THREE ESSAYS ON LATE-2000S CRISES

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Three key issues have raised wide attention during the Great Recession. They are jobless recoveries in the U.S., the excessive leverage of global banking sector, and sovereign defaults in Europe. This dissertation studies each of them by chapter, yet they are all related to financing, from firms' financial conditions, to banks' borrowing, to countries' debt. Together, they concern about the relation between macroeconomics and finance from different angles.

First, U.S. employment has recovered 3-6 quarters later relative to output recoveries in the post-1990 period, this has not happened before 1990s during the post-war period, which is what many call jobless recoveries. My first study explores how much firms' financial conditions (i.e., borrowing capacity) and firm-paid employee benefits (including health insurance cost) have contributed to the jobless recoveries, using a dynamic stochastic general equilibrium (DSGE) model. The paper makes four main contributions: 1) I document tighter financial conditions during recent three recoveries comparing to the ones before and show its impact on jobless recoveries and employment volatilities. 2) I document the underexplored cyclicality of per worker benefit costs and show that the costs decline during recessions and increase during recoveries. Moreover, the increases of per worker benefit costs during recent recoveries have become larger. 3) Using the financial conditions, the pro-cyclicality of benefit costs, and the costs' rising trend, this model produces 3-to-7-quarter delays in employment recoveries relative to business cycle troughs for the 1990, 2001, and 2007

recessions and no delay for the pre-1990 period. This is consistent with the data that has scarcely been matched in previous literature. 4) The calibrated model generates more than 76 percent of employment volatility, as well as most of the volatility in per worker hours and in output.

The second study, coauthored with Ruud de Mooij and Tigran Poghosyan, explores how corporate taxes affect the capital structure of multinational banks. Guided by a theory of optimal capital structure, it tests (i) whether local taxes induce subsidiary banks to raise leverage in light of traditional debt bias; and (ii) whether cross-country tax differences affect intra-bank capital structure through international debt shifting. Using a novel data set for 558 commercial bank subsidiaries of the 86 largest multinational banks in the world, we find that taxes matter significantly, through both the debt bias channel and the international debt shifting. Our results imply that taxation causes international debt spillovers through multinational banks.

Last, there has been a long established relationship between default and international trade in the empirical literature, however, its theoretical counterpart is scarce. My third study models the trade impact of endogenous default in a stochastic dynamic framework of two open economies that features incomplete financial markets and currency crisis (exchange rate depreciation). In the model, the exchange rate collapses due to default, therefore affecting GDP and goods trade. It predicts post-default deteriorating imports and rising exports, which is consistent with the data. This paper can be used to study both defaulter's and creditor's welfare.

BIOGRAPHICAL SKETCH

SUMMARY

Weishi (Grace) Gu, was born in Beijing, China, May 30, 1984. She has always been interested in macroeconomics and international economics. Since 2010, Grace has become increasingly engaged in computational economics. During the last 3 years, she has been primarily concerned with research advancing the understanding of jobless recoveries and employee benefits, as well as sovereign defaults, using dynamic programming. Her specialties include dynamic stochastic general equilibrium modeling and economic computation. She is presently appointed as an assistant professor at the Economics Department in University of California, Santa Cruz.

Grace joined Cornell University as a Ph.D. student in 2008 fall. Her prior education consisted of both the applied economics and international economics disciplines at University of Delaware (M.S., 2006-2008) and Beijing Foreign Studies University (B.A., 2002-2006). From 2008 to 2012, she has worked on projects with American Enterprise Institute (2008), Brookings Institution (2009), Federal Reserve Bank of Cleveland (2011), and International Monetary Fund (2012). Grace has been active in academic professional activities. She presented her papers and served as a session chair and discussant at multiple conferences and workshops, including Econometric Society North American Summer Meeting (Los Angeles, 2013), Midwest Macroeconomics Meetings (Boulder, 2012), Royal Economic Society Annual Conference (UK, 2012), and Initiative on Computational Economics (Zurich, 2011).

Grace has participated in many sports, including soccer, squash, dragon boat races, dancing, hiking, and swimming. Her biggest adventure outing so far has been a snow shoeing to the summit of Mount Marcy (5343 feet, 1629 meters), the highest peak in New York State. She has also traveled extensively around the world.

Completed Papers

- **Taxation and Leverage in International Banking** (2012), with Ruud de Mooij and Tigran Poghosyan, IMF Working Paper No. 12/281. Under journal revision.
- **Does Foreign Intellectual Property Rights Protection Affect U.S. Exports and FDI?** (2011), with Titus Awokuse. Forthcoming in *Bulletin of Economic Research*.
- **Harnessing Globalization in South Asia** (2011), with Eswar Prasad, in Ejaz Ghani, ed., *Reshaping Tomorrow-Positioning South Asia for the Big Leap*, Oxford University Press
- **An Awkward Dance: China and the United States** (2011), with Eswar Prasad, IZA Policy Paper No. 13

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This document is dedicated to my mother, Yanhong Qu, my father, Mingtian Gu, and my grandparents, as well as to all future readers of this dissertation.

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CHAPTER 1

INTRODUCTION

Three key issues have raised wide attention during the Great Recession. They are jobless recoveries in the U.S., the excessive leverage of global banking sector, and sovereign defaults in Europe. This dissertation studies each of them by chapter, yet they are all related to financing, from firms' financial conditions, to banks' borrowing, to countries' debt. Together, they concern about the relation between macroeconomics and finance from different angles.

