaries are delegated monitors, they carry the interpretation of banks.

Within this theoretical framework, firms' reliance on external finance depends uniquely on the magnitude of financial frictions in the long run. Using a just-identified structural vector autoregression (hereafter SVAR), this restriction allows us to isolate changes in the cost of intermediation as well as their short and long-run effects. In particular, the approach follows along the lines of King et al. (1991) or, more recently, Gali (1999). In this case, it allows us to disentangle the components of manufacturing output fluctuations that are driven by financial innovations on the one hand, and non-financial shocks on the other.

Given this methodology, we first examine whether the significance of informational frictions in the intermediation process has changed over time? Recent work typically assumes that the financing costs that result from these frictions are constant. In contrast, our results indicate that over the period 1959:1-1998:4, intermediation costs associated with informa-

[1] For instance, the difference between the rate on commercial paper and the treasury bill rate captures not only the cost of credit, it also reflects a liquidity premium, as well as the fact that access to commercial paper is restricted to firms with strong balance sheets and high cash flows. The latter firms are much less likely to be subject to financial frictions.

tional frictions have been steadily decreasing in the manufacturing sector. From a theoretical perspective, therefore, the idea that firms possess private information has become less relevant as verification costs incurred by banks continue to decline. Our analysis also suggests that intermediation costs are subject to permanent changes.

Taken together, these results support anecdotal evidence on the many innovations that have become the hallmark of the financial services industry. Continuous improvements in information technology, including faster computers, credit scoring software, and profitability programs, have greatly lowered monitoring costs (see Mishkin and Strahan 1999, Petersen and Rajan 2000). Furthermore, in the U.S., changes in financial regulations have also been cited as a major driving force behind these innovations (Mishkin 1990).

On another note, our empirical analysis confirms Bernanke's (1983) view that an increase in the cost of credit intermediation should directly lower output, in addition to propagating the effects of other shocks. As expected, this increase also reduces industry-wide leverage. However, in both cases, the adjustment to a financial innovation is quite protracted.

Finally, we find that changes in intermediation costs account for a larger share of manufacturing output fluctuations at long horizons than at short horizons. Put another way, the direct output effects of financial innovations tend to emerge sluggishly relative to other shocks. This result holds irrespective of lag length and across various definitions of firm leverage. An immediate implication is that the relative impact of policy changes aimed at reducing financial frictions will be felt most strongly in the long run. At business cycle frequencies, the bulk of manufacturing output variations is largely driven by changes in total factor productivity and demand conditions. At the 3 year horizon, the share of output forecast error variance explained by financial innovations varies between 8 and 27 percent depending on the number of lags used in the SVAR. At long horizons, however, we find that this share is sensitive to the lag specification of the SVAR.

This paper is organized as follows. Section 2 presents the theoretical framework which motivates our empirical analysis. Section 3 introduces the econometric methodology used to isolate financial disturbances from other sources of fluctuations. This section also presents some preliminary results. In section 4, we present the results obtained from a higher dimensional system as a way of checking for robustness and eliminating parameter bias. We also discuss the sensitivity of our results in this section. Section 5 offers some conclusions.

2 Theoretical Background

In this section, we develop and analyze an industry model that allows firms to differ in both idiosyncratic productivity and equity holding. We develop such a framework so that, in deriving an industry-wide identifying restriction below, the main sources of firm level heterogeneity are accounted for.

We initially assume two exogenous driving forces: exogenous technological shifts in total factor productivity, denoted by Z, and shocks to the cost of intermediation, γ. We interpret the latter shocks as reflecting variations in the intermediation process resulting from financial innovations.

There are potentially two approaches that may be used to assess the direct effects of the shocks assumed in this paper. One approach, followed by Cooper and Ejarque (1994), is to calibrate the stochastic processes associated with these shocks and use numerical simulations to investigate these effects. This approach, however, relies crucially on the calibration used. As we have already seen, arriving at an appropriate strategy for calibrating changes in the cost of intermediation over time can be difficult. The second approach, which we adopt, is to use the model to identify the various shocks in the data. In doing so, we use the model mainly to guide our empirical work.

2.1 The Environment

For simplicity, we first describe the model within a deterministic setting. There exists a continuum of risk-neutral firms indexed by $\eta \in [\underline{\eta}, \overline{\eta}]$, a firm specific parameter that captures differences in firms' managerial ability. These differences may include the ability of firms' managers to identify and develop new products, to organize activity, to motivate workers, and to adapt to changing circumstances. In each period, firms have access to a production technology summarized by $y = \eta Z k^{\alpha}$, $0 < \alpha < 1$, where Z is a productivity shift parameter common to all firms (that may be a combination of both sectoral and aggregate factors), and k denotes capital input. Capital depreciates at the rate δ. A firm draws its idiosyncratic index of productivity η when it first enters the economy, which then remains constant throughout its life. The random variable η is assumed to be distributed according to the continuously differentiable probability distribution function $G(\eta)$.

Firms can finance their investments by either using their internal funds or borrowing. We assume that as a result of financial frictions, the cost of external finance exceeds the opportunity cost of internal funds, denoted r, by a proportional factor $\gamma > 1$. As a way of illustrating what microfoundations might help determine this premium, consider a simple version of the costly state verification environment described in Gale and Hellwig (1985) or Williamson (1987). Specifically, suppose that a firm borrowing k units of capital produces either $\eta Z k^{\alpha}$ with probability π or zero with probability $1 - \pi$. While a firm knows its own output costlessly, other agents can only learn this information at a cost. In other words, the friction is informational in nature. Since production is private information, each firm has an incentive to underreport its output in any financing arrangement. Financial intermediaries, therefore, naturally arise as a means of economizing on verification costs otherwise borne by investors. In this sense, the verification cost captures real resources spent by intermediaries in collecting information and liquidating assets in the event of bankruptcy. Assuming that this verification cost is proportional to the interest payments accruing to investors, and denoting this proportion by ω, it can be easily shown that $\gamma = 1 + (1 - \pi)\omega$ under a zero-profit condition for financial intermediaries. Put another way, the wedge which separates the cost of internal finance, r, from that of raising external funds, $r\gamma$, depends on the verification technology and firms' bankruptcy rate (i.e., ω and $1 - \pi$, respectively). Note that the theory we have just described is one of delegated monitoring. To respect this framework, therefore, our empirical analysis will center on bank lending.

In the above example with informational frictions, the Modigliani-Miller theorem breaks down. As we show below, firms prefer to finance investments using their internal funds before resorting to debt. That is to say, they choose to reinvest their retained earnings as a way of building equity, a process often referred to as the "pecking order" concept of capital structure.

To allow for heterogeneity not only in terms of firm specific productivity but also in terms of equity holding (i.e., firm size), we assume that at each point in time, firms face a probability $1 - \lambda > 0$ of becoming unproductive. Therefore, firms exit at a constant rate and, in equilibrium, a firm's equity will increase in age. Should exit occur, the firm is liquidated for an amount equal to its equity value. For simplicity, we follow Campbell and Fisher (1998) and assume that the age distribution of firms is time invariant. This feature will help us considerably below in aggregating firms' optimal decision rules. We denote by ψ_i the measure of firms of age $i \geq 0$ and, given this environment, $\psi_i = \psi_0 \lambda^i$. Since the measure of firms across all ages must sum up to 1, we also have that $\sum_{i=0}^{\infty} \psi_i = 1$, in which case $\psi_0 = 1 - \lambda > 0$. In other words, the entry and exit rate are identical. New entrants are assumed to have no equity.

2.2 The Firm's Problem

In every period, each firm chooses its capital input, dividend policy, and the amount of equity to be held in the following period so as to maximize the expected discounted value of its future dividends. Let $k_{t-s,s}$, $d_{t-s,s}$, and $a_{t-s,s}$ designate respectively the date t capital, dividend payment, and equity level of a firm born at $s \in (-\infty, t]$. The variables' first subscript, therefore, keeps track of the firm's age while the second subscript indicates its time of birth. We shall keep this notational convention throughout the paper. A newly born firm, whose intrinsic productivity level is η, then chooses the sequence of variables $\{k_{t-s,s}, d_{t-s,s}, a_{t-s+1,s}\}_{t=s}^{\infty}$ to solve the following problem:

$$V_s(\eta) = \max \sum_{t=s}^{\infty} \lambda^{t-s} (\Pi_{j=s}^{t} \frac{1}{1+r_j}) d_{t-s,s} + \sum_{t=s}^{\infty} \lambda^{t-s-1} (1-\lambda) (\Pi_{j=s}^{t-1} \frac{1}{1+r_j}) a_{t-s,s} \tag{1}$$

subject to,

$$\begin{aligned} a_{t-s+1,s} + d_{t-s,s} &\leq \eta Z_t k_{t-s,s}^{\alpha} - (r_t \gamma_t) \max\{\underbrace{k_{t-s,s} - a_{t-s,s}}_{\text{external debt}}, 0\} + r_t \max\{a_{t-s,s} - k_{t-s,s}, 0\} \\ &\quad - \delta k_{t-s,s} + a_{t-s,s}, \qquad (2) \\ d_{t-s,s} &\geq 0, \qquad (3) \end{aligned}$$

where r_t is rate of interest at time t. The first term on the right hand side of equation (1) captures the expected discounted value of the firm's dividends. The second term denotes its expected discounted liquidation value. Equation (2) is the firm's resource constraint while equation (3) imposes a nonnegativity constraint on dividend payments. Equation (2) shows that while the firm may lend at rate r_t when it has excess internal funds, financial frictions only allow it to borrow at rate $r_t \gamma_t$, $\gamma_t > 1$.

