Multinational Corporations and the Moderation of U.S. Output Volatility*

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Abstract

In the last 20 years the U.S. economy has experienced a strong reduction in the volatility of GDP growth. By some measures it has declined nearly by half. This paper identifies, documents and models the rapid growth of multinational corporations as a source of gradual decline in output and investment volatility. The paper introduces internationally diversified multinational firms into the *financial accelerator* framework; where international operations provide multinational firms with smoother paths of net worth that result in less volatile financing costs, investment and production. When calibrated to resemble the U.S. economy, model simulations suggest that larger multinational corporations imply up to a 19 percent and 27 percent decline in output and investment volatility, respectively.

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Keywords: Volatility of GDP; Multinational Corporations; Credit Market Frictions.

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1 Introduction

The decline in the volatility of U.S. GDP growth in the last two decades has been extensively documented. Yet, the causes are not fully understood. The channels that brought it about, and whether this phenomenon reflects a gradual trend or a structural break remain open questions. This paper explores how the expansion of U.S. multinational corporations (MNCs) might have mitigated the propagation of shocks in the economy over time. In particular, when the firms' ability to borrow depends on their balance sheet, international diversification provides MNCs with smoother streams of earnings that lead to lower cost and less volatile terms of credit relative to domestic firms. This in turn, translates into smoother net worth, production and investment. The degree to which this effect is reflected in the aggregate economy increases with the multinationals' share of domestic output and the size of their foreign operations.

To assess the importance of MNCs in the moderation of U.S. output growth, the paper first documents evidence about the suggested channel, and then extends Bernanke, Gertler and Gilchrist (1999) *financial accelerator* framework to quantify the effect of international diversification on the firms' terms of credit, output and investment. The focus of the investigation is centered in understanding the linkages between international diversification by U.S.–owned MNCs and the implied macroeconomic dynamics, hence the paper abstracts from some of the common features associated with multinational corporations such as knowledge and technology transfers, and vertical integration.

The contribution of the paper consists in identifying a previously overlooked mechanism that may be at play in the moderation of output and investment volatility. Furthermore, it develops a theoretical framework that allows to disentangle and quantify the importance of MNCs in the moderation. Model simulations suggest that international diversification can lead to a decline of up to 19 percent and 27 percent in output and investment volatility, respectively.

1.1 Output Moderation in the U.S.

Kim and Nelson (1999), and McConnell and Perez-Quiros (2000) were among the first to identify the moderation in output volatility; then Stock and Watson (2002, 2003) and Blanchard and Simone (2001) further showed that the phenomenon is not unique to aggregate output but it is also present in most U.S. macroeconomic time series.[1] What has become common knowledge in this branch of the literature is: 1) that the moderation is common to many nominal and real macroeconomic variables, and it is robust to frequency (quarterly or annual) and detrending techniques; 2) that there seems to be evidence of a structural break around 1984 in some of the series; and 3) that around 25 percent of the output moderation comes from better monetary policy, another 25 percent from small realizations of productivity and price shocks, and the remaining 50 percent is unknown, or attributed to other forms of good luck.[2]

For comparative purposes, throughout the study both empirical and model generated time series are Hodrick-Prescott filtered. Hence, all volatility measures are based upon the deviations of the series from their trend (that is, the level of the logarithm of the series minus the HP-filtered series). Table 1 presents the volatility of U.S. real Gross Domestic Product, real Gross National Product and real investment at a quarterly frequency. For illustration the sample is divided into two periods: 1960 to 1983 and 1984 to 2004. These measures show that the volatility of GDP, GNP and investment between 1960 and 1983 was larger than that between 1984 and 2004. Moreover, the table shows that the volatility of GDP is almost identical to the volatility of GNP.

Table 1. Volatility of U.S. GDP, GNP

and Investment (% Std. Dev.)

	Real GDP	Real GNP	Real Investment
1960:Q1 - 1983:Q4	1.76	1.78	7.85
1984:Q1 - 2004:Q4	0.93	0.92	4.60
1960:Q1 - 2004:Q4	1.54	1.55	7.08

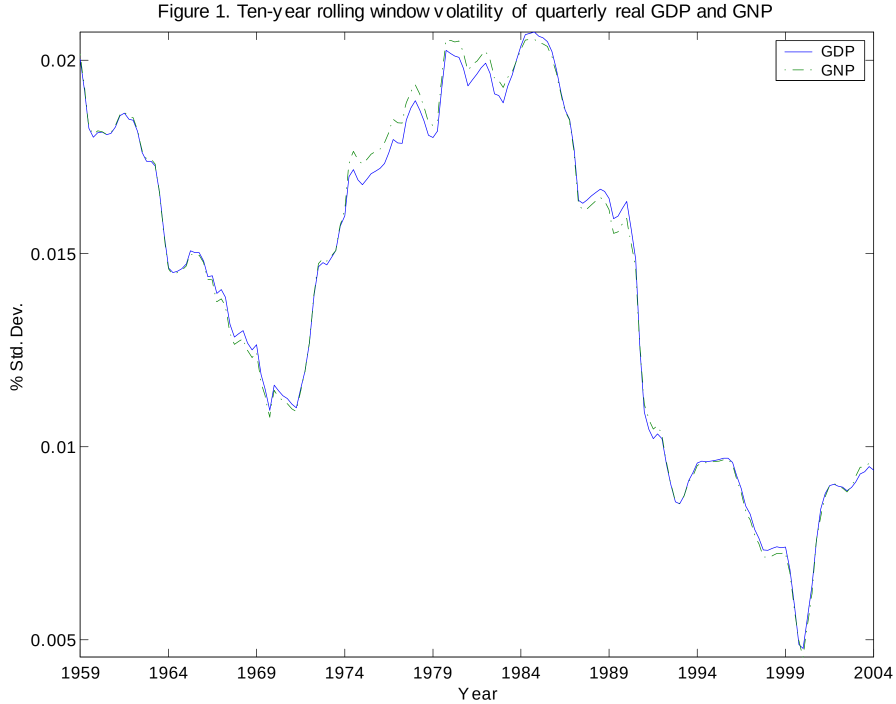
An alternative way to show the decline in output volatility is to plot the ten–year rolling standard deviation of output growth. For a given quarter this statistic captures the volatility of real activity in the previous 40 quarters including itself. For example, the volatility reported for the last quarter of 2004, spans

[1] Stock and Watson (2003) and Blanchard and Simone (2001) also document a decline in output volatility in other G-7 countries.

[2] Additional references on the moderation of output volatility include Ahmed, Levin and Wilson (2004), and Faust and Doyle (2004).

to the first quarter of 1995. Figure 1 highlights the moderation over the last 20 years and confirms the parallel movement of GDP and GNP.[3] This co–movement is relevant for the investigation since the GNP excludes the operation of non–U.S. foreign affiliates in the U.S.—which is included in the GDP—and includes the output U.S.–owned foreign affiliates.

Figure 1. Ten-year rolling window volatility of quarterly real GDP and GNP



From an economic perspective, the most common explanations for the moderation in real activity are better inventory and input management due to advances in information technology, innovations in financial markets, better monetary policy, and good luck. Though as noted before these channels account for half of the decline.[4] On the other hand, changes in data construction (pre–war and post–war), the shift in the composition of output towards services, and more–stabilizing fiscal policy have been shown not to be at play in the moderation.[5]

[3]The increase in volatility in the early 1970s has been related to transitory supply shocks rather than changes in the fundamentals of the economy (see Blanchard and Simone, 2001; and Faust and Doyle, 2004).

[4]See Kim and Nelson (1999), McConnell and Perez-Quiros (2000) and Stock and Watson (2002). For a thorough analysis of the role of financial innovations in the moderation see Dynan, Elmendorf and Sichel (forthcoming). Peek and Wilcox (2006) study the impact of financial market innovations in the decline of residential investment volatility.

[5]See Dynan, Elmendorf and Sichel (forthcoming).

1.2 Multinational Corporations and Output Moderation in the U.S.

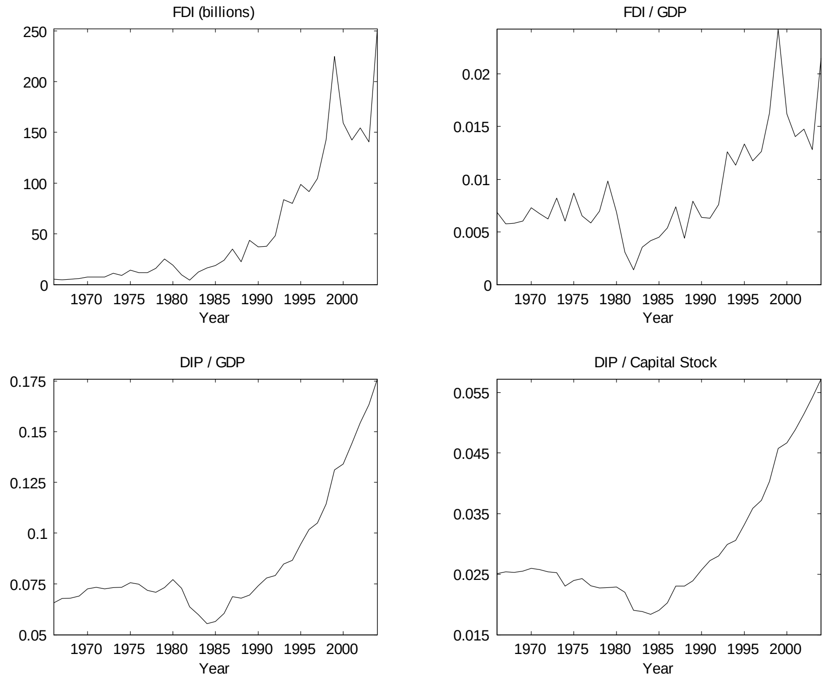
In spite of a growing literature about the international transmission of business cycles, one avenue that is yet to be explored in the study of the moderation of aggregate volatility, is the one that assesses the effect of greater international integration in the propagation of shocks within the economy. This paper takes a first step in such direction by highlighting how the rapid growth of multinational corporations may have contributed to the reduction in the volatility of U.S. GDP. Intuitively, to the extent that the operations of parents and affiliates of U.S. multinationals are not perfectly positively correlated, the multinationals' ability to pool foreign and domestic risks may affect the way in which shocks are propagated in the economy.[6]

At the surface level there are three factors that hint at such link: 1) the U.S. direct investment position (DIP) abroad increased almost ninefold between 1984 and 2004; 2) the average growth rate of foreign direct investment (FDI) in the same period was 20 percent per year; and 3) between 1994 and 2000, the value added of U.S. multinational parent firms accounted for approximately one–fifth of U.S. GDP (BEA, 2002). Furthermore, figure 2 shows that both FDI relative to GDP and the U.S. DIP relative to the U.S. capital stock (including U.S. capital abroad) exhibit a strong increase during the same period. These facts suggest that the decline in U.S. output volatility coincides with a period of increased multinational corporations activity.