First, to examine the U.S. jobless recoveries, I ask: how much can firms' financial frictions and firm paid employment benefit costs explain U.S. recent employment movement? This is to study the aggregate employment impact not only of firms' financial conditions but also of the underexplored cyclical employee benefit costs that firms need to pay. I find that both factors have significant effects on the delayed employment recovery timing during the post-1990 period, with financial conditions also stimulating employment volatility. Using dynamic stochastic general equilibrium (DSGE) model, this research generates much better match to employment fluctuation depth and timing than previous works.

It is not only firms' financial conditions that have raised attention during the crises but also banks'. In the second research project, my coauthors Ruud de Mooij, Tigran Poghosyan and I seek to answer: How does corporate taxes affect the capital structure of multinational banks? Previously, many have studied regulatory impact on bank leverage, our work is among the first to examine potential fiscal impact. The reason for taxation to affect any corporate's leverage has to do with a rich literature on debt bias. Due to the deduction of debt interest expenses out of tax base, firms have incentives to raise leverage in a high tax regime. It is particularly interesting for multinational companies, because potentially they can manipulate their subsidiaries' leverage according to host countries' tax rates, in order to save tax payment as a group. We focus our exercise on multinational banks, which is timely relevant to G8 summit's concern on tax evasion.

Last but not least, many advanced countries' government financial status have also called for attention, along with firms' financing constraint and banks' high leverage, especially in Europe. Indeed, the Great Recession has showed us that sovereign debt is closely related to the private sectors as bailout cost can severe sovereign default risks. Given this relation and the rising sovereign debt burden in advanced countries, in the last chapter I build a two-country DSGE model and examine how sovereign default may affect international trade between countries, through post-default currency crisis.

The dissertation is structured as follows. Chapter II presents my study on the U.S. jobless recoveries, Chapter III on multinational banks' leverage, and Chapter IV on sovereign defaults. The data, tables, figures, and technical details are included in the appendix.

CHAPTER 2

FINANCIAL CONDITIONS, BENEFIT COSTS, AND EMPLOYMENT DYNAMICS IN RECENT U.S. RECOVERIES

2.1 Introduction

U.S. employment dynamics have changed significantly since the mid-1980s. This is true for both the depth of declines in employment during recessions, and the timing of its recoveries afterwards. In particular, the left panel of Figure A.1 plots cumulative employment growth for the 15 quarters immediately following NBER business cycle *peaks* into the pre-1990, 1990, 2001 and 2007 recessions, respectively. The 1990 and 2001 downturns suffered employment declines as deep as those in the pre-1990 period, for roughly 3 percent. During the 2007 recession, by contrast, employment plummeted more than twice as much to nearly 8 percent below its previous peak.

Moreover, it has taken longer time in the three most recent recoveries for employment to return to its previous peak level, as shown in Figure A.1 (left). To examine employment recovery timing more closely, the right panel of Figure A.1 plots cumulative employment growth for 10 quarters following NBER business cycle *troughs*. The lowest point on each line is the actual employment trough. In the post-1990 recessions, employment troughs have been reached 3-to-6 quarters later than the NBER business cycle troughs at point zero in the plot, while after previous recessions employment recovered at most one quarter later than output did.[1] Most of the previous studies have not closely replicated

[1]The same conclusion follows when I compare employment troughs with actual output troughs.

these new puzzling phenomena of the employment dynamics in recent U.S. recoveries. In this paper I attempt to make some progress along these dimensions.

This paper's results cover seven NBER business cycles since 1964.[2] I focus on three factors that have contributed to these changes in the post-1990 U.S. employment dynamics: (1) relatively earlier adjustments to per worker hours than to employment, (2) rising employment benefit costs (including health insurance cost) and the cyclicality of those costs, as well as (3) firms' financial conditions.[3] I build a DSGE model with an explicit role for each of the contributing factors. Particularly, the intuition for the employment impact of benefit costs is simple. Majority of the benefit costs (including health insurance, defined benefit plans, paid leaves, etc) are quasi-fixed, that is, they increase with number of workers but not per worker hours, so changes in per worker benefit costs can alter the tradeoff between per worker hours and employment.

During the early stages of a recession, employers decrease per worker hours and cut employee benefits to reduce labor costs while retaining workers (Richtel, 2008; Hallock, Strain and Webber, 2012). However, as the recession deepens, firms eventually have to lay off some employees. In the wake of a recovery, firms' benefit costs rise, they increase per worker hours as a buffer (Schreft, Singh and Hodgson, 2005) but do not hire new workers or even continue firing. Moreover, firms are financially constrained from expanding production and the

[2] The recessions started in 1969, 1973, 1980, 1981, 1990, 2001, and 2007, respectively.

[3] In this paper, financial conditions refer to a trio of financial constraint, shocks and frictions. The financial constraint specifies a firm's borrowing capacity without default, whose tightness can be changed by the financial shocks. The financial frictions reflect the firm's flexibility in adjusting its financial structure under a tighter or looser financial constraint. Other contributing factors to the recent slow employment recoveries may include increasing imports and immigration, declining union, technological progress, job polarization, industry reallocation, economic and policy uncertainties, and slow output growth. However, a survey by the National Federation of Independent Business finds that high health insurance cost is the most significant problem faced by U.S. small businesses in 2008 and 2012 (*The Economist*, 2012).

workforce.