It is easy to see that the solution to the firm's problem has three components. First, when internal funds fall short of capital expenditures, $a_{t-s,s} < k_{t-s,s}$, so that the firm raises funds externally, it will do so up to an amount k_t^*, where $k_t^* = \arg\max_{k_{t-s,s}} \{\eta Z_t k_{t-s,s}^{\alpha} - r_t \gamma_t (k_{t-s,s} - a_{t-s,s}) - \delta k_{t-s,s}\}$, and will not distribute any dividends, $d_{t-s,s} = 0$. In other words, the firm always uses its own resources first when there are financial frictions. At the other extreme, when $a_{t-s,s} > k_{t-s,s}$ and the firm has excess internal funds, it will choose to use no more than k_t^{**} in production, where $k_t^{**} = \arg\max_{k_{t-s,s}} \{\eta Z_t k_{t-s,s}^{\alpha} - r_t (k_{t-s,s} - a_{t-s,s}) - \delta k_{t-s,s}\}$, and any dividend policy $d_{t-s,s} \geq 0$ is optimal. Once its assets have reached the optimal level k_t^{**}, the firm is indifferent between using its profits to build up equity or paying them out as dividends. Finally, in the intermediate case where $a_{t-s,s} = k_{t-s,s}$, the firm no longer finds it necessary to rely on external finance but nevertheless will not distribute dividends until its equity has reached k_t^{**}.

In the data, cases where firms rely solely on their internal funds (i.e., $a_{t-s,s} \geq k_{t-s,s}$) are seldom observed. Therefore, with the empirical analysis in mind, we restrict ourselves to the case that involves nontrivial borrowing, $a_{t-s,s} < k_{t-s,s}$. As we have just described, it is optimal for the firm not to distribute dividends in the latter case. The proof in Appendix A makes it clear that the key to this result lies in the simple fact that $r_t \gamma_t > r_t$ whenever $\gamma_t > 1$. When there are no frictions and $\gamma_t = 1$, the Modigliani-Miller theorem holds and firms are indifferent between using their own funds or using bank debt. In terms of the framework with delegated monitoring introduced earlier, $\gamma_t = 1$ whenever $\omega_t = 0$ or $\pi_t = 1$. Put simply, when either collecting information is costless or firms never fail, the notion of private information no longer matters as a potential friction.

The optimality conditions of a typical firm that uses external finance are

$$\alpha \eta Z_t k_{t-s,s}^{\alpha-1} = r_t \gamma_t + \delta, \tag{4}$$

and

$$a_{t-s+1,s} = \eta Z_t k_{t-s,s}^{\alpha} - r_t \gamma_t (k_{t-s,s} - a_{t-s,s}) - \delta k_{t-s,s} + a_{t-s,s}. \tag{5}$$

Equation (4) determines the firm's optimal asset level. This asset level depends only on the effective interest rate the firm faces at time t and, consequently, does not vary with age. Thus, we denote the solution to (4) by $k_t(\eta)$. Moreover, we can express the optimal industry capital stock at time t as $K_t = (1-\lambda) \int_{\underline{\eta}}^{\overline{\eta}} \sum_{s=-\infty}^{t} \lambda^{t-s} k_t(\eta) dG(\eta)$. In this last expression, we first sum across age for firms with the same index of idiosyncratic productivity, and then integrate over productivity levels. Carrying out these operations yields[2]

$$K_t = \left[\frac{r_t \gamma_t + \delta}{\alpha Z_t} \right]^{\frac{1}{\alpha-1}} \int_{\underline{\eta}}^{\overline{\eta}} \eta^{\frac{1}{1-\alpha}} dG(\eta). \tag{6}$$

Since no dividends are paid out when borrowing takes place, Equation (5) summarizes changes in the firm's equity level. Using this equation, Appendix B shows that the evolution of industry equity can be written as

$$A_{t+1} = \left(\frac{1-\alpha}{\alpha} \right) [r_t \gamma_t + \delta] \lambda K_t + (1 + r_t \gamma_t) \lambda A_t, \tag{7}$$

where $A_t = (1-\lambda) \int_{\underline{\eta}}^{\overline{\eta}} \sum_{s=-\infty}^{t} \lambda^{t-s} a_{t-s,s}(\eta) dG(\eta)$.

2.3 The Industry Steady State

We now solve for the industry steady state equilibrium. Using a long-run restriction based on this equilibrium, we will then be in a position to identify shocks to the cost of intermediation

[2] Embedded in this definition of K_t is an approximation that is made for analytical tractability. In principle, some firms become old enough, say age $N(\eta)$ for those whose idiosyncratic productivity level is η, to have built enough equity and no longer require external finance. Formally, their measure is $(1-\lambda) \sum_{s=-\infty}^{t-N(\eta)} \lambda^{t-s}$ and, given that we only wish to capture the behavior of firms that use debt, a precise definition of K_t is $(1-\lambda) \int_z \sum_{s=t-N(\eta)}^{t} \lambda^{t-s} k_{t-s,s}(\eta) dG(\eta)$. However, as indicated earlier, the fraction of firms that are completely self-financed is quite small in practice. In terms of our model, this means that either λ is small enough or $N(\eta)$ large enough $\forall \eta$ (or both) so that $(1-\lambda) \sum_{s=-\infty}^{t-N(\eta)} \lambda^{t-s} \simeq 0$.

in the data. In the steady state, industry assets and equity are time invariant for given values of r, γ, and Z. Thus, from equations (6) and (7), we obtain

$$K = \left[\frac{r\gamma + \delta}{\alpha Z}\right]^{\frac{1}{\alpha-1}} \int_{\underline{\eta}}^{\overline{\eta}} \eta^{\frac{1}{1-\alpha}} dG(\eta) \text{ and } A = \frac{(1-\alpha)\left[r\gamma+\delta\right]\lambda K}{\alpha\left[1-(1+r\gamma)\lambda\right]} \tag{8}$$

As expected, the long-run industry optimal asset level increases when factor productivity rises, $\partial K/\partial Z > 0$, and when intermediation costs fall, $\partial K/\partial \gamma < 0$. Given the technology, the same relationships hold for long-run industry output. These results formalize the notion that changes in intermediation costs should directly influence output (Bernanke 1983). Moreover, policy changes aimed at reducing the wedge associated with financial frictions should also help raise production in the long run.

Equation (8) also allows us to examine the steady state asset:equity ratio for the industry as a whole. Since assets are financed either by debt or internal funds, the greater the ratio, the more industry-wide borrowing takes place. Thus, we may interpret this ratio as a measure of long-run industry leverage. Rajan and Zingales (1998) also adopt this interpretation of industry-wide asset:equity ratios in their cross-country study of financial development and growth. In practice, internal funds do not exactly account for all of measured equity since large corporations also issue stock. However, Mayer (1990) points out that stock issue is typically small relative to total equity. Denoting the steady state industry asset:equity ratio by X, equation (8) immediately implies that

$$X \equiv \frac{K}{A} = \frac{\alpha\left[1-(1+r\gamma)\lambda\right]}{(1-\alpha)\left[r\gamma+\delta\right]\lambda}, \tag{9}$$

and the following proposition emerges.

Proposition: *Under the maintained assumptions, industry-wide leverage is independent of total factor productivity in the long run.*

The intuition behind the proposition is relatively straightforward. On the one hand, we have already shown that the long-run capital stock increases with factor productivity. On the other hand, equity consists of accumulated retained earnings, the latter being simply production less interest payments. Since our production function exhibits constant elasticity with respect to its input, the output of each firm increases with its capital stock at a proportional rate. It follows that when the level of assets and equity are chosen optimally, their ratio will be independent of total factor productivity. Furthermore, since the two main exogenous driving forces are assumed to be total factor productivity and intermediation costs, a long-run restriction involving the industry-wide asset:equity ratio may be used to identify

γ. However, to assess the legitimacy of this identification strategy, we should pause briefly to address important aspects of our theoretical framework.

First, Appendix C shows that the analysis can easily be extended to one that allows for the distinction between collateralized and non-collateralized debt. The only requirement needed for the proposition to hold under this distinction is that the value of the collateral be proportional to the firm's value. Since collateral is typically constituted of assets, this requirement is trivially satisfied in practice. Second, our theory abstracts from endogenous exit by assuming a constant survival rate λ. This simplification allows us to flesh out analytically the intuition behind our proposition. While closed form solutions cannot be worked out when we allow for this additional margin, numerical simulations suggest that the proposition holds in this case as well.[3] This result is to be somewhat expected since allowing for endogenous entry does not alter the basic optimality conditions that govern the evolution of assets and equity.