To determine whether this is only coincidence or there is a connection between these facts, first we document evidence that supports the view that MNCs indeed enjoy smoother patterns of earnings and sales; and furthermore, that these attributes lead to smoother and lower financing costs relative to domestic or smaller firms. We also show that for a subset of industries, the decline in output volatility between 1984 and 1998 was more concentrated in sectors with the larger increase in foreign holdings. Then, we develop a model that is consistent with these features of MNCs, and quantifies the macroeconomic impact of increased international diversification.

[6] Burnstein, Kurz and Tesar (2004) study international business cycle synchronization due to increased trade. Their model includes multinational corporations to explore the role of technological transfers between parents and affiliates. They find that such transfers lead to higher output correlation across regions and larger investment volatility (relative to GDP).

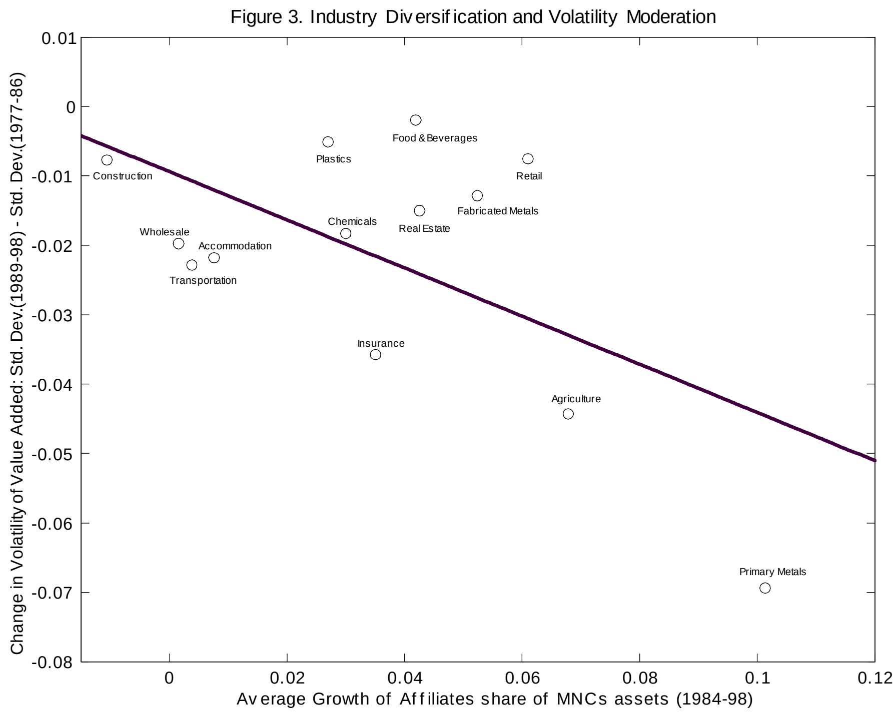
Figure 2. U.S. Foreign Direct Investment and Direct Investment Position (1966-2004)



Recent findings strengthen the notion that relative to domestic firms, multinational corporations exhibit less volatile streams of earnings, profits, and sales. For example, Kim, Kim, and Pantzalis (2001) show that geographic diversification of U.S.–based MNCs is linked to lower earnings volatility. In a similar study, Wan (1998) finds that for a sample of Hong Kong based multinationals, geographic diversification is as well associated with smoother profits and sales growth.

Another branch of the literature focuses in understanding the financial side of multinational corporations. Whether MNCs experience lower financing costs due to their diversified nature, or they are deemed riskier because of the agency costs tied with distance, has been a long standing debate. Reeb, Mansi and Allee (2001), and Mansi and Reeb (2002) show that the former offsets the latter. They found that MNCs financing costs are lower than those of domestic firms. In these studies, the connection between international diversification and better terms of credit lies on credit ratings being increasing in firms' international activities after controlling for firm and industry–specific factors.

Evidence of the effect of international diversification on output volatility is found at the industry level. Using data from the Bureau of Economic Analysis, figure 3 plots the average annual growth rate of the affiliates' share of U.S.–owned MNCs' assets, against the change in the volatility of value added by industry. For example, in the chemical industry between 1984 and 1998, the fraction of the affiliates' assets relative to the MNCs' total assets grew approximately at a four percent rate; while the standard deviation of value added in the chemical industry in the U.S. between 1989 and 1998 was two percentage points lower than that between 1977 and 1986. With this in mind, though only indicative, the figure suggests that those industries whose foreign operations grew faster experienced larger declines in output volatility.[7]



All these facts suggest that the decline in U.S. output volatility matches a period of increased multinational corporations activity. Moreover, the multinationals' ability to pool risks from foreign and domestic

[7]The selected industries were those for which parents' and affiliates' data from 1983 to 1998 could be matched to their industry–wide value added counterparts. In 1999 the Bureau of Economic Analysis revised the industry classification by which the activities of MNCs are reported. The reason for choosing the old classification was the length of the series. Due to unreported information about the parents' or affiliates' assets in some years, or because of a temporary reclassification, the following industries were left out the analysis: oil and gas extraction, mining, utilities, and paper products.

Information for value added in the U.S. by industry goes as far back as 1977 for most of the industries under study. The ten-year subsamples (1977 to 1986 and 1989 to 1998) were HP-filtered and provide an even basis of comparison to establish the trend in volatility. The change in volatility was calculated as the difference in the standard deviation of value added from 1977 to 1986 and value added from 1989 and 1998 at the industry level.

operations potentially translates into smoother terms of credit, and thus smoother production patterns that can reduce industry wide volatility.

In short, the connection between multinational corporations and the decrease in the volatility of U.S. business cycles is introduced in the form of diversification. Since MNCs' operations depend on the economic conditions at home and abroad, good conditions at home may offset adverse conditions abroad (and vice versa); in contrast to domestic corporations (DCs), which exclusively depend on country specific developments. Accordingly, it may be the case that while preserving the same shock process, larger multinationals in some measure explain the moderation in aggregate volatility.

1.3 Modelling Strategy

To explore the linkages between MNCs and the moderation of real activity, we propose an extension that introduces multinational corporations to Bernanke, Gertler and Gilchrist (1999) *financial accelerator* framework. The new framework satisfies the following objectives: 1) traces out the effect of larger international diversification at the firm and at the aggregate level; 2) accounts for aggregate and idiosyncratic (firm–specific) shocks, and their interaction; 3) has realistic credit markets to help determine the effect of international diversification in the terms of credit, and thus in investment and in production; and 4) is able to generate business–cycle statistics that can be mapped to the real data.

The *financial accelerator* framework is a general equilibrium model in which the firms' ability to borrow to finance their investment depends on the firms' net worth. For a given amount of credit, the lower the net worth the higher the interest rate at which a firm borrows. This feature, the *financial accelerator,* amplifies the propagation of shocks through the economy. For instance, in bad times firms are not only hit by lower productivity but also tighter credit conditions that lower investment and output further; in good times high net worth leads to better terms of credit that boost investment and expand the business cycle.[8]

[8] The proposed model is closely linked to the literature on propagation mechanisms based on credit market imperfections. Although this literature is vast, the suggested model can be traced to the line of research started by Bernanke and Gertler (1989) where they laid the theoretical foundations of the *financial accelerator* within a general equilibrium framework. The propagation mechanism in this framework arises due to a moral hazard problem in credit markets based on Townsend's (1979) costly state verification. Carlstrom and Fuerst (1997) were the first to quantitatively assess the impact of such mechanism and to contrast it to observed business cycle statistics. Subsequently, Bernanke, Gerlter and Gilchrist (1999) introduced the friction

The main finding of the paper is that when MNCs are built into the model, the *financial accelerator* is dampened. Lower volatility of net worth—due to international diversification—is associated with better and smoother credit conditions, which in turn lead to lower volatility of investment and output. This result is consistent with the simultaneous increase in MNCs operations and the decline in output volatility in the U.S. Furthermore, Bernanke, Gertler and Gilchrist (1996) find that in the U.S. manufacturing sector smaller firms exhibit more financial–accelerator–like frictions than larger firms. Therefore, the larger MNCs become, the less vigorously shocks propagate through the economy and aggregate production becomes more stable.

A similar diversification–based explanation for the moderation in output volatility could be based on industry concentration. The series of mergers and acquisitions carried out in the 1980s may have provided U.S. firms a comparable diversification effect.[9] Yet, Liebeskind, Opler and Hatfield (1996) report that between 1981 and 1989 overall industry concentration in the U.S. declined or at most remained constant. Correspondingly, Carlton and Perloff (2000) show that the share of valued added by the top–fifty and top–hundred largest U.S. manufacturing firms did not change between 1982 and 1992.

The paper is organized as follows: section 2 presents the model, section 3 describes the calibration of the model and the solution method, section 4 reports the model's results, and section 5 provides concluding remarks.

2 The Model

To assess the effect of multinational firms in the moderation of output volatility in the U.S., we use an extension of Bernanke, Gertler and Gilchrist (hereafter BGG) *financial accelerator* model. The framework is a Real Business Cycle model with credit market frictions and multinational corporations. We abstract from the nominal side in BGG and we incorporate MNCs to explore the impact of international diversification on the real side of the model.[10]

on the production side of the model and added a monetary framework in which to study nominal rigidities. See Kiyotaki and Moore (1997) for a propagation mechanism based on collateral constraints rather than moral hazard.

[9] Jensen (1993) reports that the value of merger and acquisitions transactions between 1976 and 1990 in the U.S. was in the order of 2.6 trillion dollars.

[10] To keep the focus of the investigation on the real side of the economy, we abstracted from the monetary side of BGG; whose motivation included the study of nominal rigidities. While removing the nominal side of BGG, care was taken in preserving the closure of the model.