This paper makes four main contributions to the literature. First, I document tighter financial conditions during recent three recoveries comparing to the ones before and study its impact on employment. I find financial conditions significant for both the employment's volatility and its delayed recoveries. Particularly, with the financial conditions alone, my model can generate 2-to-7-quarter delays relative to NBER business cycle troughs for the employment recoveries following the 1990, 2001, and 2007 recessions. But they also produce excessive employment volatilities than data.

My second contribution is documenting the underexplored cyclicality of per worker benefit costs.[4] I show that the cyclical components of benefit costs and employment growth display a positive correlation, and this relationship has been evolving as the benefit costs' trend has soared over the past two decades. Third, I incorporate these *dynamic* benefit costs and their changing relationship with employment growth into my business cycle model and find that they are important mechanisms for capturing the recent sluggish employment recoveries. More specifically, the dynamic benefit costs alone enable my model to deliver 1-to-6-quarter delays relative to NBER business cycle troughs for the employment recoveries following the most recent three recessions.

Last, I put together the two mechanisms, benefit costs and financial con-

[4]This paper does not aim to explain the reasons for the cyclicality of per worker benefit costs, but use this observation. Yet, briefly, from the literature on health insurance underwriting cycles and related premium fluctuations, Kipp, Cookson, and Mattie (2003) find that strong economic growth (as firms seek to attract workers) and prior low reserve investment return during recessions generally accelerate growth in health insurance costs for the private sector at the beginning of recoveries. Also, Brown and Finkelstein (2008) report the substitution effects between public health insurance programs and the private. The former expenditure usually declines during recoveries and is made up by the private sector. These evidence is consistent with my observation.

ditions, enabling the model to generate 3-to-7-quarter delays of employment recoveries for the post-1990 period while generating no delay before that and to deliver more than 76 percent of employment volatility for the post-1990 period. This is in line with the data that has scarcely been matched in the previous literature. Moreover, the model with both mechanisms does not generate excessive employment volatilities and can still explain about 86 percent of the cyclical fluctuation.

The central feature of my model is the pecking order in firms' labor input adjustment decisions between per worker hours and employment. Increasing hours is preferred to increasing employment in the wake of recent recoveries because of the constrained financial conditions, the rising trend in employment benefit costs as well as the pro-cyclicality of those costs. The empirical evidence for this is strong, as shown in the next two subsections.

2.1.1 Per Worker Hours

Figure A.2 (left) shows that indeed per worker hours have recovered earlier than employment has for the post-1990 period, by 1-to-5 quarters, while after previous recessions they always recovered at the same quarter. Additionally, there has been an upward trend in overtime, from 3.3 hours for the pre-1990 period to 4.3 hours since then (Figure A.2, right), which suggests a changing tradeoff between hours and workers such that firms would rather increase per worker hours than hire more workers.[5] Hence, I include both extensive and

[5]However, one may question this insofar as the standard deviation of cyclical per worker hours has declined from 0.0047 before 1990 to 0.0042 since then. But under the Great Moderation, in fact, since 1984, volatility in per worker hours has increased *relative* to that of employment (Barnichon, 2010), and there has been increasing use of per worker hours rather than

intensive labor margins in my model to enable the choice between them.

2.1.2 Financial Conditions

Figure A.3 reflects firms' financial conditions from data. Its top panel shows credit supply, which tightens during recessions and gradually loosens in recent recoveries. The bottom panel depicts for longer period de-facto procyclical credit conditions through debt flows as a percentage of GDP. Overall, financial situations are unpleasant for firms during economic downturns, exhibiting pro-cyclicality. Particularly, during the post-1990 period the financial conditions have worsened more significantly during recessions, and following the 1990 and 2001 recessions, they did not improve very well until two years later. Whereas before 1990s, firms' financial conditions improved much faster right out recessions.

When a firm's financial condition worsens (i.e., borrowing constraint tightens), it could choose to adjust its financial structure by cutting debt and reducing dividends to stock shareholders (Jermann and Quadrini, 2012), or decrease investment and labor costs. However, financial frictions exist regarding the flexibility with which a firm can change its financial structure (Lintner, 1956).[6] Therefore, the firm has to shrink investment and labor cost instead; hence, the financial conditions are related to the real business activities, especially deeper employment declines.[7]

employment as labor input adjustments.

[6]Lintner (1956) shows that managers are concerned about smoothing dividends over time, a fact further confirmed by subsequent studies.

[7]Empirical evidence is found in Sharpe (1994), Nickell and Nicolitsas (1999), Campello, Graham, and Harvey (2010), Benmelech, Bergman, and Seru (2011), and Duygan-Bump, Levkov, and Montoriol-Garriga (2011), Calvo, Coricelli, and Ottonello (2012). However, one may doubt

The financial condition mechanism in my model is exactly as the evidence described above suggests it should be: when a negative innovation to financial conditions (i.e., a negative financial shock) tightens a firm's financial constraint, the firm has to cut its labor cost instead of adjusting its financial structure due to the frictions in the latter.[8] In this respect my paper is closely related to Jermann and Quadrini (2012). However, they focus upon the impact of financial conditions on total hours rather than employment and its recent slow recoveries. In my model, the financial conditions, by themselves (without benefit costs), raise employment volatility too much beyond what is in the data; however, when I factor in the dynamic benefit costs, their impact is smoothed and generates a close match with the employment data. More specifically, the benefit costs prevent employment from adjusting immediately as a response to financial shocks. Altogether, the model explains more than 76 percent of employment volatility.