According to equation (9), the lower the resource costs associated with intermediation, the more firms are willing to borrow to finance their investments in the long run. In a stochastic world, therefore, we expect that permanent shifts in the cost of intermediation will directly result in long-run changes in industry-wide leverage. Two questions immediately arise. First, is the time series behavior of the latter ratio indeed integrated or, loosely speaking, "nonstationary?" Second, even if the asset:equity ratio possesses a stochastic trend (and given its expression in the steady state), how do we know that long-run movements in this variable do not reflect permanent changes in factors other than the cost of intermediation, in particular, the real rate of interest? We provide evidence in the next section that supports the hypothesis of a unit root in the asset:equity ratio. With regard to the second question, considerable empirical work suggests that the *ex post* real rate of interest is best characterized as a stationary series. Of course, the order of integration in the *ex ante* real rate is difficult to characterize since it is unobserved. Depending on the deflator used to define inflation and the sample period under consideration, the first-order autoregressive parameter in the real interest rate typically lies between .79 and .83. More formal tests favoring real rate stationarity are provided in Shapiro and Watson (1988), Kugler and Neusser (1993), as well as Gali (1992, 1999). It follows that in terms of the expression for K/A, the stochastic interpretation of the steady state interest rate is simply that of its long run mean which is constant over time.[4]

[3] In accounting for endogenous entry, these simulations allow firms' idiosyncratic productivty disturbances to vary over time. Thus, it will be optimal for a firm to exit if it encounters an adverse enough shock.

[4] If we introduced a representative household, the steady state real rate would then be pinned down by preferences as usual. In particular, we would have $r = 1/\beta$, where β is the household discount factor. There

3 Econometric Methodology

We now explicitly address the model's stochastic transitional dynamics in terms of the driving processes, and explore the intuition just presented in greater detail. This section will also serve to present the basic bivariate SVAR that we first use to disentangle shocks to the cost of intermediation and to total factor productivity. We later examine a higher dimensional system as a way of checking for robustness as well as eliminating biases in parameter estimates.

3.1 Description of a Bivariate SVAR

Let the process for total factor productivity be described as a logarithmic random walk,

$$\ln Z_t = \ln Z_{t-1} + \mu_Z + \theta_Z(L)\varepsilon_t^Z. \tag{10}$$

The lag polynomial $\theta_Z(L)$, as well as all other polynomials described below, is assumed to have absolutely summable coefficients with roots lying outside the unit circle. Similarly, suppose that changes in intermediation costs can be expressed as

$$\ln \gamma_t = \ln \gamma_{t-1} + \mu_\gamma + \theta_\gamma(L)\varepsilon_t^\gamma. \tag{11}$$

We assume that the shocks ε_t^γ and ε_t^Z are mutually and serially uncorrelated. To the extent that a new technology, say the introduction of greater computing power, might influence both total factor productivity and intermediation costs, the orthogonality of the structural errors identifies ε_t^γ with the specific application of this new technology to financial services. Implicitly, therefore, this application is assumed to generate its own noise and uncertainty. As we pointed out earlier, another important source of movement in the cost of intermediation includes changes in regulations applying to financial services. More generally, we will think of ε_t^γ as representing any financial innovation that affects the intermediation process. Note that μ_γ, the drift in the cost of intermediation, may be negative. This would imply that financial frictions are gradually becoming less relevant.

Given equations (10) and (11), Appendix D shows that log-linearizing the model's aggregate industry equations, (6) and (7), around their deterministic steady state yields the following expression for the industry-wide asset:equity ratio,

$$\Delta \ln X_t = \mu_X + \theta_{X\gamma}(L)\varepsilon_t^\gamma + (1-L)\xi_X(L)[\varepsilon_t^\gamma, \varepsilon_t^Z]', \tag{12}$$

is no reason to believe, therefore, that the real rate should be a nonstationary process. To close the model, note that the representative household would derive its income from deposits with intermediaries, $(1+r_t)s_t$, where s_t is household savings, aggregate dividends D_t, and firms' liquidation value L_t. In equilibrium, savings would equal the difference between aggregate assets and firms' internal funds, $K_t - A_t$.

where μ_X and $\theta_{X\gamma}(L)$ are negatively related to μ_γ and $\theta_\gamma(L)$ respectively, and the 1×2 vector $\xi_X(L)$ is a function of both $\theta_\gamma(L)$ and $\theta_Z(L)$. Thus, finding a positive drift in the ratio of total assets to internal funds, $\mu_X > 0$, would necessarily imply a negative drift in the cost of intermediation, $\mu_\gamma < 0$. Furthermore, consistent with our proposition above, shocks to the cost of intermediation, ε_t^γ, have a long-run effect on $\ln X_t$ while shocks to total factor productivity, ε_t^Z, will only affect the asset:equity ratio temporarily. Equation (12) represents one of the structural equations to be estimated.

To complete our bivariate specification, we write the stochastic process for industry output as

$$\Delta \ln Y_t = \mu_Y + \theta_{Y\gamma}(L)\varepsilon_t^\gamma + \theta_{YZ}(L)\varepsilon_t^Z, \tag{13}$$

where, as shown in appendix D, μ_Y depends positively on μ_Z and negatively on μ_γ, $\theta_{Y\gamma}(L)$ is negatively related to $\theta_\gamma(L)$, and $\theta_{YZ}(L)$ is positively related to $\theta_Z(L)$. By contrast to the ratio of assets to internal funds, both shocks can lead to permanent changes in output. In fact, our theory predicted that a permanent fall in intermediation costs would lead to an unambiguous rise in long-run output (recall from equation (8) that lower intermediation costs contributed to raising the long-run industry capital stock). Long-run increases in output also resulted from permanent increases in factor productivity. Consequently, in terms of equation (13), our estimation results should yield $\theta_{Y\gamma}(1) < 0$ and $\theta_{YZ}(1) > 0$.

We can summarize our empirical framework in the form of a vector moving average,

$$\mathbf{Y}_t = \boldsymbol{\mu} + T(L)\boldsymbol{\varepsilon}_t, \tag{14}$$

where $\mathbf{Y}_t = (\Delta \ln X_t, \Delta \ln Y_t)'$ $\boldsymbol{\mu} = (\mu_X, \mu_Y)'$, and $\boldsymbol{\varepsilon}_t = (\varepsilon_t^\gamma, \varepsilon_t^Z)'$. The matrix polynomial $T(L)$ consists of the polynomials $\theta_{X\gamma}(L)$, $\xi_X(L), \theta_{Y\gamma}(L)$, and $\theta_{YZ}(L)$ in equations (12) and (13). The matrix of long-run multipliers, $T(1)$, may be written as

$$T(1) = \begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix}. \tag{15}$$

Thus, the first row of $T(1)$ formalizes the intuition presented in our proposition. Specifically, the use of external finance is exclusively determined by intermediation considerations in the long run.

3.2 Data Analysis and Integration

The data set we use is obtained from the *Quarterly Financial Report for Manufacturing, Mining, and Trade Corporations.* The QFR data summarize quarterly estimated statements of income and retained earnings, as well as balance sheet information for all manufacturing corporations. This information is available for the period 1959:1-1998:4. Relative to other data sets, such as *Compustat* for instance, the QFR data explicitly take into account smaller firms. These firms mainly rely on bank debt as a source of external finance. (See Gertler and Gilchrist 1994 for a detailed description of this data set).[5]

Figure 1A shows the logarithm of output in manufacturing. This series is constructed as the sum of sales (net sales, receipts, and operating revenue) and inventory investment. Because the QFR inventory variable does not distinguish between finished goods and materials, this measure of output is somewhat imperfect. Inventory investment, however, represents only a very small fraction of output. Hence, sales could also have been used in the analysis with little change in the results. As expected, the plot in Figure 1A displays a steady upward trend.

Figure 1B plots the asset:equity ratio for the manufacturing industry. The asset series is simply defined as the sum of equity and liabilities, where the latter variable is defined as short and long-term bank loans, as well as loan installments due within a year. Thus, consistent with our theory of delegated monitoring, the concept of intermediation costs captured here is one that focuses mainly on bank lending. As in Figure 1A, the asset:equity ratio shows a pronounced upward trend. According to our theory, this trend results from a positive drift in $\ln X_t$ and, therefore, a negative drift in intermediation costs, $\mu_\gamma < 0$. In this sense, our measure of reliance on outside financing indicates a steady fall in the importance of financial constraints. Temporary changes in the asset:equity ratio, of course, will reflect a host of other factors including shifts in total factor productivity. We should note that the plots in Figure 1A and 1B do not appear to share the same trend. It is interesting that Figure 1B seemingly captures the well documented merger wave of the late 1960s. It also captures the large increase in leveraged buyouts of the late 1980s, a substantial portion of which was financed by syndicated bank debt. That being said, there are several issues that should be addressed regarding the plot in Figure 1B and its implications for the drift in intermediation costs.

First, if the size distribution of firm is changing over time (contrary to our model), part of the progressive rise in the asset:equity ratio could be attributed to an increase in the relative measure of small firms. As mentioned earlier, data on the relative size distribution of firms (i.e. firm level data) is difficult to obtain. Table 1 at least shows that the average number of employees per establishment has remained relatively constant since 1958.

[5] In this paper, we consider only aggregated time series data. While firm level data exists, the Bureau of the Census does not directly record it in panel form. Constructing the appropriate panels over time would not only be costly (this would require purchasing a seat at the Census) but also time consuming.

Second, recall that in the example we gave earlier, our concept of intermediation costs, γ, was related to both the bankruptcy rate $1-\pi$, and monitoring costs, ω. Table 2 shows that from 1984 to 1997, the failure rate of manufacturing firms has only varied from a low of .80 percent to a high of 1.31 percent without any noticeable trend. Consequently, while progressively falling intermediation costs may account for most of the secular rise in the asset:equity ratio, it may be that recent changes in intermediation costs have themselves been driven by improvements in monitoring technology. The data on failure rates compiled by Dun & Bradstreet, unfortunately, is not available prior to 1984.