An important modelling concern when introducing international diversification is to separate the effect of the multinationals' foreign operations from the transmission of international business cycles on the home economy. That is, to be able to determine whether the moderation arises from larger MNCs or from a decline in business cycle correlations across countries, which could as well induce a similar effect.[11] Hence, to isolate the effect of firm diversification, we assume that the breadth of the MNCs diversification is such that foreign aggregate shocks offset each other through the MNCs' international network and that aggregate technology shocks at home are passed on to foreign affiliates.[12] This way, any aggregate moderation can only be attributed to the interaction of the MNCs' firm–specific home and foreign shocks.

The structure of the model is as follows. *Households* hold deposits with a *financial intermediary* that lends to *domestic firms (DCs)* and *MNCs* to finance the purchases of their desired capital stock from *capital producers*. *Entrepreneurs* own the firms (DC or MNC) and hire labor from households in order to produce the consumption good. However, there is a moral hazard problem in the credit market: the financial intermediary cannot observe the firms' returns on their assets unless the intermediary pays a verification cost. The solution to this problem leads to a standard debt contract, which generates the *financial accelerator*.

There are two broad sides in the model, one is the design of the optimal contract due to the Costly State Verification, and the other corresponds to the standard real business cycle (RBC) features of the model such as household behavior, the evolution of the capital stock, and the technology available to firms. The presentation of the model is based on this division; most of the insights on the role of MNCs in explaining the moderation in the volatility of output come from the first part.

To focus on the effect of larger international diversification on macroeconomic dynamics, the paper abstracts from some of the features associated to multinational corporations such as knowledge and technology transfers, and vertical integration; and there is only one type of multinational: home–based.[13] Also, common

[11] Heathcote and Perri (2004) document a significant decline in output, investment and employment correlations between the U.S. and the rest of the industrialized world after 1987. Though not the focus of their work, such de–synchronization could as well be important in the U.S. moderation, and calls for further study. Other references about the decline in international business cycle correlations include Stock and Watson (2003) and Faust and Doyle (2004).

[12] Desai and Foley (2004) find a high correlation between parents' and affiliates' return and investment rates; this being consistent with the transmission of productivity shocks within the MNC. Furthermore, they establish that the direction of causality goes from parents to foreign affiliates.

[13] By only modelling U.S.–based multinationals, the effect of larger foreign operations is simultaneously captured in the

in the real business cycle literature, the model features only one consumption good, which is produced at home by DCs and the parents of MNCs, and abroad by the MNCs' affiliates. The decision to be a domestic or a multinational company, and the determinants of the size of foreign affiliates are beyond the scope of the study; these features, relevant for the calibration of the model, are taken as given from the data. In short, the objective of the model is to determine the effect of the increase in U.S. multinational operations on investment and output volatility all else equal.

2.1 Multinational Corporations and the "Financial Accelerator"

This sub–section introduces MNCs to BGG's *financial accelerator*. In BGG the Costly State Verification problem that gives rise to the *financial accelerator* is characterized by the inability of the financial intermediary (the principal) to costlessly observe the firm's (the agent) idiosyncratic return on its assets. This induces borrowers to declare too many 'poor' returns on their projects. Then, following Townsend (1979), Bernanke, Gertler and Gilchrist design a truth-telling optimal contract so that the firm and the financial intermediary agree on a non–default interest rate and a cutoff return, for which realizations below it trigger the lender's verification.

2.1.1 MNC Balance Sheet and Financing

The distinctive feature of the model presented in this paper is that by introducing MNCs, firms face two idiosyncratic shocks: at home and abroad. The MNC consists of a *parent* firm and a *majority owned foreign affiliate (MOFA)*. To introduce some notation, the financial structure of the MNC in a given period is summarized by the following balance sheet.[14]

model's GDP (by means of the multinationals' parents) and GNP (through the multinationals' parents and affiliates).

[14]For expositional simplicity time subscripts are omitted in this subsection since all variables are contemporaneous.

Multinational Corporation Balance Sheet

	Parent	MOFA	MNC
Assets	QK	QK^*	$QK + QK^*$
Liabilities	B	B^*	$B + B^*$
Net Worth	N	N^*	$N + N^*$

Where $K(K^*)$, $B(B^*)$ and $N(N^*)$ represent the parent's (MOFA's) capital stock, debt and net worth, respectively, and Q denotes the price of capital in terms of the consumption good. In contrast, the balance sheet of a DC would only include the 'Parent' column in the table above.

In the model there is a continuum of firms indexed by $j \in [0, 1]$. What distinguishes a MNC from a DC is that DCs do not have any assets, liabilities or net worth abroad. In general, a DC is a mirror image of a MNC parent. To model firm–specific risk, let $\omega_j(\omega_j^*)$ be an idiosyncratic shock to the firm's return on its assets at home (abroad). Then, the multinational's return on its assets is given by:[15]

Parent:	$\omega_j R^k QK_j$
MOFA:	$\omega_j^* R^k QK_j^*$
MNC:	$\omega_j R^k QK_j + \omega_j^* R^k QK_j^*$

Where R^k denotes the economy–wide gross return on capital, and ω_j and ω_j^* are assumed to be two jointly distributed random variables with mean $\mu_\omega = \mu_{\omega^*} = 1$; variance $\sigma_\omega^2 = \sigma_{\omega^*}^2$; and correlation ρ_{ω,ω^*}.[16]

A key aspect of the model is the extent of the affiliates' operations, as these determine the degree of diversification. In the model, international exposure is captured by σ_j, which denotes the parent's share of

[15] For an alternative interpretation, in appendix A it is shown that $R^k QK = Y + (1 - \delta)QK - WL$. That is, the idiosyncratic shock on the MNC's asset return is equivalent to an idiosyncratic shock on a measure of the value of the firm: output plus undepreciated capital minus labor costs.

[16] The economy–wide return on capital is the average idiosyncratic return among firms. Since parents and affiliates share the same technology, and (as will be shown) all firms are scaled versions of each other, the mean idiosyncratic return of a unit of capital at home or abroad is given by $E[\omega_j R^k] = E[\omega_j^* R^k] = R^k$; which is in turn determined by the capital–labor ratio common to all firms. This also implies that the price of capital at home and abroad are equal. See sections 2.2.2 and 2.2.3.

MNC's assets. The smaller the parent's share of the multinational's assets (σ_j), the larger the importance of the affiliates. Since DCs do not hold any assets abroad, by definition σ_j is equal to one for a domestic company; that is, all of its assets are held at home. When the parent and the affiliate hold an equal share of the MNC's assets, meaning that the firm is fully diversified, σ_j equals one half.[17]

This way, let $K_j = \sigma_j K_{MNC,j}$ and $K_j^* = (1-\sigma_j)K_{MNC,j}$ represent the parent's and the affiliate's capital stock holdings within the j^{th} multinational, respectively. This implies that the affiliate's assets can be expressed as $K_j^* = \left(\frac{1-\sigma_j}{\sigma_j}\right) K_j$. Then, the multinational's return on its assets can be expressed as: $\left[\omega_j + \left(\frac{1-\sigma_j}{\sigma_j}\right)\omega_j^*\right] R^k Q K_j$.

In the model, firms finance their desired capital stock with their own funds (net worth) and by borrowing from the financial intermediary. Hence, the capital structure of the j^{th}MNC is given by the parent's and affiliate's debt $\left(B_j \text{ and } B_j^*\right)$ and net worth $\left(N_j \text{ and } N_j^*\right)$. However, due to the Costly State Verification, the Modigliani–Miller (1958) theorem does not hold and there is a wedge in the cost of external and internal financing.[18] The firm–specific cost of external financing is greater than the opportunity cost of internal funds, where the latter is given by the economy–wide risk–free rate. In a given period, the multinationals' debt is given by:[19]

$$B_{MNC} = B_j + B_j^* = \left[B_j + \left(\frac{1-\sigma_j}{\sigma_j}\right) B_j\right] = \frac{1}{\sigma_j} B_j.$$

As before, for DCs σ_j is equal to one implying that B_j^* is equal to zero. Because international financial markets are not explicitly modeled, MNCs are assumed to borrow from the home country the difference between their net worth and their desired capital stock for domestic and foreign operations.[20]

[17] The study of determinants of the parent's share of the multinational's assets (σ_j) is beyond the scope of the paper. However, σ bridges the models with and without multinationals. By setting $\sigma_j = 1$ for every j, the model collapses to BGG. Section 3 describes the calibration of σ, for conducting the model simulations.

[18] Bernanke and Gertler (1989) present evidence from the U.S. manufacturing industry, where informational asymmetries in credit markets raise the firms' cost of external financing relative to internal funds. More recently, Levin, Natalucci, and Zakrajsek (2004), based on a sample of publicly traded firms for the period between 1997 and 2003, consistently reject the hypothesis of frictionless financial markets in different tests.

[19] It has been observed that the parents' share of the MNCs' assets has coincided with their share of debt, net worth, employment and capital expenditure during the 1984-2000 period (BEA, 2002). This way, σ_j is also used to represent the parent's share of the MNC's debt. Though declining, this share has been approximately 0.75.

[20] In practice, foreign affiliates borrow from local and international sources. Nonetheless, Desai, Foley and Hines (2004) document that parents are an important source of funding for foreign affiliates. Furthermore, Altshuler and Grubert (1996)

2.1.2 MNC Diversification

The difference between a multinational and domestic company is that while the DC's performance solely depends on domestic events, the multinational firm is also subject to shocks in its foreign operations. This subsection describes how the interaction of home and foreign idiosyncratic shocks reduce the multinational's cost of capital and also leads to smoother dynamics of net worth. In essence, when home and foreign idiosyncratic shocks are not perfectly positively correlated a good realization of a shock in one location may offset a poor realization from another location; leading to more stable net worth, a lower probability of default and smoother terms of credit. Given the parent's capital stock (K_j), debt (B_j), borrowing interest rate (Z_j), the economy–wide price of capital (Q) and return on capital (R^k), the multinational's performance is summarized by the following cases.[21]

Case 1: The MNC exactly repays its debt and disappears.

$$\left[\omega_j + \left(\frac{1-\sigma_j}{\sigma_j}\right)\omega_j^*\right] R^k Q K_j = \frac{1}{\sigma_j} Z_j B_j$$

Case 2: The MNC pays back its debt and accumulates the difference as net worth.

$$\left[\omega_j + \left(\frac{1-\sigma_j}{\sigma_j}\right)\omega_j^*\right] R^k Q K_j > \frac{1}{\sigma_j} Z_j B_j$$

Case 3: The MNC defaults on its debt.

$$\left[\omega_j + \left(\frac{1-\sigma_j}{\sigma_j}\right)\omega_j^*\right] R^k Q K_j < \frac{1}{\sigma_j} Z_j B_j$$

In this event, the financial intermediary incurs verification cost μ, and keeps the liquidation value $(1-\mu)\left[\omega_j + \left(\frac{1-\sigma}{\sigma}\right)\omega_j^*\right] R^k Q K_j$.