2.1.3 The Trend and Cyclicality of Benefit Costs

Employment-based benefits no longer represent only a fringe cost. A moderate estimation of benefit costs in real terms topped 14310 USD per employee (25 percent of total compensation) in 2004, from 5134 USD (14 percent) in 1964 (Figure A.4, left). It also has been growing much faster than wages (Figure A.4, right). This relative suppression of wages gives firms an incentive to increase per worker hours more than employment in the wake of recent recover-

how important the financial constraint is for big firms that hoard cash. For them the delay in hiring more workers during recoveries may have to do with self-austerity and factors other than credit, such as the quasi-fixed employment costs.

[8]In the model, financial constraint is an enforcement constraint for borrowing without default, reflecting the firm's capacity to issue bonds from its existing debt and output after deducting investment expenditure. More information can be found in the Model section. Also, I exclude firms' default possibilities throughout the paper.

ies. More importantly, Figure A.5 shows the cyclicality of the real per worker benefit costs (HP-filtered, with a standard deviation of 0.0106), suggesting varying employment-hour tradeoffs during recessions and recoveries. In particular, at the beginning of a recovery, per worker benefit costs rise, increasing the cost of hiring an additional employee relative to the cost of increasing per worker hours.

Figure A.5 also displays a positive correlation between the cyclical components of per worker benefit costs and employment growth.[9] Benefit costs move above its trend at about the same time employment growth does. Based on this observation, I quantify the per worker benefit costs using a dynamic function of labor market employment growth in my model, where better (or worse) labor market conditions (additional (or less) employment) increases (or decreases) the marginal benefit costs today but decreases (increases) the costs in the next period. This generates an incentive for expanding firms to keep hiring into the beginning of a recession while shrinking firms continue firing into the wake of a recovery, which is in line with data. This is one of the two main mechanisms (the other is financial conditions) in my model for generating the post-1990 slow employment recoveries.

Furthermore, from Figure A.5 we can see that after 1989 the same percentage increases above the trend of per worker benefit costs appear to correspond with lower positive employment growth. Intuitively, this is consistent with the fact that the level of benefit costs has been trending upwards: the same percentage increase above their higher trend results in a larger rise in the dollar value of the benefit costs and a heavier burden on firms to hire new workers, which

[9] See Parameterization section and Figure A.8 for a more precise measure of their correlation.

discourages employment growth.[10] In the model calibration, to measure this change quantitatively, I estimate the positive relationship between the cyclical components of per worker benefit costs and employment growth using OLS, and show that indeed it has evolved since 1990 as indicated by Figure A.5.[11] Therefore, given the benefit costs' trend and changing cyclical relationship with employment growth, I employ different parameter values of the benefit costs and of the cyclical benefit-employment relationship for the pre-1990 and post-1990 periods. Together with financial conditions, they are the key to my model's ability to use the same mechanism to deliver the delayed employment recoveries in the post-1990 period but not before.

The benefit cost mechanism employed in this paper share some similarities with DeLoach and Platania (2008) and Bachmann (2009). My model substantially differs, however, in two important dimensions. First, the benefit costs considered in my firms' labor input decisions are *dynamic*, reflecting endogenous employment changes. This generates significantly slower aggregate employment adjustments as in the data than a fixed or stochastic labor adjustment cost can in the existing literature. Second, I further incorporate financial conditions that interact with benefit costs. Even though the benefit costs alone (with productivity shocks) can allow the model to explain up to 49 percent of employment volatility for the post-1990 period, the volatility result is greatly strengthened when I include financial conditions, since they have been playing an increasingly crucial role in affecting real activities such as production and employment (Duygan-Bump, Levkov, and Montoriol-Garriga, 2011; Calvo, Coricelli, and Ottonello, 2012).

[10] Throughout this paper, I assume that all workers receive benefits once they are hired. An extension can be made to ease this assumption.

[11] See Parameterization section for more details.

The paper is structured as follows. Since employment benefit costs are less familiar to macroeconomists in general, section II presents additional empirical facts pertaining to quasi-fixed employment costs, i.e. the more general overall costs that include benefit costs as well as others which are associated with employment. In the same section, I also provide a brief theoretical literature review on recent slow employment recoveries. Section III proposes a simple DSGE model that includes firms' dynamic benefit costs, financial conditions, and the tradeoff between extensive and intensive labor margins. Section IV studies the quantitative properties of the model, and Section V concludes.

2.2 Quasi-fixed Employment Costs and Theoretical Literature Review

2.2.1 Quasi-fixed Employment Costs

Benefit costs are only part of the story for the overall costs that are associated with employment. More generally, quasi-fixed employment costs are the portions of labor cost that increase with the number of workers but not per worker hours. They include costs from hiring, firing, employment-based benefits, and training.[12] In fact, the mechanism employed by my model precisely applies to reoccurring quasi-fixed employment costs that vary with net employment, i.e., benefits and training costs; the former, as shown in the previous section, is easier to measure. Benefit costs are composed of the items in Table A.1. Health and

[12] Benefits and training vary with the net number of workers, while hiring and firing vary with the gross amount. They also have different frequencies of reoccurrences.

life insurance is the largest component in benefit costs and is quasi-fixed. But, not all of the benefit costs are purely quasi-fixed, about 60 percent is (Ehrenberg and Smith, 2012). However, even for the benefit costs that are not purely quasi-fixed, such as defined contribution plans and social security, it rises more rapidly with new hires than with increased hours. In the model calibration, I consider all of the benefit costs as purely quasi-fixed.