Finally, the fact that the asset:equity ratio in manufacturing drifts upward is consistent with two stylized facts in the capital structure literature. First, internal sources have historically constituted a large but steadily declining fraction of firms' funds, even outside of manufacturing (Masulis 1988). Second, as early as 1985, Taggart already noted a secular increase in leverage across U.S. corporations.

Our empirical specification in (14) assumes that both the asset:equity ratio and manufacturing output are integrated of order one, and that first differencing these variables achieves stationarity. Table 3, panel A, presents the largest estimated root from a sixth order autoregression, denoted $\widehat{\rho}$, as well as the augmented Dickey-Fuller (ADF) t-statistics for the asset:equity ratio and output ($\widehat{\tau}$ with six lags). As suggested by Figures 1A and 1B, regressions for both variables were carried out with a constant and a time trend. Observe that the ADF t-statistics for both the asset:equity ratio and manufacturing output are far less extreme than the 10 percent critical values. We cannot, therefore, reject the null hypothesis of a unit root in both cases. In Table 3, panel B, we present bivariate unit root tests developed by Stock and Watson (1988) which confirm the outcome of the ADF tests. Stock and Watson's $Q_l^f(k,m)$ statistic tests the null of k unit roots against the alternative of m, $(m<k)$, unit roots using dynamic OLS. Specifically, if there are n variables and h cointegrating vectors, the procedure estimates h regression equations containing a constant, $n-h$ regressors in levels, as well as leads and lags of the first differences in these regressors as right-hand side variables. The l subscript indicates that a linear trend is included in the regressions. Both the $Q_l^f(2,0)$ and $Q_l^f(2,1)$ statistics are consistent with the null hypothesis of two unit roots against the alternatives of zero and one unit root, respectively. The p-values are relatively large in both instances.

Under the assumption that $T(L)$ in (14) is invertible, the triangular nature of $T(1)$ and the assumption that the structural errors are mutually uncorrelated allow us to recursively estimate each equation in $T(L)^{-1}\mathbf{Y}_t$.[6]

[6] See King and Watson (1997) for a clear discussion of how to estimate just-identified SVARs using an instrumental variable approach.

3.3 Empirical Results

Figure 2 displays the estimated impulse response functions obtained from our bivariate system with six lags. The figures depict responses to a one standard deviation shock in intermediation costs and total factor productivity, which we denote by $\sigma_{\varepsilon^\gamma}$ and σ_{ε^Z}, respectively. Our empirical framework yields that $\sigma_{\varepsilon^\gamma} = 0.5$ percent while $\sigma_{\varepsilon^Z} = 3.1$ percent. Thus, these results support the numerical simulations in Cooper and Ejarque (1994) who find that a calibrated real business cycle model best fits the data when shocks to the cost of financial intermediation are small relative to productivity shocks.

Consistent with the steady state equilibrium described in the theoretical section, we find that a fall in intermediation costs ultimately leads to a rise in both the asset:equity ratio and output. The asset:equity ratio response is unambiguous both during the transition and in the long run. In contrast, it is difficult to tell whether, on impact, output responds positively or negatively to a loosening of financial constraints. With smaller costs of intermediation, firms are immediately able to increase their leverage and output should contemporaneously rise. The fact that our impulse response shows little change initially may indicate that expanding production requires time-consuming reorganization. After forty quarters, however, the point estimate of the output impulse response as well as most of its 95 percent confidence interval lie above zero.[7] As expected, output increases to a higher steady state in response to a rise in total factor productivity. Interestingly, the initial impulse response is relatively large and eventually dampens in an oscillatory fashion. By construction, the same increase in total factor productivity eventually leaves the asset:equity ratio unaffected.

In terms of the magnitudes of the impulse responses, we note that a one standard deviation increase in total factor productivity has a greater effect on output than a corresponding decrease in the wedge associated with financial frictions. This is particularly true in the short run. One should not necessarily be surprised by this result since, as indicated above, the standard deviation of a productivity shock is about 6 times that of a shock to intermediation costs. Nevertheless, this finding suggests that fluctuations in intermediation costs are not likely to explain much of the variation in manufacturing output, especially at business cycle frequencies.

Having explored how the variables in (14) respond to the structural shocks ε_t^γ and ε_t^Z, we now gauge the relative importance of these shocks in determining variations in the data. We have just seen that the response of manufacturing output to a fall in intermediation costs

[7] Approximate confidence intervals were computed by Monte Carlo simulations. These simulations were carried out using draws from the normal distribution for the shocks to total factor productivity and intermediation costs. One thousand replications were carried out.

is generally consistent with our theoretical framework, at least at longer horizons. Another question we wish to answer is whether shocks to the cost of intermediation play a direct and significant role in determining output fluctuations. To investigate the importance of the role played by each structural shock, we now turn to the variance decompositions of the k-step ahead forecast errors.

Table 4 shows that, in fact, innovations in the cost of intermediation explain little of manufacturing output fluctuations at horizons of 1-12 quarters. The share of output forecast error variance attributed to financial innovations is 11% at the three-year horizon. It follows that in the short and medium run, fluctuations in output seem to be driven almost entirely by innovations to total factor productivity. While this finding is generally consistent with the real business cycle view, which heavily stresses factor productivity as a driving process, we wish to underscore three important points.

First, although financial frictions appear relatively unimportant as a direct source of output fluctuations in the short run, they can nevertheless play a significant role as an indirect propagation mechanism for other shocks. This is precisely the point which Bernanke and Gertler (1989), Gertler and Gilchrist (1994), as well as Carlstrom and Fuerst (1997), among others, emphasize. Second, the fraction of manufacturing output forecast error explained by financial innovations increases (almost) monotonically over time. This would suggest that changes in intermediation costs matter more as a source of long-run rather than short-run variations. In a sense, this result is perhaps not surprising as the application of financial innovations to the production process is evidently less immediate than direct changes in the technology. Of course, since biases in parameter estimates are necessarily present in a bivariate SVAR, a higher dimensional system is needed to explore this issue further. In addition, a more complete SVAR is likely to better estimate the portion of output forecast error attributable to total factor productivity, especially at shorter horizons. This last point is made especially clear at the aggregate level in King et al. (1991).

4 Evidence from a Five-Variable System

We now discuss results from a higher dimensional system that allows for additional shocks orthogonal to both total factor productivity and intermediation costs. Together, these are identified as disturbances that do not have permanent effects on output and leverage. Aside from providing us with a more general empirical framework in which to gauge the direct importance of financial frictions, this larger system will also allow us to check that the long-run impulse responses of $\ln X_t$ and $\ln Y_t$ continue to be consistent with the equilibrium steady state described in section 3. We make no attempt at identifying each of the additional shocks separately. To do so, we would have to impose new, and perhaps controversial, restrictions. In our theoretical framework, firms make use of costly external finance because they possess insufficient retained earnings to meet their optimal investment level. Thus, we include the additional shocks to capture temporary variations in profits that might have been incorrectly attributed to either financial innovations or productivity in a smaller system. Specifically, the data considered in this section includes relative prices of manufactured goods, relative wages in manufacturing, as well as interest rates. Hence, we can think of the additional shocks as being a mix of demand and temporary cost disturbances. Ultimately, our focus remains on innovations to the cost of intermediation as a direct source of manufacturing output variations.

To the extent that movements in the real interest are exogenous, our theory suggests that these movements should help explain the short-run dynamics of both output and industry-wide leverage. Simply put, the real interest rate represents the opportunity cost of internal funds and it is the wedge between this rate, which firms use to discount the future, and the cost of outside financing that drives the mechanics of our theoretical specification. However, we also argued that long-run movements in the manufacturing asset:equity ratio could not ultimately be determined by the real rate since, as a stationary process, its permanent component is constant. Using the whole sample period for which data is available (i.e., 1947:1-1998:4), ADF tests did reject the null of a unit root in the *ex-post* real rate at both the 10 and the 5 percent significance level. In particular, the estimated ADF t-statistic was -3.487 compared to critical values of -2.569 and -2.876, respectively. Here, the real rate is defined as $R_t - \Delta \ln p_{t+1}$, where R_t is the three-month Treasury Bill Rate and p_t is the GDP price deflator. When using the consumer price index (CPI) as the price of final goods, the ADF t-statistic was -3.390. These results confirm earlier work by Shapiro and Watson (1988), as well as Gali (1992). We should note that over smaller samples, and depending on the definition of the deflator used, ADF tests can fail to reject the null of a unit root at the 5 percent level. Nevertheless, it is generally the case that the largest autoregressive root, $\widehat{\rho}$ with six lags, is less than 0.83. Thus, we will follow the latter authors and proceed under the assumption that the real rate is stationary.

In preliminary analysis, standard ADF tests could not reject the null hypothesis of a unit root in the relative price of finished goods, $\ln(p_t^m/p_t)$, as well as manufacturing wages, $\ln(w_t/p_t)$. However, we did reject the unit root null in $\Delta\ln(p_t^m/p_t)$ and $\Delta\ln(w_t/p_t)$. These results suggest expanding our initial bivariate VAR as follows, $[\Delta \ln X_t, \Delta \ln Y_t, R_t - \Delta \ln p_{t+1}, \Delta\ln(p_t^m/p_t), \Delta\ln(w_t/p_t)]$. Although this new system is only partially identified, the assumption that shocks to the cost of intermediation are orthogonal to all other innovations still allows us to recover their short- and long-run effects. More importantly, we can also recover the relative contributions to output fluctuations from disturbances in intermediation costs, total factor productivity, and the sum of the other orthogonal disturbances. All additional series in this section were drawn directly from the National Income and Product Accounts.