Case 1 is the benchmark upon which the debt contract between the firm and the financial intermediary is designed. As will be discussed, this contract is characterized by the amount borrowed, the borrowing interest rate, and the set of cutoff values for ω and ω^* for which there is verification. For expositional convenience let $l_j \equiv \frac{Z_j B_j}{R^k Q K_j}$, be a measure of the firm's leverage so that case 1 can be expressed as: $\left[\sigma_j \omega_j + (1-\sigma_j)\,\omega_j^*\right] = l_j$.

The effectiveness by which a MNC can hedge domestic risk depends on the importance of its foreign operations. To illustrate this argument, figure 4 presents the three cases for two values of σ_j.

report evidence that U.S. multinationals use assets held abroad to support loans at home.

[21] The performance of a DC is also characterized by these cases, provided that σ_j is equal to 1.

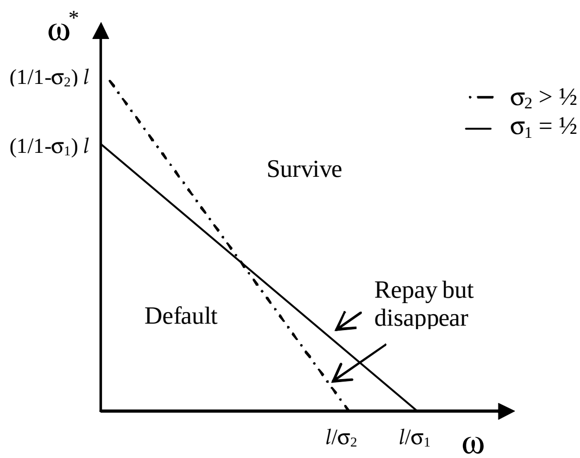


Figure 4. Multinational Corporation Performance

For a given value of l_j and σ_j, the straight lines represent the combinations of (ω_j, ω_j^*) for which the MNC breaks even (case 1). Realizations under the line lead to bankruptcy and verification (case 3), while with realizations above the line the firm accumulates net worth (case 2). In contrast, a domestic firm does not have the safeguard from international diversification against a poor realization at home. By comparing the frontiers associated with σ_1 and σ_2, one can observe that the less diversified the MNC is (bigger σ_j), low realizations of ω (close to zero) require increasingly large realizations of ω^* for the MNC to survive. That is, the MNC must get a high realization abroad to make up for the poor performance at home.[22]

An alternative way to see the diversifying effect of σ_j, is that by way of example suppose ω and ω^* are independently and uniformly distributed. Then, σ_j equal to a half minimizes the probability of default $\left(\frac{1}{2}\frac{l_j^2}{\sigma_j(1-\sigma_j)}\right)$ for a given l_j. Hence, as will be shown, $\sigma_j < 1$, translates into lower risk, better terms of credit, and more stable net worth, investment, and output relative to a DC.

From the figure it can be seen that the probability of default of a MNC is given by:[23]

[22] Though, when the MNC is less diversified (high σ_j) poor realizations abroad require smaller realization at home to survive.

[23] The notation convention adopted in the paper is that ω_j and ω_j^* represent the firm specific realizations of the random variables ω and ω^*. When either ω or ω^* are part of the limits of integration, integrals are defined over s and s^*, which stand for ω and ω^*, respectively.

$$\Psi(l_j) \equiv \int_0^{l_j/\sigma_j} \int_0^{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)} f(s, s^*) ds^* ds.$$

The formal argument behind the lower volatility of the multinationals' net worth due to diversification is summarized in the following proposition.

Proposition 1 *Let $K_j \in \Re_{++}$, represent a firm's capital stock, and $\sigma_j \in [0,1]$ represent the firm's share of capital at home. Also let, R^k and Q respectively denote the economy–wide gross return on capital and price of capital. Suppose $[\sigma_j\omega_j + (1-\sigma_j)\omega_j^*]$ represents a firm–specific shock to the gross return on its capital, with $\sigma_j = 1$ characterizing a domestic firm and $\sigma_j \in (0,1)$ a multinational corporation; where ω and ω^* are jointly distributed random variables with mean $\mu_\omega = \mu_{\omega^*}$; variance $\sigma_\omega^2 = \sigma_{\omega^*}^2$; and correlation $\rho_{\omega,\omega^*} \in [-1,1)$. Then $var\{[\sigma_j\omega + (1-\sigma_j)\omega^*]R^kQK_j\} < var\{\omega R^kQK_j\}$. That is, the gross return of a MNC's assets is less volatile than that of a DC's assets as long as home and foreign idiosyncratic shocks are not perfectly positively correlated.*

Proof. *See Appendix B.* ■

What the proposition shows is that if a DC and a MNC have the same capital stock, unless home and foreign idiosyncratic shocks are perfectly positively correlated, the volatility of the return on the multinational's capital will always be less than that of a domestic corporation.

2.1.3 The Financial Contract

Though the model is set up in a dynamic framework, the debt contract is realized within each period. The timing is as follows. The firm enters the period with a given net worth, then observes the realization of the aggregate technology shock, hires labor and decides how much to borrow in order to finance the difference between its net worth and its desired capital stock; then the idiosyncratic shock(s) are realized and the firm pays back its debt and labor costs, sells its capital, and keeps any remaining funds as net worth with which it goes into the next period.

The first element of the debt contract is the lending side represented by the Financial Intermediary. The financial intermediary is assumed to be a competitive entity that funds itself from households' deposits, on which it pays the risk–free gross interest rate R. Zero–profits in financial intermediation implies that the funding of a MNC must satisfy the following participation constraint:

$$[1-\Psi(l_j)]\frac{1}{\sigma_j}Z_jB_j+(1-\mu)\int_0^{l/\sigma_j}\int_0^{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)}\left[s+\left(\frac{1-\sigma_j}{\sigma_j}\right)s^*\right]f(s,s^*)ds^*dsR^kQK_j=\frac{1}{\sigma_j}RB_j.$$

The first term of this equation accounts for the expected non-default payback of the loan by the firm. The second term represents the financial intermediary's expected recovery value in the event of default, after accounting for the verification cost. The right side of the equation represents the financial intermediary's funding costs; that is, the gross risk–free interest rate on the lent amount. Using the MNC's balance sheet the equation can be rewritten as:

$$[1-\Psi(l_j)]\frac{1}{\sigma_j}Z_j(QK_j-N_j)+(1-\mu)\Upsilon(l_j)R^kQK_j=\frac{1}{\sigma_j}R(QK_j-N_j), \tag{1}$$

where $\Upsilon(l_j)\equiv\int_0^{l/\sigma_j}\int_0^{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)}\left[s+\left(\frac{1-\sigma}{\sigma}\right)s^*\right]f(s,s^*)ds^*ds.$

The other side of the contract corresponds to the firm. Firms are assumed to be risk neutral, and borrow from the financial intermediary the difference between their desired capital stock and their net worth. Their objective is to maximize the difference between the expected return on their assets and the expected financing costs. From figure 4, it can be seen that this is given by:[24]

$$\int_0^{l/\sigma_j}\int_{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)}^{\infty}\left[s+\left(\frac{1-\sigma_j}{\sigma_j}\right)s^*\right]f(s,s^*)ds^*dsR^kQK_j+$$
$$\int_{l/\sigma_j}^{\infty}\int_0^{\infty}\left[\omega+\left(\frac{1-\sigma_j}{\sigma_j}\right)\omega^*\right]f(\omega,\omega^*)d\omega^*d\omega R^kQK_j-[1-\Psi(l_j)]\frac{1}{\sigma_j}Z_jB_j.$$

Given that the mean of the two idiosyncratic shocks is equal to one, this expression can be further simplified to:[25]

$$\left[\frac{1}{\sigma_j}-\Upsilon(l_j)\right]R^kQK_j-[1-\Psi(l_j)]\frac{1}{\sigma_j}Z_j(QK_j-N_j). \tag{2}$$

[24] This formulation is equivalent to the firm maximizing its expected net worth. Refer to section 2.2.4.

[25] Details presented in appendix A.

Where the first term is the expected non–default return on the firm's assets and the second term represents the non–default financing costs.

Following BGG, given the firm's net worth, the economy–wide price of capital and the economy–wide return on capital, the profit-maximizing contract between the MNC and the financial intermediary is such that the parent's choice for the capital stock (K_j) maximizes equation 2 subject to Z_j being the solution to equation 1. That is,

$$\max_{\{K_j, Z_j\}} \quad \left[\frac{1}{\sigma_j} - \Upsilon(l_j)\right] R^k QK_j - [1 - \Psi(l_j)] \frac{1}{\sigma_j} Z_j(QK_j - N_j)$$

$$\text{subject to} \quad [1 - \Psi(l_j)] \frac{1}{\sigma_j} Z_j(QK_j - N_j) + (1 - \mu)\Upsilon(l_j)R^k QK_j = \frac{1}{\sigma_j} R(QK_j - N_j).$$

Along with the optimal borrowing interest rate (Z_j) and the desired capital stock (K_j), the solution to this problem implies a unique cutoff value for l_j that determines the combinations of ω and ω^* for which there is verification (refer to case 1).[26]

2.1.4 The Financial Accelerator and Aggregation

The properties of the *financial accelerator* are obtained from equation 1; namely that the borrowing interest rate is decreasing in net worth and that the firms' demand for capital is increasing in net worth. The first feature lies at the core of the propagation mechanism since the firms' investment and output depend on the terms of borrowing, which are in turn determined by the dynamics of net worth. The linearity of the demand for capital serves as the basis for aggregation in the model.[27]

To see the relationship between the borrowing interest rate Z_j and the MNC's net worth, equation 1 can be expressed as follows:

$$Z_j = \left\{\frac{1}{[1 - \Psi(l_j)]}\right\} \left[R - \frac{\sigma_j(1 - \mu)\Upsilon(l_j)R^k QK_j}{(QK_j - N_j)}\right].$$

[26] For a domestic company, l_j represents the upper bound of a range of realizations of ω for which there is verification (see BGG, 1999). The equilibrium allocation that solves the debt contract is Pareto efficient. See Townsend (1979) for a proof of the general formulation. As is noted ahead, the solution of this problem is part of the model's general equilibrium.