Recall Figure A.4, benefit costs have been increasing over the past several decades. In fact, they are not the only quasi-fixed employment costs that have been rising. According to Oi (1962) and Manning (2010), in 1951 hiring and training costs in the U.S. equal about 5.4-7.3 percent of the wages. More recently, from the employee results of the BLS 1995 Survey of Employer Provided Training, I calculate workers' training cost to be about 9 percent of total wages.[13] Manning (2010), using the results from Barron, Berger and Black (1997), also estimates that the training cost is within the range of 34-156 percent of monthly payment for U.S. firms between 1980 and 1993.

In addition, there has been evidence for the cyclical behavior of other quasi-fixed employment costs besides the benefit costs. Bils (1987) infers that the marginal employment adjustment cost is cyclical. Majumdar (2007) finds that the probability that U.S. workers receive company training is procyclical. Blatter, Muehlemann, and Schenker (2012) confirm that the hiring cost depends on macroeconomic conditions: a one-percentage-point increase in the unemployment rate reduces average hiring costs by more than five percent.[14] This paper calibrates both the benefit costs and the general quasi-fixed employment costs (i.e., the benefit costs and the training cost) to use them in the model.

[13]See Parameterization section for more details about my calculation.
[14]For a thorough review, refer to Brunello (2009).

The extant empirical literature supports the position that quasi-fixed employment costs affect labor structure, leading firms to increase per worker hours and deter employment growth (Ehrenberg, 1971; Ehrenberg and Schumann, 1982; Gruber, 1994; Beaulieu, 1995; Gruber, 2000; Reber and Tyson, 2004; and Baicker and Chandra, 2005). In particular, Cutler and Madrian (1998) show that rising health insurance costs have increased the hours worked by up to 3 percent. More recently, Baicker and Chandra (2006) find that a 10-percent increase in health insurance premiums reduces the probability of being employed by 1.2 percentage points.

However, opponents may argue that employers can respond to the quasi-fixed employment cost increases by reducing wages, assuming no rigidity (Summers, 1989). But, as Currie and Madrian (1999) conclude, little empirical evidence suggests that a tradeoff between health insurance costs and wages exists. Anand (2011) also finds that the pass-through of a health insurance cost increase from firms to workers is only partial. Consequently, firms are forced to absorb some of the cost increase. Moreover, even if the quasi-fixed employment cost increase is offset by wage reductions, it still alters the tradeoff that firms face in allocating employment and per worker hours, leading them to substitute workers for additional hours (Cutler and Madrian, 1998).

2.2.2 Theoretical Literature Review

I categorize theoretical work pertaining the recent slow employment recoveries into three groups. The first group, which is closely related to mine, argues that the problem is rooted in the labor market itself. Causes include employment-based health insurance costs (DeLoach and Platania, 2008),[15] employment adjustment costs and increasing use of flexible work hours with over-time (Bachmann, 2009),[16] wage rigidity (Shimer, 2010), and the disciplinary role of unemployment that serves to increase employees' working effort (Riggi, 2012).[17] The second group believes that other non-labor conditions inevitably change, such as technology progresses and production restructuring, and it takes time for the labor market to adapt. Those changes include time-consuming technology diffusion (Andolfatto and MacDonald, 2006), increasing capital-labor complementarity (Cantore, Levine, and Melina, 2011), firm restructuring and labor productivity surges (Berger, 2012), job polarization (Jaimovich and Siu, 2012), and industry reallocation (Garin, Pries, and Sims, 2011).[18] However, few existing papers provide convincing empirical support for their theories while at the same time delivering good results matching with the data.

The third perspective claims that the prolonged employment loss is simply due to slow output recoveries in the post-1990 period, because there seems to be no significant change in the output-employment relationship (Gali, Smets and Wouters, 2012). To evaluate this finding, Figure A.6 shows that while 2007 finan-

[15]My paper differs from DeLoach and Platania (2008) in the use of *dynamic* benefit costs rather than a fixed cost as well as my inclusion of financial conditions.

[16]Unlike my dynamic benefit costs associated with *endogenous* employment growth, Bachmann (2009) uses a *stochastic* employment adjustment cost. It also does not include capital or financial conditions and finds no good match for employment in deeper recessions such as the one in 2007.

[17]For Shimer (2010), it is still ambiguous in the empirical literature whether wages really have become more rigid in recent decades (Haefke, Sonntag, and van Rens, 2009; and Kudlyak, 2010). Riggi (2012)'s theory fails to explain why the recent three employment recoveries have been different from before.

[18]Cantore, Levine, and Melina (2011) do not offer much empirical evidence to support their assumption of increasing capital-labor complementarity. With surging labor productivity, Berger (2012) cannot explain the fact that firms not only do not hire new workers but also continue *laying off* workers *into* recent recoveries. Also, Manovskii and Bruegemann (2010) show evidence against Berger's assumption of changing labor productivity during the recent two decades. Regarding industry reallocation, controversial empirical evidence has emerged on this argument (Aaronson, Rissman, and Sullivan, 2004; Groshen and Potter, 2003; and Lilien, 1982).

cial crisis suffered the deepest output decline and has experienced the slowest recovery, the 1990 and 2001 recessions were followed by output recoveries as fast as the average of the pre-1990 period. However, recall that in Figure A.1 the employment recoveries from the 1990 and 2001 recessions are shown to have been delayed significantly compared with the pre-1990 period. Therefore, factors other than slow output recoveries should also have driven the sluggish employment recoveries, at least following the 1990 and 2001 recessions. Moreover, the correlation between average cumulative growth of employment and that of output following NBER business cycle peaks is 0.95 before 1990, but it drops to merely 0.41 after 1990.[19] The relationship between output and employment indeed has changed. Yet, the slow output recoveries may still contribute to the slow employment recoveries; however, since output and employment are endogenous, it is difficult to untangle how much of the former may actually be caused by the latter, as well as the other way around.