Figure 3 shows that the impulse responses obtained from this higher dimensional system share the same basic features as those obtained from the bivariate VAR. A loosening of financial constraints directly leads to a long-run increase in both the degree to which firm use external finance and output. As before, industry-wide leverage rises during the transition before attaining a higher steady state value. Output continues to respond strongly to a positive innovation in total factor productivity, both in the short and long run. An important difference with our earlier results, however, is that the impulse responses display considerably more persistence. For example, the half-life of the output response to a fall in intermediation costs is approximately 15 quarters in the five-variable model as compared to 8 quarters in the bivariate case.

Table 5A shows the decomposition of the k-step ahead forecast errors in manufacturing output for the five-variable model. We wish to emphasize two main points. First, at business cycle frequencies, the bulk of manufacturing output fluctuations is explained by factors other than financial innovations. At the three year horizon, factor productivity and demand shocks account for roughly 90 percent of the forecast error variance in output when six lags are used. With eight lags, this share is still 75 percent. At longer horizons, the variance decompositions become more sensitive to the lag specification of the VAR. In spite of this, however, the relative share of output fluctuations attributed to financial innovations always increases monotonically over time. Therefore, any policy change aimed at reducing financial frictions is likely to be most effective in the long run. Second, the five-variable model indicates that when additional shocks are included, a significant fraction of output fluctuations is no longer attributable to total factor productivity in the short run. Interestingly, our estimated decomposition of manufacturing output variance is very similar to that found with aggregate national data in King et al. (1991). To put our results in perspective, these authors find that after 16 quarters, the portion of aggregate output fluctuations attributable to total factor productivity, which they refer to as the "balanced-growth" shock, is 54 percent. After 20 quarters, this fraction increases to 59 percent. As shown in Table 5A, at the manufacturing sector level, we find that total factor productivity accounts for 60 percent of output variations at the 16 quarter horizon, and 63 percent at the 20 quarter horizon.

We mentioned earlier that the QFR measure of inventories does not distinguish between finished goods and materials. Therefore our constructed output series is somewhat imperfect. Comparing Tables 5A and 5B, we see that there is in fact very little difference in the way that financial innovations contribute either to sales or output fluctuations. In both cases, the relative importance of changes in intermediation costs is small at short horizons and increases with time. Moreover, the point estimates are quite similar across tables.

When the price of finished goods, manufacturing wages, and the real rate is measured relative to the CPI or the personal consumption expenditure (PCE) deflator, the share of output fluctuations explained by financial innovations remains relatively unaffected. This share varies between 12 and 16 percent at business cycle frequencies. However, because the CPI is used in the indexing of contracts, historical estimates of this series are never revised. In addition, in trying to capture variations in firms' profits, we should be more concerned with measuring product rather than consumer prices.

Finally, the concept of intermediation costs captured in this paper is one that is most closely related to bank lending. Recall that our theory of intermediation was based primarily on asymmetric information between lenders and borrowers. Hence, we motivated the wedge between the cost of internal and external finance in terms of the resources spent in collecting information, auditing, and liquidating assets in the event of bankruptcy. However, to the degree that collecting information and auditing also play a role in underwriting, our focus on bank loans can arguably be broadened. Furthermore, our theoretical framework was silent on the issue of term structure since all loans in our model were one-period loans. For these reasons, we also carried out the empirical analysis using the QFR measures of total short term debt, including corporate bond issue, and short term bank loans only. In both cases, shocks to the cost of intermediation continue to play a minor role in explaining variations in output in the short run.[8]

5 Summary and Conclusions

In this paper, we have investigated the dynamic effects of intermediations costs which arise from informational frictions on U.S. manufacturing output fluctuations. In doing so, we have offered a way to isolate changes in the resource costs associated with intermediation. Specifically, we have argued that long-run variations in industry-wide leverage are uniquely determined by changes in the importance of financial constraints. This identifying restriction was derived in the context of a dynamic industry model characterized by asymmetric information between firms and financial intermediaries. Additionally, at any point in time, firms were allowed to differ in terms of both idiosyncratic productivity and age. We further showed that the identifying strategy used in this paper held irrespective of the collateral

[8] Additional Tables are available upon request.

nature of the debt. Finally, to the degree that real interest rate movements affect firms' dependence on external finance, we argued that they could only matter as a source of short and medium run variation.

The empirical analysis suggests that the importance of informational frictions in the intermediation process has steadily fallen over the post-war period. As first suggested by Bernanke (1983), it also shows that a fall in intermediation costs can raise output directly as opposed to just propagating the effects of other shocks. However, the response of output to a financial innovation can be protracted. Finally, we find that at business cycle frequencies, shocks to the cost of intermediation play a relatively small role in explaining manufacturing output variations. However, the share of output forecast error variance explained by financial innovations does increase monotonically over time. Therefore, policy changes that reduce financial frictions, and thereby increase output, matter most in the long run.

Table 1.
Average Size of U.S. Manufacturing Establishments

Year	Avg. Number of Employees per Establishment
1958	52.84
1963	54.37
1967	62.10
1972	59.33
1977	54.43
1982	53.33
1987	51.37
1992	47.69

Source: 1996 Annual Survey of Manufactures

Table 2.
U.S. Manufacturing Business Failure Rates

Year	Failure Rate (percent)
1984	1.24
1985	1.19
1986	1.14
1987	0.95
1988	0.99
1989	0.79
1990	0.92
1991	1.27
1992	1.31
1993	1.14
1994	0.90
1995	0.89
1996	0.83
1997	0.80

Source: Business failure record (The Dun & Bradstreet Corporation).

Note: Dun & Bradstreet's business failures consist of businesses involved in court proceedings or voluntary actions involving losses to creditors.

Table 3.

Unit Root Descriptive Statistics

A. Univariate Unit Root Tests		
Series	Augmented Dickey-Fuller t-statistic	$\widehat{\rho}$
$\ln X_t$	-2.12	0.96
$\ln Y_t$	-2.88	0.90
B. Bivariate Unit Root Tests		
2 vs. 0 unit root	$Q_l^f(2,0) = -13.14$	p-value = 65.00 percent
2 vs. 1 unit root	$Q_l^f(2,1) = -11.24$	p-value = 16.50 percent

Note: The ADF t-statistics are calculated from a regression that includes six lags of the differenced data, a constant, and a time trend. The 10 percent critical values for $\ln X_t$ and $\ln Y_t$ are -3.16. The 5 percent critical values are -3.45. $\widehat{\rho}$ is the largest root in the sixth order autoregression used to calculate the ADF t-statistics. The bivariate tests (Q_l^f) are described in Stock and Watson (1988). They are calculated using linearly detrended data with a VAR(6) correction.

Table 4.

Decomposition of Forecast Error Variance

Bivariate System

Fraction of Output Forecast Error Variance Attributable to the Different Shocks

Horizon	Financial Innovations	Factor Productivity
1	0.03 (0.05)	0.97 (0.05)
2	0.02 (0.05)	0.98 (0.05)
4	0.04 (0.06)	0.96 (0.06)
6	0.06 (0.08)	0.94 (0.08)
8	0.08 (0.09)	0.92 (0.09)
12	0.11 (0.11)	0.89 (0.11)
16	0.13 (0.13)	0.87 (0.13)
20	0.15 (0.14)	0.85 (0.14)
24	0.16 (0.15)	0.84 (0.15)
28	0.17 (0.15)	0.83 (0.15)
50	0.19 (0.17)	0.81 (0.17)

Note: Based on a just-identified structural vector autoregression of $\mathbf{Y}_t = (\Delta \ln X_t, \Delta \ln Y_t)'$ estimated with six lags of $\mathbf{Y}_t$ and a constant. Approximate standard errors, shown in parentheses, were computed by Monte Carlo simulations using one thousand draws.

Table 5.

Decomposition of Forecast Error Variance

Five-Variable Model

A. Fraction of Output Forecast Error Variance Attributable to the Different Shocks

Horizon	Financial Innovations	Factor Productivity	Other Orthogonal Components
1	0.00 (0.05)	0.35 (0.19)	0.65 (0.19)
2	0.00 (0.05)	0.44 (0.19)	0.56 (0.19)
4	0.02 (0.06)	0.50 (0.19)	0.48 (0.19)
6	0.05 (0.07)	0.50 (0.19)	0.45 (0.19)
8	0.06 (0.09)	0.51 (0.19)	0.43 (0.18)
12	0.08 (0.11)	0.56 (0.19)	0.34 (0.16)
16	0.10 (0.12)	0.60 (0.18)	0.30 (0.14)
20	0.12 (0.14)	0.63 (0.18)	0.25 (0.12)
24	0.13 (0.15)	0.66 (0.18)	0.21 (0.11)
28	0.14 (0.16)	0.67 (0.18)	0.19 (0.09)
50	0.19 (0.19)	0.72 (0.20)	0.09 (0.04)

Note: Based on a partially identified structural vector autoregression of $\mathbf{Y}_t = [\Delta \ln X_t, \Delta \ln Y_t, R_t - \Delta \ln p_{t+1}, \Delta \ln(p_t^m/p_t), \Delta \ln(w_t/p_t)]$ estimated with six lags of $\mathbf{Y}_t$ and a constant.