[27] The derivations of the results presented in this subsection are collected in appendix C.

This equation shows that in equilibrium the borrowing interest rate is decreasing in net worth N_j; and increasing in the probability of default, $\Psi(l_j)$.

Different levels of net worth across firms requires keeping track of each firm when solving the model. However, following BGG we show that the problem of dealing with firm heterogeneity need not arise since firms are scaled versions of each other. Constant returns to scale in production, together with the demand for capital being linear in net worth, suffice to determine the aggregate demand for capital given the total stock of net worth.[28] In particular, equation 1 can be written as:

$$QK_j = \left\{ \frac{R - [1 - \Psi(l_j)]}{R - [1 - \Psi(l_j)]\, Z_j - \sigma_j(1-\mu)\Upsilon(l_j)R^k} \right\} N_j.$$

This equation shows that the MNC's demand for capital is increasing in net worth (N_j) and in the economy's return on capital (R^k); and decreasing in the risk free interest rate (R)—the financial intermediary's funding costs. However, to aggregate across firms, the term in brackets should be a the same for every firm. When the factor of proportionality is a constant that only depends on economy–wide variables, one can integrate over the continuum of firms to determine the aggregate demand for capital.

Relative to BGG, the model with MNCs adds a dimension in which firms can differ: the degree of openness. In addition to different net worth, MNCs can also vary in the parent's share of the multinational's assets (σ). In appendix C, it is shown that when σ is constant across firms, that is $\sigma_i = \sigma_j$ for $i \neq j$; the term in brackets is only determined by economy–wide variables $\left(R^k, R \text{ and } Q\right)$, thus allowing for aggregation.[29] Then, the aggregate demand for capital is given by:

$$QK = \left\{ \frac{R - [1 - \Psi(l)]}{R - [1 - \Psi(l)]\, Z - \sigma(1-\mu)\Upsilon(l)R^k} \right\} N.$$

[28] Constant returns to scale imply that in equilibrium the capital-labor ratio is constant across firms.

[29] For calibration purposes we assume that σ is constant across firms, though declining over time to account for the increase in international diversification.

2.2 Households, Capital Producers, Production and Evolution of Net Worth

The optimal contract between firms and financial intermediaries is embedded into a standard real business cycle model. The main aspects of this side of the model involve households, the production technology, capital producers, and the law of motion of the capital stock.

2.2.1 Households

In the model there is a continuum of infinitely-lived households, taken to be of measure one, whose preferences are defined over consumption and leisure. Households are assumed to maximize their discounted lifetime utility and hold deposits with the financial intermediary, who pays a riskless rate of return. Household utility is separable over time, consumption, and leisure. The i^{th} household problem is:

$$\max_{\{C_{t,i}, H_{t,i}, D_{t+1,i}\}} \quad U_i = E_0 \sum_{t=0}^{\infty} \beta^t u(C_{t,i}, H_{t,i})$$

$$\text{subject to} \quad C_{t,i} + D_{t+1,i} = W_t H_{t,i} + R_t D_{t,i}.$$

Where $C_{t,i}, H_{t,i}$ and $D_{t+1,i}$ are period t decisions over consumption, labor, and period $t+1$ available deposits with the financial intermediary, who pays gross return R_t. The intertemporal discount factor is given by $\beta \in (0,1)$.

Given that households' decisions are driven by economy–wide variables (W_t and R_t), individual values of consumption and labor correspond to their aggregate counterparts.

2.2.2 Capital Producers

In the model, firms borrow the households' deposits from the financial intermediary. Once firms have access to the funds, they buy their desired capital stock from capital producers. Capital producers are competitive entities that transform investment expenditures (I_t) and the undepreciated capital stock into new capital. Capital is homogeneous so new capital is indistinguishable from used capital, and the price of capital (Q_t) represents the amount of the consumption good that must be exchanged for a unit of capital. Capital producers are assumed to solve the following profit maximization problem:

$$\max_{\{I_t\}} \quad \Pi_t^{cp} = Q_t \left[\Phi \left(\frac{I_t}{K_t} \right) K_t + (1-\delta) K_t \right] - I_t - (1-\delta) Q_t K_t.$$

The term $\Phi\left(\frac{I_t}{K_t}\right)$, represents the production function for capital and it is used to reflect adjustment costs in the capital stock. This production function is assumed to exhibit diminishing marginal productivity (that is, $\Phi'(\cdot) > 0$ and $\Phi''(\cdot) < 0$), implying that large changes in the capital stock are increasingly costly.

The solution to the capital producers' problem determines the economy–wide price of capital, and the law of motion of the capital stock, which is given by:[30]

$$K_{t+1} = \Phi\left(\frac{I_t}{K_t}\right) K_t + (1-\delta) K_t.$$

2.2.3 Production

To produce the consumption good, entrepreneurs' use the capital, labor, and are subject to aggregate technology shocks. In addition, entrepreneurs are assumed to supply their labor inelastically.[31] In each period t the aggregate production function is given by:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}.$$

Where $L_t = H_t^{\Omega}(H_t^e)^{1-\Omega}$, is a composite of household labor, H_t, and entrepreneurial labor, H_t^e; and A_t represents the aggregate technology shock. In the model, the wage rate for households is denoted by W_t and by W_t^e for entrepreneurs. Like in BGG, H_t^e is normalized to one.

The technology shock is assumed to be governed by the following process:

[30] The first order condition of the capital producers' problem is $Q_t = \Phi'\left(\frac{I_t}{K_t}\right)^{-1}$, for every t. This expression determines the economy–wide price of capital.

[31] Entrepreneurial labor is introduced to avoid firms eventually having zero net worth and to keep the optimal contract well defined. Note from section 2.1.4 that zero net worth implies that the demand for capital is zero (see BGG, 1999).

$$A_t \equiv e^{z_t}, \quad \text{where } z_t = \rho_z z_{t-1} + \varepsilon_t; \quad \text{with } \varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right).$$

The mean economy–wide gross return on a unit of capital (in units of capital), R_t^k, is given by the marginal product of capital plus the undepreciated fraction.[32] This is represented by:

$$R_t^k = \frac{\alpha A_t K_t^{\alpha-1}[H_t^{\Omega}(H_t^e)^{1-\Omega}]^{(1-\alpha)}}{Q_t} + (1-\delta).$$

The first term on the right side of the equation corresponds to the marginal product of capital in units of capital, and the second term represents the undepreciated portion.

2.2.4 Evolution of Net Worth

Following BGG, firms in the model not only disappear due to bankruptcy but also there is an exogenous probability $(1-\theta)$ that the firm exits the industry on a given period. Firm turnover along with the equilibrium bankruptcy rate determine the evolution of aggregate net worth. The law of motion of net worth is given by the value function associated to the optimal contract—substituting equation 1 into equation 2—weighted by the probability of survival and adding entrepreneurial wages, W^e.

$$N_{t+1} = \theta \left\{ \left[\frac{1}{\sigma} - \mu \Upsilon(l_t) \right] R_t^k Q_t K_t - \frac{1}{\sigma} R_t \left(Q_t K_t - N_t \right) \right\} + W_t^e$$

The term in brackets represents the economy's non–default expected asset return net of the financial intermediaries funding costs.

"Dying" firms are assumed to consume their net worth giving rise to entrepreneurial consumption (C_t^e) that is used to start up new firms. Entrepreneurial consumption is defined as:

$$C_t^e = (1-\theta) \left\{ \left[\frac{1}{\sigma} - \mu \Upsilon(l_t) \right] R_t^k Q_t K_t - \frac{1}{\sigma} R_t \left(Q_t K_t - N_t \right) \right\}.$$

[32] Since $E[\omega] = E[\omega^*] = 1$ the mean return on capital across firms is R_t^k.

2.3 Equilibrium

An equilibrium for this economy is defined by a sequence of prices $\left\{W_t, W_t^e, R_t^k, R_t, Q_t, Z_t\right\}_{t=0}^{\infty}$; decision rules for $\{C_t, H_t, I_t\}_{t=0}^{\infty}$; and laws of motion for $\{K_{t+1}, N_{t+1}, D_{t+1}, A_{t+1}\}_{t=0}^{\infty}$, such that every period t :

1. The households' problem is solved.

2. Entrepreneurs' maximize the expected return on their assets (the agency problem is solved).

3. Capital producers maximize profits.

4. The labor market clears:[33]

$$\begin{aligned} W_t &= (1-\alpha)\Omega A_t K_t^{\alpha} H_t^{(1-\alpha)\Omega-1}; \\ W_t^e &= (1-\alpha)(1-\Omega) A_t K_t^{\alpha} H_t^{(1-\alpha)\Omega}. \end{aligned}$$

5. The market for savings clears:

$$\begin{aligned} \frac{1}{\sigma} Q_t K_t &= \frac{1}{\sigma}\left(B_t + N_t\right); \\ \frac{1}{\sigma} B_t &= D_t. \end{aligned}$$

6. The goods market clears:

$$\frac{1}{\sigma} Y_t = C_t + C_t^e + I_t + \mu \Upsilon(l_t) R_t^k Q_t K_t.$$

The last equilibrium condition states that the goods market clears when national income is allocated between household consumption, entrepreneurial consumption, investment, and audit costs spent on bankrupt firms. Since the "rest of the world" is not explicitly modeled, the model is closed by including the affiliates' production in this equilibrium condition. Even though this feature allows to interpret the model as a one–country two–sector economy, it guarantees that any change in output volatility arises from the interaction of the parent's and affiliate's idiosyncratic shocks, and not from the international transmission of aggregate productivity shocks. For instance, if one were to build a two–country real business cycle model, the effect

[33] The firm's demand for labor represents the profit maximizing condition that the marginal product of labor should be equal to the real wage. These conditions arise when $R_t^k Q_t K_t$ is replaced by $A_t K_t^{\alpha}[H_t^{\Omega}(H_t^e)^{1-\Omega}]^{1-\alpha} - w_t H_t - w_t^e H_t^e + (1-\delta) Q_t K_t$, in the firm's problem and H^e is normalized to one. See appendix A.

of larger multinational corporations would be hard to identify since investment and output volatility would also be determined by international investment flows driven the countries' relative productivity, even when foreign aggregate shocks could be shut down.