2.3 Model

This section introduces intensive and extensive labor margins, dynamic benefit costs, and financial conditions to the standard business cycle model. I start with the description of the environment in which a representative firm operates, as this is where my model diverges from the standard one. Then I present the representative household and define general equilibrium.

[19]Cumulative employment growth for 15 quarters following each NBER business cycle peak since 1964 is calculated (except for the short 1980 recession). Then, together they are averaged over the pre-1990 and post-1990 cycles, respectively. The same is done for output.

2.3.1 Firm

Assume there is a representative firm, with a production function $F(z, k, n, h_f) = zk^{1-\theta}[an^{\gamma} + (1-a)h_f^{\gamma}]^{\frac{\theta}{\gamma}}$. The variable z is the stochastic level of productivity, k is capital input, n is employment, and h_f is hours per worker. Both k and n are predetermined, while h_f can be changed at the present time. Capital evolves according to $k' = (1-\delta)k + i$, where k' is next-period capital stock, i is investment and δ is depreciation rate.

In the model's production function, employment and per worker hours are embedded in a general CES function, which is nested in a Cobb-Douglas function with capital. This captures the idea that while capital is a substitute for labor input, the substitutability between employment and per worker hours is flexible. As Feldstein (1967) and Rosen (1968) note, the assumption that employment and hours worked enter the production function multiplicatively (i.e., nh_f) may not be a good one. For example, lengthening per worker hours may have diminishing returns because of increased fatigue; rising employment does not increase fatigue but typically dilutes the capital-to-labor ratio. Therefore, adding per worker hours by a given percentage may affect output differently than increasing the number of workers by the same percentage (Bernanke, 1986). Following a general specification as in Bernanke (1986), I choose the CES function for labor inputs.[20]

Apart from wages, the firm also has to pay benefit costs, $\phi \cdot (n'/n)^g$, for each worker hired next period. Importantly, the per worker benefit costs are driven by market forces, each individual firm has no power in influencing them. But

[20]Perri and Quadrini (2011) also use a CES formulation for hours and labor utilization, similar to this paper.

since this is a representative model all firms behave the same, together they determine the benefit costs per worker. In other words, the benefit cost mechanism is exogenous to individual firms but at the same time endogenous to the overall market. Here, n' is tomorrow's employment, and ϕ is steady-state per worker benefit costs. In fact, more precisely, ϕ should be the calibrated parameter for the steady state of overall quasi-fixed employment costs, which ideally include quasi-fixed benefit costs, training cost, and other reoccurring quasi-fixed employment costs. The formulation of $(n'/n)^g$ is rooted in the observed positive correlation between the cyclical components of benefit costs and employment growth, as shown in Figure A.5. g is the parameter for the endogenous relationship between them.[21]

Together, $\phi \cdot (n'/n)^g$ produces an above-trend per worker benefit costs when employment increases and below-trend benefit costs when employment decreases, consistent with the data, as shown in Figure A.5. Varying values of ϕ and g can capture the rising trend of benefit costs and the changed relationship between the cyclical components of benefit costs and employment growth. That is, with the same percentage increase above the trend of benefit costs at the beginning of a recovery, employment grows by smaller steps in the post-1990 period than it did before, i.e. g becomes larger in the post-1990 period.

More importantly, the benefit costs $\phi \cdot (n'/n)^g$ delay employment adjustments in a dynamic fashion. If firms are firing, a decrease in the next period employment n' lowers their per worker benefit costs, i.e., the marginal benefit of further firing in the current period – so the firms will have less incentive to lay off too many workers right away. But next period, as n' becomes n, the previous employment decrease will relatively raise the marginal benefit of firing – so the

[21]See Parameterization section for more precise measure of their relationship.

firm will continue firing in near future. That is to say, the smaller a firm becomes today, the more it shrinks tomorrow. Intuitively, after laying off workers through a recession, at the beginning of a recovery, firms may continue reducing employment due to the relatively high benefit from firing. In this sense, the dynamic benefit cost formulation captures the notion of employment adjustment formation: rather than adjusting a lumpy amount, aggregate employment changes bit by bit, and the adjustment duration is amplified by extended layoff into output recoveries and continued hiring into output recessions, as in the data.

An alternative way to interpret the per worker benefit cost formulation is that the total benefit costs $n'[\phi \cdot (n'/n)^g]$ exhibit convexity. It is expensive for a firm to recruit a large number of workers at once. In contrast, if the firm faces non-convex employment costs, then the optimal response to a large productivity shock is to adjust employment immediately. However, this is not the case for recent aggregate employment recoveries.[22] The dynamic benefit costs are one of the two main mechanisms in my model for matching recent slow recoveries of employment.