B. Fraction of Sales Forecast Error Variance Attributable to the Different Shocks

Horizon	Financial Innovations	Factor Productivity	Other Orthogonal Components
1	0.00 (0.06)	0.53 (0.20)	0.48 (0.20)
2	0.00 (0.06)	0.59 (0.19)	0.41 (0.18)
4	0.04 (0.07)	0.62 (0.18)	0.34 (0.17)
6	0.07 (0.09)	0.60 (0.18)	0.33 (0.16)
8	0.10 (0.10)	0.61 (0.18)	0.29 (0.15)
12	0.12 (0.13)	0.62 (0.18)	0.26 (0.13)
16	0.14 (0.14)	0.65 (0.18)	0.21 (0.11)
20	0.15 (0.15)	0.67 (0.18)	0.18 (0.10)
24	0.16 (0.16)	0.69 (0.18)	0.15 (0.09)
28	0.17 (0.16)	0.70 (0.19)	0.13 (0.08)
50	0.20 (0. 19)	0.74 (0.20)	0.06 (0.04)

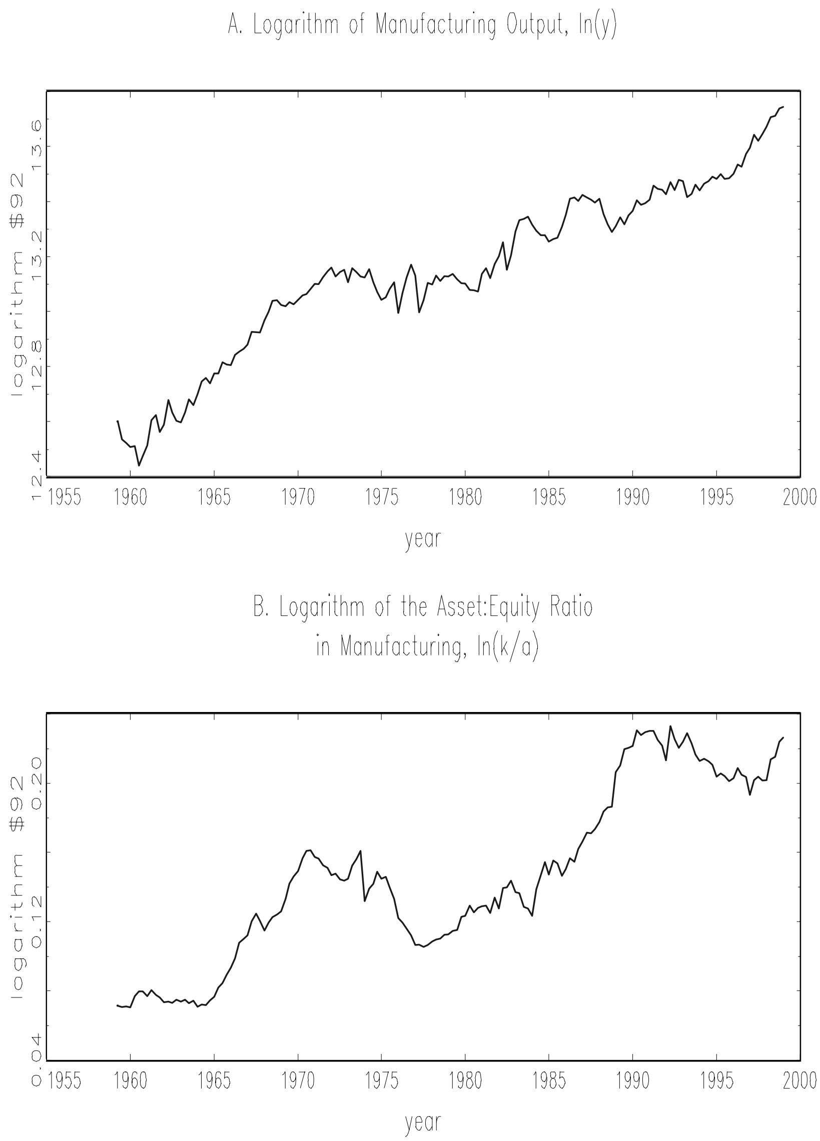
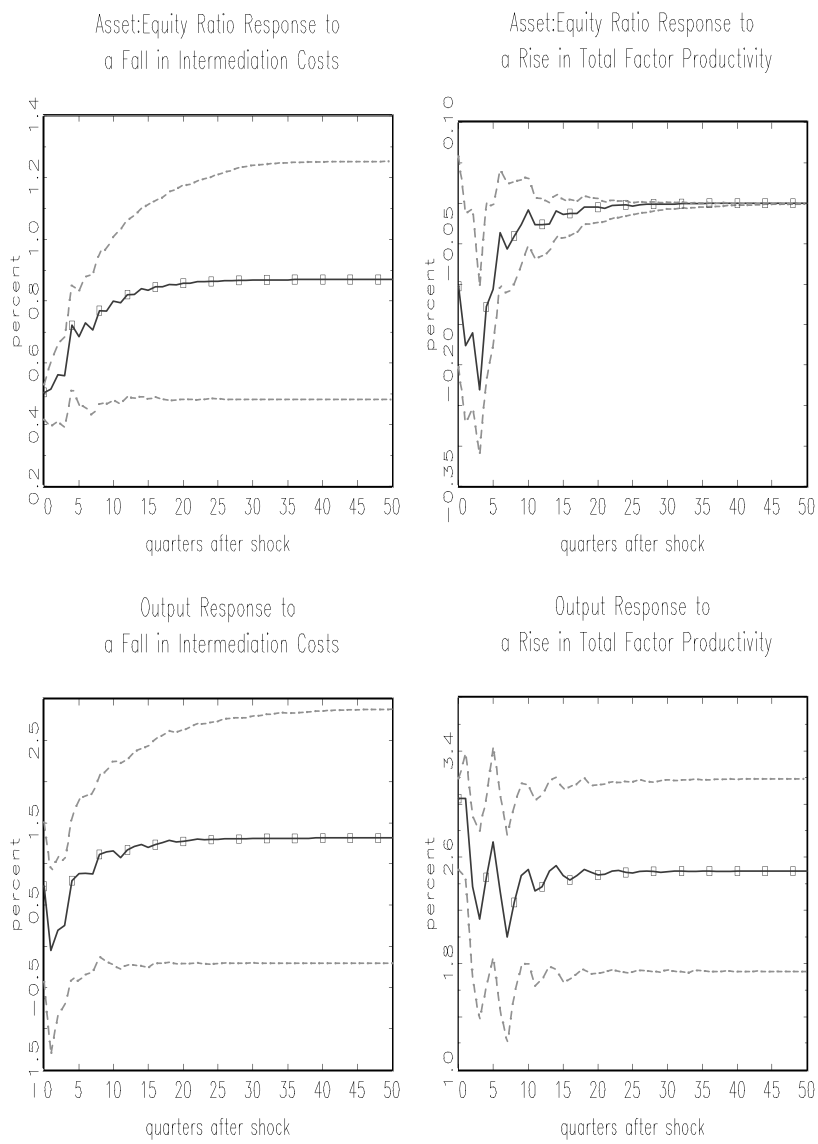
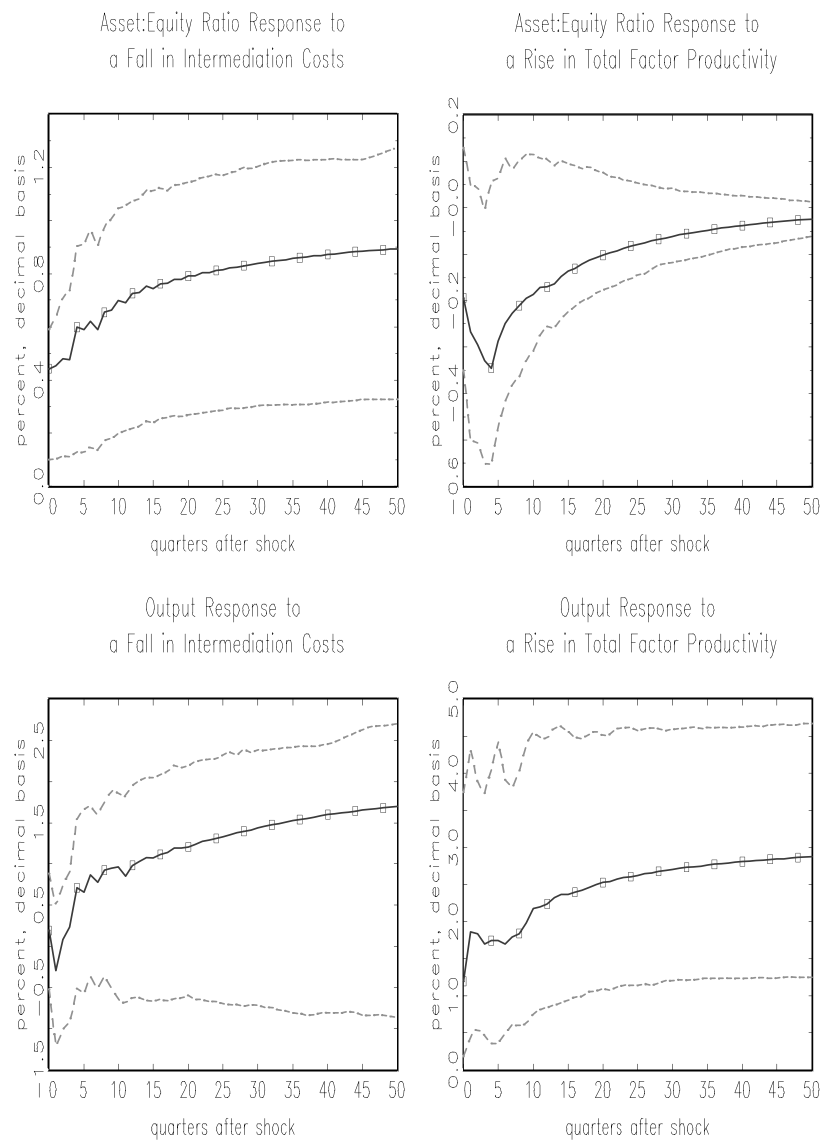