In the light of this trade–off, the cost of cleanly identifying the impact of diversification in the model's dynamics is that instead of having affiliates use home capital and foreign labor, all income receipts from the affiliates' operations accrue to domestic capital and labor. In a two–country model, the balance of payments would account for income receipts from the multinationals' capital abroad, for foreign direct investment and for the trade balance, mainly driven by the countries' productivity differentials.

3 Calibration and Solution Method

The model was solved by linearizing around the steady state, and then applying the Schur decomposition to compute the decision rules of the non–predetermined variables and the laws of motion of the pre–determined variables.

To solve the model numerically, we assumed the following functional forms:

Households utility function : $u(C_t, H_t) = \log(C_t) + \psi \log(1 - H_t).$

Aggregate production function : $Y_t = A_t K_t^{\alpha} L_t^{1-\alpha}$ with $L_t = H_t^{\Omega} (H_t^e)^{1-\Omega}.$

Capital production function : $\Phi\left(\frac{I_t}{K_t}\right) = \left(\delta^* - \frac{\delta^*}{\gamma}\right) + \left(\frac{1}{\gamma \delta^{*(\gamma-1)}}\right)\left(\frac{I_t}{K_t}\right)^{\gamma},$

with δ^* being the steady state value for $\left(\frac{I}{K}\right)$.

Aggregate productivity shock : $A_t \equiv e^{z_t}$, where $z_t = \rho_z z_{t-1} + \varepsilon_t$; with $\varepsilon_t \sim N\left(0, \sigma_{\varepsilon}^2\right).$

Idiosyncratic shocks : $\omega_t \equiv e^{x_t}$ with $x_t \sim N(0, \sigma_x^2)$, and $\omega_t^* \equiv e^{x_t^*}$ with $x_t^* \sim N(0, \sigma_{x^*}^2)$;

and σ_x^2 equal to $\sigma_{x^*}^2$.

The distributional assumptions on ω_t and ω_t^* imply that their distribution is lognormal with $E(\omega_t) = E(\omega_t^*) \simeq 1$, and $var\,(\omega_t) = var\,(\omega_t^*) \simeq \sigma_x^2$.

The calibration of the model is such that each model period represents one "quarter" of a year. Table 2, reports the specific values used for solving the model. Most of the structural parameters, commonly used in the business cycle literature, were borrowed from BGG and Cooley (1995). The parameter values associated with the extension of the model are those regarding international diversification: the home share of capital, the correlation of idiosyncratic shocks, and the volatility of idiosyncratic shocks.

Table 2. Model Parametrization

Preferences	Discount factor	$\beta = 0.99$
	Labor weight	$\psi = 2$
Technology	Capital share	$\alpha = 0.36$
	Persistence of productivity innovations	$\rho = 0.95$
	Std. Dev. of productivity innovations	$\sigma_\varepsilon = 0.01$
	Depreciation rate	$\delta = 0.02$
	Capital adjustment	$\gamma = 0.86$
Financial Accelerator	Verification cost	$\mu = 0.12$
	Firm's probability of surviving	$\theta = 0.9728$
	Std. Dev of idiosyncratic shocks	$\sigma_\omega = 0.07$
	Entrepreneur's share	$1 - \Omega = 0.0064$
International Diversification	Share of capital at home	$\sigma = [0.95, 0.99]$
	Correlation of idiosyncratic shocks	$\rho_{\omega,\omega^*} = 0.2$

To quantify the effect of the U.S. capital stock abroad on the aggregate economy, the model is calibrated such that σ represents the share of the home–based U.S capital stock relative to the total U.S. capital stock (home fixed assets and direct investment position abroad). That is, all firms in the economy are treated as "small" multinationals with a proportional stake on the capital stock abroad.[34] To account for the evolution of the capital stock abroad, a range of values from 0.99 (the least open) to 0.95 (the most open) were used for σ. These values capture the increasing importance of U.S. foreign operations and were calculated using the

[34] Alternatively, the mass of firms could have been split into DCs and MNCs; however, this would further require to model credit market segmentation and the financial intermediary's decision about which market to serve. Future research should account for this distinction, and study further whether trade based spill–overs between MNCs and DCs can also be linked to the output moderation.

U.S. direct investment position abroad and the domestic capital stock series from the Bureau of Economic Analysis (see appendix D). The bottom right panel in figure 2, plots the path of the share of the U.S. direct investment position relative to the total capital stock; that is, the evolution of $(1 - \sigma)$.

In the absence of an observable counterpart to the model's idiosyncratic shocks, following BGG, the variance of ω was calibrated to match the model's output volatility with that observed for the U.S. between 1960 and 1983. However, to calculate the correlation between domestic and foreign idiosyncratic shocks we constructed a model equivalent series of $R^k QK$ for U.S. parents and affiliates. To this end we took a sample of nine industries from the Bureau of Economic Analysis Annual Survey of U.S. Direct Investment Abroad for the period 1994 to 2003, and computed the correlation between the deviations from trend of the parents and affiliates Hodrick–Prescott filtered series.[35] Then, we calculated the simple and weighted average of the industries' correlations. To check for robustness, we applied the same procedure to calculate the correlation between parents and affiliates value added. The weights were the parents' share of value added and the parents' share of the $R^k QK$ equivalent within the sample in the year 2003. The correlation estimates range from 0.1 to 0.3, with the simple mean from each method lying in the middle of the interval. Since the sample consists of a small subset of all industries, the benchmark correlation between ω and ω^* is taken to be 0.2.[36]

4 Results

To quantify the effect of larger foreign operations of multinational corporations on the aggregate economy, we compare the implied investment and output volatilities of a model with only DCs relative to those of a model with MNCs. All else equal, the model supports the view that international diversification leads to lower investment and output volatilities. Smoother net worth translates into less volatile borrowing conditions allowing for more stable investment financing and production. That is, international operations dampen the *financial accelerator* and shocks propagate less vigorously through the economy.

[35] The Annual Survey of U.S. Direct Investment Abroad includes U.S. multinationals' balance sheets, sales, production, and transfers of parent companies, majority owned foreign affiliates and foreign affiliates.

[36] The model equivalent series were built using U.S. parents and affiliates value added, total assets, and compensation of employees reported in the Bureau of Economic Analysis Annual Survey of U.S. Direct Investment Abroad (see appendix A). The depreciation rate corresponds to the annual counterpart to that reported in table 2. The selection of industries was determined by the consistency in industry definitions and availability of the data. The industries in the sample are: agriculture, mining, utilities, primary metals, fabricated metals, wholesale trade, retail trade, transportation and accommodation.

In order to test the model, we computed a numerical approximation to the population moments of the model with and without multinationals. In particular, since the model is stationary, the effect of foreign operations ought to be captured by variance of the model's variables. To conduct the experiment we simulated 100 model periods 10,000 times. Then, we computed the variance of the deviations form trend of HP–filtered series for output, investment and net worth for each 100 period simulation. In the last step we calculated the average volatility of the 10,000 simulations.

Table 3 presents the mean percentage standard deviation of the selected series for the model with multinationals with different values for σ, for the model without multinationals (BGG), and for a standard RBC model with no credit market frictions. The simulations suggest that as international diversification increases, output, investment and net worth volatilities tend to fall.

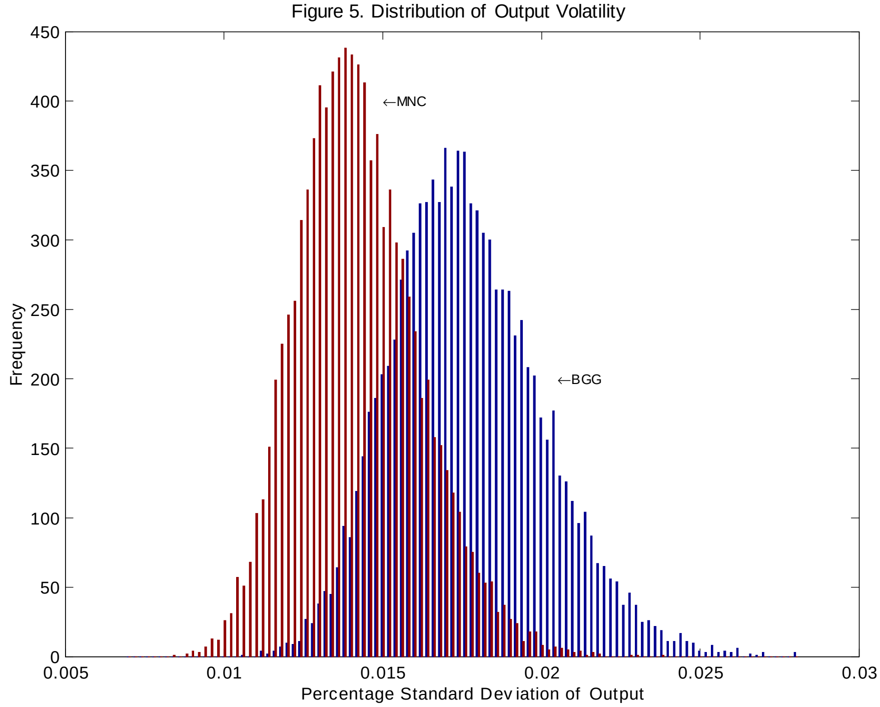
Table 3. Volatility of Selected Variables

	Benchmark		Multinationals (σ)				
Variable	BGG	RBC	0.99	0.98	0.97	0.96	0.95
% Std. Dev. of Output	1.76	1.58	1.70	1.61	1.53	1.48	1.42
% Std. Dev. of Net Worth	3.47	-	3.15	2.20	1.58	1.54	1.37
% Std. Dev. of Investment	5.30	3.93	4.65	4.30	4.16	3.96	3.88

A complementary representation of these findings, is given by the distribution of output volatilities from the simulations. In particular, figure 5 plots the distribution of the 100–period volatility of output from the 10,000 simulations for the BGG model and the model with MNCs with σ set at 0.95. In the figure, the distribution of output volatility from the model with multinationals is to the left and exhibits lower dispersion than that from the BGG model. The mean of these distributions correspond to the numbers reported in the top row of table 3 for BGG and multinationals (0.95).