The firm also uses equity and debt. Equity payout to investors is denoted by d. Since firms tend to keep a steady stream of dividend flow and find it costly to adjustment equity payout (Lintner, 1956; and Jermann and Quadrini, 2012), I assume in the model that dividend changes are subject to a quadratic adjustment cost. Therefore, the actual dividend cost for the firm is $\varphi(d) = d + \kappa(d - \overline{d})^2$, where parameter $\kappa \geq 0$, and $\overline{d}$ is the long-run dividend payout target (steady

[22] Firm-level data seem to show lumpy employment adjustments. But this paper is using a representative firm to capture aggregate employment, which includes all firms' non-simultaneous employment adjustments and entails gradual adjustments. It would be interesting to use a heterogeneous-firm model to study lumpy employment adjustments for each firm while the aggregate changes remain gradual.

state). The firm's debt, denoted by b_f, is preferred to equity because of its tax advantage (i.e., debt bias).[23] This is also the assumption made in Hennessy and Whited (2005) and Jermann and Quadrini (2012). Given market interest rate r, the *effective* gross interest rate for the firm is $R = 1 + r(1 - \tau)$, where τ represents the tax discount.

Using its new debt issues $\frac{b'_f}{R}$, the firm partially pays its labor cost, investment, stock shareholders and lenders, but promises to pay the rest upon the realization of output revenue $F(z, k, n, h_f)$. After production, the firm chooses to repay by an amount that is exactly equal to $F(z, k, n, h_f)$ according to its budge constraint, or to default by the same amount:[24]

$$\frac{b'_f}{R} + F(z, k, n, h_f) = k' - (1 - \delta)k + nwh_f + n'[\phi(\frac{n'}{n})^g] + b_f + \varphi(d) \tag{2.1}$$

where the variable w is the hourly wage rate.

In case of a default, the assets left for creditors to take is the market value of the firm's capital stock after deducting its new borrowing, that is, $\varepsilon(k' - \frac{b'_f}{R})$ with ε being a market evaluation factor. Therefore, the firm would never choose to default if the market value of assets left for creditors to take is larger than its default amount, i.e., the firm is subject to the enforcement constraint:[25]

$$\varepsilon(k' - \frac{b'_f}{R}) \geqslant F(z, k, n, h_f). \tag{2.2}$$

On the one hand, higher debt and expanding production make the enforcement constraint tighter. On the other hand, higher capital stocks relax the constraint. These properties are shared by most of the enforcement or collateral

[23]See De Mooij (2011) for a comprehensive survey on debt bias.

[24]Another way to interpret this can be found in Jermann and Quadrini (2012).

[25]The assets of the firm can also be considered as a collateral, and their value constrains the borrowing capacity of the firm.

constraints used in the literature (Jermann and Quadrini, 2012). ε is stochastic and depends on market conditions. Because this variable affects the tightness of the enforcement constraint and, thus, the borrowing capacity of the firm, I refer to its stochastic innovations as *financial shocks*. Therefore, I have two sources of aggregate uncertainty: the productivity, z, and the financial condition, ε.

To see more clearly how ε affects the financial and production decisions of the firm, I rewrite the enforcement constraint Equation 2.2, using the budget constraint from Equation 2.1 to eliminate $k' - \frac{b'_f}{R}$:

$$\frac{\varepsilon}{1-\varepsilon}[(1-\delta)k - nwh_f - n'\phi(\frac{n'}{n})^g - b_f - d - \kappa(d-\overline{d})^2] \geqslant F(z,k,n,h_f) \tag{2.3}$$

At the beginning of each period, k, b_f and n are given. The only variables that are under the control of the firm are the per worker hours, h_f, the next-period employment, n', and the equity payout, d. Therefore, suppose the enforcement constraint is binding and the firm wishes to keep the production plan unchanged, a negative financial shock (lower ε) requires a reduction in the per worker hours, h_f, the next period employment, n', or the equity payout, d. However, since d is rigid to reduce due to the dividend adjustment cost, the firm has to cut the per worker hours, h_f, or the next-period employment, n'. But between the two, employment adjustment is delayed because of the dynamic benefit costs. Therefore, the firm will first resort to per worker hours, h_f.

Furthermore, a reduction in the per worker hours, in turn, increases the firm's desire to pay a lower wage for additional hours worked. As the hourly wage drops, it deters the firm from hiring new workers because hours become *relatively* cheaper than workers given that quasi-fixed employment costs remain unchanged. Therefore, wage movements also work like an endogenized cyclical adjustment cost.

Now I write the firm's problem recursively. The endogenous states are the capital stock k, the employment n, and the debt b_f. The exogenous aggregate states are the productivity z and the financial conditions ε. The firm chooses its per worker hours h_f, dividends d, next-period employment n', capital k', and debt b'_f. The optimization problem is subject to its budget and financial constraints.

$$V(z, \varepsilon, k, n, b_f) = \max_{h_f, d, k', n', b'_f} \left\{ d + Em'V(z', \varepsilon', k', n', b'_f) \right\} \tag{2.4}$$

subject to

$$\frac{b'_f}{R} + F(z, k, n, h_f) = k' - (1 - \delta)k + nwh_f + n'[\phi \cdot (\frac{n'}{n})^g] + b_f + \varphi(d) \tag{2.5}$$

$$\varepsilon(k' - \frac{b'_f}{R}) \geqslant F(z, k, n, h_f) \tag{2.6}$$

in which $\varphi(d) = d + \kappa(d - \overline{d})^2$, $F(z, k, n, h_f) = zk^{1-\theta}[an^\gamma + (1-a)h_f^\gamma]^{\frac{\theta}{\gamma}}$, and $R = 1 + r(1 - \tau)$.