A. Logarithm of Manufacturing Output, ln(y)
logarithm $92
12.4
12.8
13.2
13.6
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
year
B. Logarithm of the Asset:Equity Ratio
in Manufacturing, ln(k/a)
logarithm $92
0.04
0.12
0.20
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
year

Figure 1



Asset:Equity Ratio Response to
a Fall in Intermediation Costs
percent
quarters after shock
Asset:Equity Ratio Response to
a Rise in Total Factor Productivity
percent
quarters after shock
Output Response to
a Fall in Intermediation Costs
percent
quarters after shock
Output Response to
a Rise in Total Factor Productivity
percent
quarters after shock

Figure 2



Asset:Equity Ratio Response to
a Fall in Intermediation Costs
Asset:Equity Ratio Response to
a Rise in Total Factor Productivity
Output Response to
a Fall in Intermediation Costs
Output Response to
a Rise in Total Factor Productivity
percent, decimal basis
quarters after shock

Figure 3

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Appendix A

Proof that firms choose not to distribute dividends when $a_{t-s,s} < k_{t-s,s}$.

In this case, the Lagrangian associated with the firm's problem is:

$$\begin{aligned} L \;=\; & \Sigma_{t=s}^{\infty}\lambda^{t-s}(\Pi_{j=s}^{t}\frac{1}{1+r_j})d_{t-s,s} + \Sigma_{t=s}^{\infty}\lambda^{t-s-1}(1-\lambda)(\Pi_{j=s}^{t-1}\frac{1}{1+r_j})a_{t-s,s} + \\ & \Sigma_{t=s}^{\infty}\lambda^{t-s}(\Pi_{j=s}^{t}\frac{1}{1+r_j})\mu^{t-s}[\eta Z_t k_{t-s,s}^{\alpha} - (r_t\gamma_t)(k_{t-s,s} - a_{t-s,s}) - \delta k_{t-s,s} \\ & + a_{t-s,s} - a_{t-s+1,s} - d_{t-s,s}] + \Sigma_{t=s}^{\infty}\lambda^{t-s}(\Pi_{j=s}^{t}\frac{1}{1+r_j})\xi^{t-s}d_{t-s,s}, \end{aligned}$$

where μ^{t-s} and ξ^{t-s} are the Lagrange multipliers associated with constraints (2) and (3) respectively. The implied first order conditions are:

$$\frac{\partial L}{\partial k_{t-s,s}} \leq 0,\; \frac{\partial L}{\partial k_{t-s,s}}k_{t-s,s} = 0,\; k_{t-s,s} \geq 0 \text{ where}$$

$$\frac{\partial L}{\partial k_{t-s,s}} = \alpha\eta Z_t k_{t-s,s}^{\alpha-1} - (r_t\gamma_t + \delta), \tag{A1}$$

$$\frac{\partial L}{\partial d_{t-s,s}} \leq 0,\; \frac{\partial L}{\partial d_{t-s,s}}d_{t-s,s} = 0,\; d_{t-s,s} \geq 0 \text{ where}$$

$$\frac{\partial L}{\partial d_{t-s,s}} = \lambda^{t-s}(\Pi_{j=s}^{t}\frac{1}{1+r_j}) - \lambda^{t-s}(\Pi_{j=s}^{t}\frac{1}{1+r_j})\mu^{t-s} + \lambda^{t-s}(\Pi_{j=s}^{t}\frac{1}{1+r_j})\xi^{t-s}, \tag{A2}$$

$$\frac{\partial L}{\partial a_{t-s+1,s}} \leq 0,\; \frac{\partial L}{\partial a_{t-s+1,s}}a_{t-s+1,s} = 0,\; a_{t-s+1,s} \geq 0 \text{ where}$$

$$\begin{aligned} \frac{\partial L}{\partial a_{t-s+1,s}} \;=\; & \lambda^{t-s}(1-\lambda)(\Pi_{j=s}^{t}\frac{1}{1+r_j}) - \lambda^{t-s}(\Pi_{j=s}^{t}\frac{1}{1+r_j})\mu^{t-s} + \\ & \lambda^{t-s+1}(\Pi_{j=s}^{t+1}\frac{1}{1+r_j})\mu^{t-s+1}(1 + r_{t+1}\gamma_{t+1}), \end{aligned} \tag{A3}$$

$$\begin{aligned} & \mu^{t-s}[\eta Z_t k_{t-s,s}^{\alpha} - (r_t\gamma_t)(k_{t-s,s} - a_{t-s,s}) - \delta k_{t-s,s} \\ & + a_{t-s,s} - a_{t-s+1,s} - d_{t-s,s}] = 0,\; \mu^{t-s} \geq 0, \end{aligned} \tag{A4}$$

$$\xi^{t-s} d_{t-s,s} = 0, \ \xi^{t-s} \geq 0. \tag{A5}$$

We now show that $d_{t-s,s} = 0$ whenever $a_{t-s,s} \geq 0$. The proof proceeds by contradiction. First, suppose $d_{t-s,s} > 0$ and $a_{t-s+1,s} > 0$. Then from (A5), $\xi^{t-s} = 0$. Rearranging equations (A2) and (A3), we have

$$1 - \mu^{t-s} + \xi^{t-s} = 0, \tag{A2a}$$

and

$$(1-\lambda) - \mu^{t-s} + \frac{\lambda}{1+r_{t+1}} \mu^{t-s+1}(1 + r_{t+1}\gamma_{t+1}) = 0. \tag{A3a}$$

It follows that $\mu^{t-s} = \mu^{t-s+1} = 1$ and $\lambda(1 + r_{t+1}) = \lambda(1 + r_{t+1}\gamma_{t+1})$, clearly a contradiction when $\gamma_{t+1} > 1$. Therefore $d_{t-s,s} > 0$ and $a_{t-s+1,s} > 0$ cannot hold simultaneously.

Suppose now that $d_{t-s,s} > 0$ and $a_{t-s+1,s} = 0$. As before $\xi^{t-s} = 0$ and $\mu^{t-s} = 1$ from (A5) and (A2) respectively. Moreover, it follows from (A3) that

$$\lambda(1 + r_{t+1}) \geq \lambda(1 + r_{t+1}\gamma_{t+1}),$$

which cannot hold when $\gamma_{t+1} > 1$. Hence $d_{t-s,s} = 0$ whenever $a_{t-s+1,s} \geq 0$.

Appendix B

Using equation (4), we can re-write equation (5), which describes the evolution of an individual firm's equity, as

$$a_{t-s+1,s}(\eta) = \left(\frac{1-\alpha}{\alpha}\right)[r_t\gamma_t + \delta]\,k_t(\eta) + (1 + r_t\gamma_t)a_{t-s,s}(\eta). \tag{B1}$$

Summing first across age for firms with the same idiosyncratic productivity level, observe that

$$A_{t+1}(\eta) = (1-\lambda)\sum_{s=-\infty}^{t+1} \lambda^{t-s+1} a_{t-s+1,s}(\eta) = (1-\lambda)\sum_{s=-\infty}^{t} \lambda^{t-s+1} a_{t-s+1,s}(\eta), \tag{B2}$$

under the assumption that new firms start with no equity. Substituting equation (B1) into equation (B2) gives

$$\begin{aligned} A_{t+1}(\eta) &= \left(\frac{1-\alpha}{\alpha}\right)[r_t\gamma_t + \delta]\,\lambda(1-\lambda)\sum_{s=-\infty}^{t} \lambda^{t-s} k_t(\eta) + (1 + r_t\gamma_t)\lambda(1-\lambda)\sum_{s=-\infty}^{t} \lambda^{t-s} a_{t-s,s}(\eta) \\ &= \left(\frac{1-\alpha}{\alpha}\right)[r_t\gamma_t + \delta]\,\lambda K_t(\eta) + (1 + r_t\gamma_t)\lambda A_t(\eta). \end{aligned} \tag{B3}$$

We can now integrate over idiosyncratic productivity levels $[\underline{\eta}, \overline{\eta}]$ to obtain equation (7).

Appendix C

Suppose that firms can borrow two types of loans from financial intermediaries, namely collateralized and non-collateralized loans. Further denote these loans by l_t^c and l_t^n respectively. A firm can put up τ proportion of its capital after production as collateral, where $0 \leq \tau \leq 1$. The firm, therefore, pays the market interest rate r_t on its collateralized loans, and $r_t\gamma_t$ on its non-collateralized loans for the reasons discussed in the text.