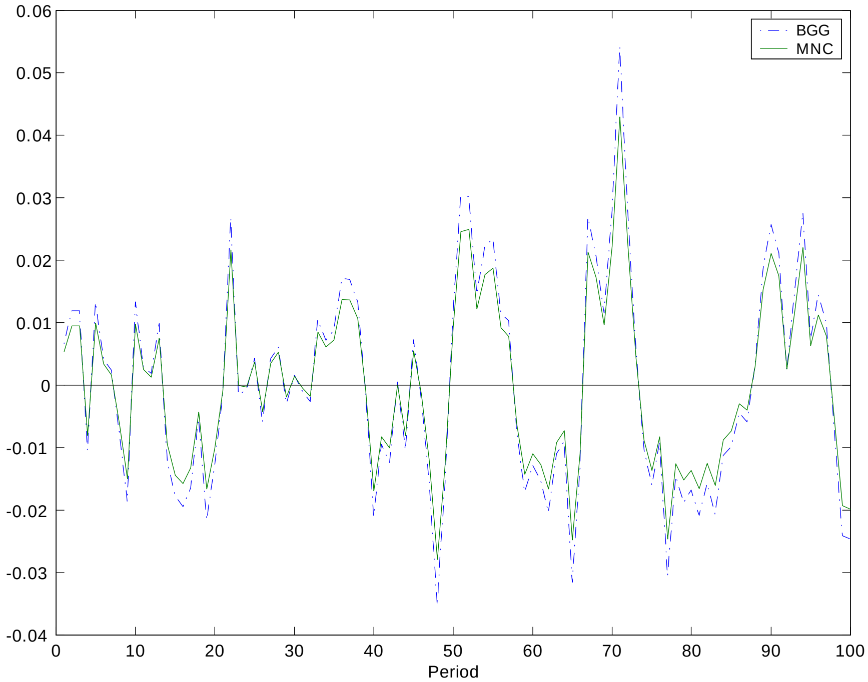
Finally, we compare the response of the model with multinationals to that without multinationals to positive and negative realizations from a given sequence of shocks. Figure 6 compares the dynamics of the two models from one of the 10,000 simulations. When subject to the same shocks, the economy with MNCs (with σ equal to 0.95) presents the lowest fall in production after a negative productivity shock. In upturns, the smoother path of net worth curbs the MNCs' response in output, while firms in the BGG economy take full advantage of the better terms of credit to increase production.

Figure 5. Distribution of Output Volatility



These results suggest that the increase in the U.S. direct investment position is expected to be associated with a moderation in output and investment volatility. Moreover, the model also establishes the direction of causality: lower volatility of net worth due to foreign operations, mitigate the credit market imperfection, leading to smoother financing costs and thus to less volatile investment and production.

Figure 6. Output: Deviations from trend



To gauge the model's predictions against the decline in U.S. output volatility, there are two possible points of reference: the gradualist view, and the structuralist view of the moderation. In practice, these views are not that far apart. From the stance of a gradual moderation, the decline in the ten–year rolling window output and investment volatility between the first quarter of 1960 and the last quarter of 2004 was 51 percent and 42 percent, respectively. On the other hand, the drop in the volatility of output and investment between the last quarter of 1984 and the last quarter of 2004, relative to the period between the first quarter of 1960 and the last quarter of 1983, was 47 percent and 41 percent, respectively.

In fact, this paper shares part of both views by linking the beginning of the rapid expansion in U.S. multinational corporations in 1984 to a gradual decline in output and investment volatilities. From a quantitative perspective, the increase in international operations in the model imply a 19 percent and 27 percent decline in the volatility of output and investment, respectively, had foreign operations of U.S. MNCs suddenly increased. In contrast, a gradual opening represented by the average volatility of output and investment from σ falling from 0.99 to 0.95 over the 1984–2004 period, would account for a 12 percent and a 21 percent decline in the volatility of output and investment, respectively. That is, all else equal, the continuing expansion of

U.S. MNCs' foreign operations can account for 24 percent and 49 percent of the observed decline in output and investment volatility, respectively.

4.1 Sensitivity

The structure of the model allows us to test changes in the economy aside from multinationals' operations. In particular, recent studies have documented changes in the volatility of idiosyncratic risk among U.S. firms, as well as changes in the dynamics of bankruptcy costs. Taking as a benchmark the volatility of firm–specific stock market returns, Campbell, Lettau, Malkiel and Xu (2001) have documented an increase in firm–level volatility relative to industry and market volatility between 1962 and 1997. This finding could be thought as evidence against the suggested moderation in net worth argued throughout this paper, and it is therefore important to assess.[37] In another area, Levin, Natalucci and Zakrajsek (2004) have shown some evidence of bankruptcy costs being counter–cyclical. As bankruptcy costs are crucial in determining the external–financing premium, we test the model's sensitivity to changes in μ. To control for larger multinational corporations, table 4 shows the implied volatility of output for different values of μ and of the standard deviation of ω for an economy with only DCs and credit market frictions.

Table 4. Sensitivity Analysis

μ	% Std. Dev. GDP	σ_ω	% Std. Dev. GDP
0.14	1.73	0.21	1.50
0.12 (benchmark)	1.76	0.14	1.65
0.1	1.79	0.07 (benchmark)	1.76

Table 4 suggests that μ and σ_ω are negatively related to output volatility. Though these findings can seem counter–intuitive, in the model, larger verification costs and larger volatility of idiosyncratic shocks imply a shift in the composition of firms' capital structure away from debt towards net worth in equilibrium. Intuitively, the higher monitoring costs, the larger the spread between the gross borrowing rate and the gross

[37] Even though Campbell and others' measure of idiosyncratic risk (stock market returns) lacks an equivalent counterpart in the model, the volatility of ω is the closest measure of firm specific–risk.

risk free rate, leading to less borrowing and more dependence on internal financing. Likewise, an increase in risk exposure from higher σ_ω, leads firms to increase their use of internal resources as the external financial premium rises with the probability of default. Hence, as these parameters increase, weaker credit cycles lead to smoother output and investment.[38]

5 Conclusion

The moderation in the volatility of U.S. output has often been attributed to better input and inventory management due to innovations in information technology, to the expansion of financial markets, to timely monetary policy, and to good luck. However, during the last two decades there has also been a rapid expansion in the size and range of U.S. multinational corporations' activities. This paper brings to the fore the channels and importance of international diversification by multinational corporations in the decline of output and investment volatility in the U.S. The main finding is that in the presence of credit market frictions, larger foreign operations of multinational corporations can have a dampening effect in the propagation of shocks through the economy, leading to a decline in the volatility of output and investment.

This paper documents the expansion in U.S. multinational activities and develops a model in which the presence of multinational firms lead to a reduction in the volatility of output growth. The model, an extension of Bernanke, Gertler and Gilchrist (1999) *financial accelerator* framework, accounts for the fact that MNCs are subject to idiosyncratic shocks at home and abroad, whose interaction generates a smoother evolution of the multinationals' net worth relative to domestic firms. This translates into smoother patterns of investment and production. When calibrated to account for the U.S. direct investment position abroad, the model economy exhibits output and investment volatilities closer to those in the U.S. data from the last two decades, than a model with only domestic firms.

Under the light of competing descriptions of the U.S. moderation as a gradual phenomenon or as the result of a structural break in the mid–80s, this paper shares part of both views by linking the beginning of the expansion in U.S. multinational corporations in 1984 to a gradual decline in output and investment

[38] The negative relation between idiosyncratic risk and lower output volatility, calls for further study in the moderation of U.S. output volatility as hinted by these results.

volatilities thereafter. All else equal, the model suggests that the continuing expansion of U.S. multinationals' foreign operations over the last two decades can account for up to 24 percent of the observed decline in output volatility. Considering that more than half of decline in U.S. volatility remains unexplained, identifying and modelling the effect of international diversification on the moderation brings us a step closer to understanding the nature and causes of this phenomenon.

Based on these results, future research should focus on exploring whether similar sources of diversification have played a role in the moderation in GDP growth in other industrialized countries as well. Backus and Kehoe (1992), Blanchard and Simone (2001), Stock and Watson (2003), and Faust and Doyle (2004) have documented that the business cycle moderation is not unique to the U.S., and similar forces may be at work in the rest of the world.

Appendix A: Mathematical Derivations

This appendix compiles the derivation of some mathematical equivalences used in the paper.

A1. Firm's Return on Capital

This subsection shows the equivalence between $R^k QK_j$ and $Y_j + (1-\delta)QK_j - WL_j$. This relationship is based on constant returns to scale in the production function and the firm's equilibrium conditions.

Let $L_{t,j}$ denote firm's j household and entrepreneurial labor. Constant returns to scale imply:

$$\begin{aligned}
Y_{t,j} &= (MPK_{t,j})K_{t,j} + (MPL_{t,j})L_{t,j} \quad \text{in equilibrium} \\
Y_{t,j} &= [Q_t R_t^k - Q_t(1-\delta)]K_{t,j} + W_t L_{t,j} \\
Y_{t,j} &= R_t^k Q_t K_{t,j} - (1-\delta)Q_t K_{t,j} + W_t L_{t,j} \\
R_t^k Q_t K_{t,j} &= Y_{t,j} + (1-\delta)Q_t K_{t,j} - W_t L_{t,j} \\
\left[\omega_t^j + \left(\frac{1-\sigma_j}{\sigma_j}\right)\omega_t^{j*}\right] R_t^k Q_t K_{t,j} &= \left[\omega_t^j + \left(\frac{1-\sigma_j}{\sigma_j}\right)\omega_t^{j*}\right][Y_{t,j} + (1-\delta)Q_t K_{t,j} - W_t L_{t,j}].
\end{aligned}$$

This way, the idiosyncratic shock on the MNC's asset return is equivalent to an idiosyncratic shock on a measure of the value of the firm (i.e. output plus undepreciated capital minus labor costs).

A2. Multinational's Expected Return on Capital

This subsection shows the derivation of equation 2. Figure 4, summarizes the performance of a MNC depending on the realizations of its idiosyncratic shocks. As noted before, realizations above the frontier lead to the accumulation of net worth, while realizations below lead to the MNC's liquidation. Hence, the MNC's non–default expected return is given by the following:

$$\begin{aligned}
&\int_0^{l/\sigma_j} \int_{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)}^{\infty} \left[s + \left(\frac{1-\sigma_j}{\sigma_j}\right)s^*\right] f(s,s^*)ds^* ds R^k QK_j + \\
&\int_{l/\sigma_j}^{\infty} \int_0^{\infty} \left[\omega + \left(\frac{1-\sigma_j}{\sigma_j}\right)\omega^*\right] f(\omega,\omega^*)d\omega^* d\omega R^k QK_j - [1-\Psi(l_j)]\frac{1}{\sigma_j} Z_j B_j.
\end{aligned}$$

Under the assumption that $E(\omega) = E(\omega^*) = 1$, this expression can be simplified to:

$$\left[\frac{1}{\sigma_j} - \int_0^{l/\sigma_j} \int_0^{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)} \left[s + \left(\frac{1-\sigma}{\sigma}\right) s^*\right] f(s,s^*) ds^* ds\right] R^k QK_j.$$

To see this note that:

$$\int_0^{l/\sigma_j} \int_{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)}^{\infty} \left[s + \left(\frac{1-\sigma_j}{\sigma_j}\right) s^*\right] f(s,s^*) ds^* ds R^k QK_j +$$
$$\int_{l/\sigma_j}^{\infty} \int_0^{\infty} \left[\omega + \left(\frac{1-\sigma_j}{\sigma_j}\right) \omega^*\right] f(\omega,\omega^*) d\omega^* d\omega R^k QK_j +$$
$$\int_0^{l/\sigma_j} \int_0^{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)} \left[s + \left(\frac{1-\sigma_j}{\sigma_j}\right) s^*\right] f(s,s^*) ds^* ds R^k QK_j;$$

is equal to:

$$\int_0^{\infty} \int_0^{\infty} \left[\omega + \left(\frac{1-\sigma_j}{\sigma_j}\right) \omega^*\right] f(\omega,\omega^*) d\omega^* d\omega R^k QK_j =$$
$$\int_0^{\infty} \int_0^{\infty} \omega f(\omega,\omega^*) d\omega^* d\omega R^k QK_j + \int_0^{\infty} \int_0^{\infty} \left(\frac{1-\sigma_j}{\sigma_j}\right) \omega^* f(\omega,\omega^*) d\omega^* d\omega R^k QK_j =$$
$$\int_0^{\infty} \omega f_\omega(\omega) d\omega R^k QK_j + \left(\frac{1-\sigma_j}{\sigma_j}\right) \int_0^{\infty} \omega^* f_{\omega^*}(\omega^*) d\omega^* R^k QK_j = \frac{1}{\sigma_j} R^k QK_j.$$

Hence:

$$\int_0^{l/\sigma_j} \int_{\left(\frac{1}{1-\sigma_j}\right)\ (l-\sigma_j\omega)}^{\infty} \left[s + \left(\frac{1-\sigma_j}{\sigma_j}\right) s^*\right] f(s,s^*) ds^* ds R^k QK_j +$$
$$\int_{l/\sigma_j}^{\infty} \int_0^{\infty} \left[\omega + \left(\frac{1-\sigma_j}{\sigma_j}\right) \omega^*\right] f(\omega,\omega^*) d\omega^* d\omega R^k QK_j =$$
$$\left[\frac{1}{\sigma_j} - \int_0^{l/\sigma_j} \int_0^{\left(\frac{1}{1-\sigma_j}\right)(l-\sigma_j\omega)} \left[s + \left(\frac{1-\sigma_j}{\sigma_j}\right) s^*\right] f(s,s^*) ds^* ds\right] R^k QK_j.$$

The last line together with the non–default financing costs are represented in equation 2.

Appendix B: Proof of Proposition 1

The claim from proposition 1, which states that the gross return of a multinational's assets is less volatile than that of a domestic firm's assets so long that idiosyncratic shocks are not perfectly positively correlated, is shown by contradiction. Suppose: $var\{[\sigma\omega + (1-\sigma)\omega^*]R^kQK\} > var\{\omega R^kQK\}$, and let $k \equiv R^kQK$.

$$
\begin{aligned}
var\{\sigma\omega k + (1-\sigma)\omega^* k\} &> var\{\omega k\} \\
\sigma^2 k^2 var\{\omega\} + (1-\sigma)^2 k^2 var\{\omega^*\} + 2\sigma(1-\sigma)k^2 cov(\omega,\omega^*) &> k^2 var\{\omega\} \quad \text{since} \quad var\{\omega\} = var\{\omega^*\} \\
[\sigma^2 + (1-\sigma)^2 - 1]var\{\omega\} + 2\sigma(1-\sigma)cov(\omega,\omega^*) &> 0 \\
[\sigma^2 + 1 - 2\sigma + \sigma^2 - 1]var\{\omega\} + 2\sigma(1-\sigma)cov(\omega,\omega^*) &> 0 \\
(\sigma^2 - \sigma)2var\{\omega\} + 2\sigma(1-\sigma)cov(\omega,\omega^*) &> 0 \\
(\sigma^2 - \sigma)var\{\omega\} + \sigma(1-\sigma)cov(\omega,\omega^*) &> 0 \\
\sigma^2 var\{\omega\} - \sigma var\{\omega\} + \sigma(1-\sigma)cov(\omega,\omega^*) &> 0 \\
\sigma var\{\omega\} - var\{\omega\} + (1-\sigma)cov(\omega,\omega^*) &> 0 \\
(1-\sigma)cov(\omega,\omega^*) &> (1-\sigma)var\{\omega\} \quad \text{since} \quad var\{\omega\} = var\{\omega^*\} \\
\rho_{\omega,\omega^*} var\{\omega\} &> var\{\omega\} \\
\rho_{\omega,\omega^*} &> 1 \quad \text{which contradicts } \rho_{\omega,\omega^*} \in [-1,1).
\end{aligned}
$$

This shows that unless home and foreign idiosyncratic shocks are perfectly positively correlated, the volatility of a multinational's return on its assets will always be less than that of a domestic corporation.

Appendix C: Properties of the "Financial Accelerator"

This appendix derives the properties of the financial accelerator. These are: i) the borrowing interest rate is decreasing in net worth, and ii) the firms' demand for capital is linear (and increasing) in net worth, which facilitates aggregation.

C.1 The borrowing interest rate is decreasing in Net Worth

The amplification mechanism in the *financial accelerator* framework arises from the borrowing interest rate being decreasing in net worth. From equation 1 note:

$$\frac{1}{\sigma_j}R(QK_j - N_j) - \left\{[1-\Psi(l_j)]\,\frac{1}{\sigma_j}Z_j(QK_j - N_j) + (1-\mu)\Upsilon(l_j)R^kQK_j\right\} = 0$$

$$[1-\Psi(l_j)]\,Z_j(QK_j - N_j) = R(QK_j - N_j) - \sigma_j(1-\mu)\Upsilon(l_j)R^kQK_j$$

$$[1-\Psi(l_j)]\,Z_j = R - \frac{\sigma_j(1-\mu)\Upsilon(l_j)R^kQK_j}{(QK_j - N_j)}$$

$$Z_j = \left\{\frac{1}{[1-\Psi(l_j)]}\right\}\left[R - \frac{\sigma_j(1-\mu)\Upsilon(l_j)R^kQK_j}{(QK_j - N_j)}\right].$$

In addition to the borrowing interest rate being decreasing in net worth, the last line also shows that it is increasing in the probability of default, $\Psi(l_j)$.

C.2 Aggregation

To show that the total demand for capital can be obtained by aggregating individual firms' demand for capital, following BGG, we show that the optimal financial contract only depends on economy–wide and not firm–specific variables. To show that this is the case consider the financial contract set up in section 2.1.3:

$$\max_{\{K_j, Z_j\}} \quad \left[\frac{1}{\sigma_j} - \Upsilon(l_j)\right] R^kQK_j - [1-\Psi(l_j)]\,\frac{1}{\sigma_j}Z_j(QK_j - N_j)$$

$$\text{subject to} \quad [1-\Psi(l_j)]\,\frac{1}{\sigma_j}Z_j(QK_j - N_j) + (1-\mu)\Upsilon(l_j)R^kQK_j = \frac{1}{\sigma_j}R(QK_j - N_j).$$

Diving through the objective function and constraint by N_j, assuming $\sigma_j = \sigma$ for every j, and letting $k_j \equiv \frac{QK_j}{N_j}$ the problem becomes:

$$\max_{\{K_j, Z_j\}} \quad \left[\frac{1}{\sigma} - \Upsilon(l_j)\right] R^kk_j - [1-\Psi(l_j)]\,\frac{1}{\sigma}Z_j(k_j - 1)$$

$$\text{subject to} \quad [1-\Psi(l_j)]\,\frac{1}{\sigma}Z_j(k_j - 1) + (1-\mu)\Upsilon(l_j)R^kk_j = \frac{1}{\sigma}R(k_j - 1).$$

The solution to this problem is a capital to net worth ratio $k_j(R^k, R, Q)$ and a borrowing interest rate $Z_j(R^k, R, Q)$ that are determined by economy–wide variables and not firm–specific characteristics. This implies that $\left[k_i(R^k, R, Q),\ Z_i(R^k, R, Q)\right] = \left[k_j(R^k, R, Q),\ Z_j(R^k, R, Q)\right]$ for $i \neq j$. Furthermore, the cutoff region $l_j(R^k, R, Q)$ is common to all firms, and means that all firms are equally levered regardless of their size.

Accordingly, the aggregate demand for capital is:

$$QK = \frac{R - [1 - \Psi(l)]}{R - [1 - \Psi(l)]\, Z - \sigma(1-\mu)\Upsilon(l) R^k} N.$$

Appendix D: Data Sources

The following series were obtained from the Bureau of Economic Analysis.

1. Quarterly Real GDP and GNP

National Income and Product Accounts, Table 1.7.6.

http://www.bea.gov/bea/dn/nipaweb/index.asp

2. Quarterly Real Gross Private Domestic Investment

National Income and Product Accounts, Table 1.1.6.

http://www.bea.gov/bea/dn/nipaweb/index.asp

3. U.S. Direct Investment Position Abroad

http://www.bea.gov/bea/di/home/iip.htm

4. U.S. Foreign Direct Investment

http://www.bea.gov/bea/di/home/directinv.htm

5. U.S. Current–Cost Net Stock of Fixed Assets

http://www.bea.gov/bea/dn/home/fixedassets.htm

6. U.S. Value Added by Industry

http://www.bea.gov/bea/dn2/home/annual_industry.htm

7. Balance Sheet and Operational Indicators of U.S. Multinationals

http://www.bea.gov/bea/ai/iidguide.htm#USDIA

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