In each period t, a firm born at date s, with idiosyncratic productivity η, and internal funds $a_{t-s,s}$, solves the following problem:

$$\pi_{t-s,s}(a_{t-s,s}, \eta) = \max_{k_{t-s,s}, l^c_{t-s,s}, l^n_{t-s,s}} \left\{ \eta Z_t k^{\alpha}_{t-s,s} - r_t l^c_{t-s,s} - (r_t\gamma_t) l^n_{t-s,s} - \delta k_{t-s,s} + a_{t-s,s} \right\}$$

subject to

$$\begin{aligned} r_t l^c_{t-s,s} &\leq \tau(1-\delta)k_{t-s,s}, & \text{(C1)} \\ k_{t-s,s} &= a_{t-s,s} + l^c_{t-s,s} + l^n_{t-s,s}, & \text{(C2)} \\ k_{t-s,s},\ l^c_{t-s,s},\ l^n_{t-s,s} &\geq 0. & \text{(C3)} \end{aligned}$$

Constraint $(C1)$ states that payments associated with collateralized loans cannot exceed the value of the collateral, a proportion τ of the non-depreciated capital after production; constraint $(C2)$ is an identity that defines the firm's total assets; constraint $(C3)$ is the standard nonnegativity constraint.

Consider the case where the firm borrows both types of loans (i.e. $l^c_{t-s,s}, l^n_{t-s,s} \geq 0$.) The solution to the period profit maximization problem is

$$\begin{aligned} \alpha\eta Z_t k_{t-s,s}(z)^{\alpha-1} &= r_t\gamma_t + \delta, & \text{(C4)} \\ l^c_{t-s,s} &= \frac{\tau(1-\delta)k_{t-s,s}}{r_t}, & \text{(C5)} \\ l^n_{t-s,s} &= k_{t-s,s} - a_{t-s,s} - l^c_{t-s,s}. & \text{(C6)} \end{aligned}$$

The firm's date s problem is still defined by (1) in the text, when we substitute $\pi_{t-s,s}(a_{t-s,s}, \eta)$ for the right hand side of constraint (2). Following the argument presented in Appendix A, we can now show that the optimal dividend policy dictates reinvesting retained earnings and giving out zero dividends. The firm's assets, therefore, evolve according to

$$a_{t-s+1,s} = \eta Z_t k^{\alpha}_{t-s,s} - r_t l^c_{t-s,s} - r_t\gamma_t l^n_{t-s,s} - \delta k_{t-s,s} + a_{t-s,s}. \tag{C7}$$

As before, the firm's optimal asset level is determined by equation ($C4$) and is age invariant. We denote this solution as $k_t(\eta)$ and define K_t as in the text, $K_t = (1 - \lambda) \int_{\underline{\eta}}^{\overline{\eta}} \sum_{s=-\infty}^{t} \lambda^{t-s} k_t(\eta)$.

Using equations ($C4$) - ($C6$), we can rewrite equation ($C7$) as follows,

$$\begin{aligned} a_{t-s+1,s}(\eta) &= \eta Z_t k_{t-s,s}^{\alpha} - \tau(1-\delta)k_{t-s,s} - r_t\gamma_t[k_{t-s,s} - \frac{\tau(1-\delta)k_{t-s,s}}{r_t} - a_{t-s,s}] + a_{t-s,s} \\ &= \eta Z_t k_{t-s,s}^{\alpha} - [\tau(1-\delta) + r_t\gamma_t - \gamma_t\tau(1-\delta)]k_{t-s,s} + (1+r_t\gamma_t)a_{t-s,s} \\ &= [\frac{r_t\gamma_t + \delta}{\alpha} - \tau(1-\delta) - r_t\gamma_t + \gamma_t\tau(1-\delta)]k_{t-s,s} + (1+r_t\gamma_t)a_{t-s,s}. \end{aligned} \quad \text{(C8)}$$

Summing first across age for firms with identical idiosyncratic productivity indices, we have

$$\begin{aligned} A_{t+1}(\eta) &= (1-\lambda)\sum_{s=-\infty}^{t+1} \lambda^{t-s+1} a_{t+s-1,s}(\eta) \\ &= (1-\lambda)\sum_{s=-\infty}^{t} \lambda^{t-s+1} a_{t+s-1,s}(\eta) \\ &= [\frac{r_t\gamma_t + \delta}{\alpha} - \tau(1-\delta) - r_t\gamma_t + \gamma_t\tau(1-\delta)]\lambda K_t(\eta) + (1+r_t\gamma_t)\lambda A_t(\eta). \end{aligned}$$

The first equality is obtained under the assumption that new firms start with no equity, while the second equality follows from equation ($C8$). Integrating over idiosyncratic productivity levels yields

$$A_t = [\frac{r_t\gamma_t + \delta}{\alpha} - \tau(1-\delta) - r_t\gamma_t + \gamma_t\tau(1-\delta)]K_t/[1 - \lambda(1+r_t\gamma_t)].$$

Therefore, our proposition in the text continues to hold. The specific solution for the steady state asset:equity ratio is now given by $K/A = [1 - \lambda(1+r\gamma)] / \{\lambda[\frac{r\gamma+\delta}{\alpha} - \tau(1-\delta) - r\gamma + \gamma\tau(1-\delta)]\}$.

Appendix D

This appendix derives a log-linear approximation of the dynamic industry equations, (6) and (7), in terms of the driving processes (10) and (11). For transparency, we set $\delta = 0$ and assume that the interest rate is nonstochastic. We relax the latter assumption in section 4. The log-linearization is carried out around a deterministic steady state characterized by constants K and $X = K/A$, consistent with given values of r, γ, and Z. We define $\widehat{K}_t$, $\widehat{A}_t$, and $\widehat{X}_t$ as $\ln K_t - \ln K$, $\ln A_t - \ln A$, and $\ln X_t - \ln X$ respectively. The variables $\widehat{\gamma}_t$ and $\widehat{Z}_t$ are defined similarly.

Taking a first-order approximation of equation (6) yields

$$\widehat{K}_t = \frac{1}{\alpha - 1}\widehat{\gamma}_t + \frac{1}{1-\alpha}\widehat{Z}_t. \tag{D1}$$

Given equations (10) and (11), it immediately follows that

$$\widehat{K}_t = \widehat{K}_{t-1} + \frac{1}{1-\alpha}\left(\mu_Z - \mu_\gamma\right) + \frac{1}{1-\alpha}\theta_Z(L)\varepsilon_t^Z + \frac{1}{\alpha-1}\theta_\gamma(L)\varepsilon_t^\gamma. \tag{D2}$$

Log-linearizing equation (7), we obtain

$$\widehat{A}_{t+1} = \left[1 - \lambda(1+r\gamma)\right]\widehat{K}_t + \lambda(1+r\gamma)\widehat{A}_t + (1-\lambda)\widehat{\gamma}_t. \tag{D3}$$

Subtracting both sides of (D3) from $\widehat{K}_{t+1}$ gives

$$\underbrace{\widehat{K}_{t+1} - \widehat{A}_{t+1}}_{\widehat{X}_{t+1}} = \left(\widehat{K}_{t+1} - \widehat{K}_t\right) + \lambda(1+r\gamma)\underbrace{\left[\widehat{K}_t - \widehat{A}_t\right]}_{\widehat{X}_t} - (1-\lambda)\widehat{\gamma}_t. \tag{D4}$$

Letting $\phi = \lambda(1+r\gamma)$, note that we must have $\phi < 1$ to ensure that the aggregate asset:equity ratio in (9) is well defined. Intuitively, this restriction puts an upper limit on λ in the sense that when the firm survival rate is too high, industry equity grows without bounds. Substituting equations (D2) and (11) into (D4) yields

$$\begin{aligned}(1-L)\widehat{X}_{t+1} \quad = \quad & \frac{-(1-\lambda)}{1-\phi}\mu_\gamma - \frac{(1-\lambda)\theta_\gamma(L)}{(1-\phi L)L}\varepsilon_{t+1}^\gamma \\ & + \frac{(1-L)\theta_Z(L)}{(1-\alpha)(1-\phi L)}\varepsilon_{t+1}^Z + \frac{(1-L)\theta_\gamma(L)}{(\alpha-1)(1-\phi L)}\varepsilon_{t+1}^\gamma. \end{aligned} \tag{D5}$$

Writing this last expression as of time t gives us equation (12) in the text, where $\mu_X = \frac{-(1-\lambda)}{1-\phi}\mu_\gamma$, $\theta_{X\gamma}(L) = \frac{-(1-\lambda)\theta_\gamma(L)}{(1-\phi L)L}$, and $\xi_X(L) = \left[\frac{\theta_\gamma(L)}{(\alpha-1)(1-\phi L)}, \frac{\theta_Z(L)}{(1-\alpha)(1-\phi L)}\right]$.

To derive equation (13) in the text, simply use the production technology and equation (D2) to obtain

$$(1-L)\widehat{Y}_t = \frac{1}{1-\alpha}(\mu_Z - \alpha\mu_\gamma) + \frac{\theta_Z(L)}{1-\alpha}\varepsilon_t^Z + \frac{\alpha\theta_\gamma(L)}{\alpha-1}\varepsilon_t^\gamma. \tag{D6}$$