Function $V(z, \varepsilon, k, n, b_f)$ is the cumulative-dividend market value of the firm, and m' is its stochastic discount factor. The stochastic discount factor, wage and interest rate are determined in the general equilibrium and are taken as given by the firm.

Denoting the Lagrange multiplier associated with the enforcement constraint by μ, the first-order conditions for h_f, n', k', and b'_f are:

$$F_h(z, k, n, h_f) = \frac{wn}{1 - \mu\varphi_d(d)} \tag{2.7}$$

$$Em' \frac{\varphi_d(d)}{\varphi_d(d')}[(1 - u'\varphi_d(d'))F_n(z', k', n', h'_f) - w'h'] = \phi(\frac{n'}{n})^g \tag{2.8}$$

$$Em'\frac{\varphi_d(d)}{\varphi_d(d')}[1-\delta+(1-u'\varphi_d(d'))F_k(z',k',n',h'_f)]+\varepsilon\mu\varphi_d(d)=1; \tag{2.9}$$

$$REm'\frac{\varphi_d(d)}{\varphi_d(d')}+\varepsilon\mu\varphi_d(d)=1 \tag{2.10}$$

Especially important here is the optimality condition for h_f, Equation 2.7. As usual, the marginal productivity of hours is equalized to its marginal cost. The marginal cost is all workers' hourly wages augmented by a wedge that depends on the *effective* tightness of the enforcement constraint, $\mu\varphi_d(d)$. A tighter constraint (i.e., higher μ) increases the effective costs of per worker hours and reduces its demand. Additionally, from Equations 2.9 and 2.10, it is clear that there is a negative relationship between ε and the constraint's multiplier μ. In other words, a negative financial shock to ε makes the multiplier μ higher, the enforcement constraint tighter, and thus the demand for per worker hours lower. Therefore, the main channel through which financial shocks are transmitted to the real economy is labor demand, particularly by affecting the per worker hours before the employment.

2.3.2 Household, Government and General Equilibrium

Assume there is a representative household maximizing its expected lifetime utility V_h subject to its budget. The household is the stock and bond shareholder of the firm. Its optimization problem is shown recursively below. The household chooses hours it would like to work h_h, consumption c, stock and bond shares to hold next period, s' and b'_h. The household takes stock price q, interest rate r, employment n, wage w, and tax as given.

$$V_h(s, b_h) = \max_{h_h, c, s', b'_h} \{U(c, n, h_h) + \beta E V_h(s', b'_h)\} \tag{2.11}$$

subject to

$$wnh_h + b_h + s(d + q) = c + tax + \frac{b'_h}{1 + r} + s'q \tag{2.12}$$

The household's utility function takes the form of $U(c, n, h_h) = \ln c + n\alpha \ln(1 - h_h) + n'[\phi(\frac{n'}{n})^g]$. Notice that the household's disutility towards working applies only to those who are employed, and benefits contribute to the entire household's utility but are not counted as a part of disposable income in the budget. The first-order conditions with respect to h_h, b_h, and s' are:

$$wnU_c(c, n, h_h) + U_{h_h}(c, n, h_h) = 0 \tag{2.13}$$

$$U_c(c, n, h_h) = \beta \frac{R - \tau}{1 - \tau} EU_c(c', n', h'_h) \tag{2.14}$$

$$U_c(c, n, h_h)q = \beta E(d' + q')U_c(c', n', h'_h) \tag{2.15}$$

The first two conditions determine the supply of hours and the interest rate. The last condition determines the prices of shares. Using forward substitution I derive:

$$q_t = E_t \sum_{i=1}^{\infty} \beta^i \frac{U_c(c_{t+i}, n_{t+i}, h_{h,t+i})}{U_c(c_t, n_t, h_{h,t})} d_{t+i} \tag{2.16}$$

The firm's optimization is consistent with that of the household. Therefore, its stochastic discount factor is $m' = \beta U_{c'}/U_c$.

Government collects tax from the household to subsidize the firm's borrowing. B is the total borrowing in the economy by the firm, and the government takes it as given.

$$tax = \frac{B'}{R} - \frac{B'}{1+r} \tag{2.17}$$

In equilibrium, all markets clear when $b_h = b_f = B$, $s = 1$, $h_f = h_h$, and $c = F(z, k, n, h_f) - k' + (1-\delta)k - n'[\phi(\frac{n'}{n})^g] - \kappa(d - \overline{d})^2$. I can now provide the definition of a general equilibrium. The aggregate states are the productivity z, the financial condition ε, the capital k, the bond b, and the employment n.

Definition 1. *A recursive competitive equilibrium is defined as a set of functions for (i) a household's policies s, c, h_h, and b'_h; (ii) a firm's policies d, h_f, n', k', and b'_f; (iii) the firm's value $V(z, \varepsilon; k, b_f, n)$; (iv) aggregate prices w, r, and m'; and (v) law of motion for the aggregate states, such that: (i) the household's policies satisfy Equations 2.13, 2.14, and 2.15 ; (ii) the firm's policies are optimal; (iii) the firm's $V(z, \varepsilon; k, b_f, n)$ satisfies Bellman's Equation 2.4; (iv) the w and r clear the labor and bond markets and $m' = \beta U_{c'}/U_c$; and (v) the law of motion is consistent with the stochastic processes of z and ε.*

The equilibrium shares some of the same characterization as in Jermann and Quadrini (2012). First, if $\tau > 0$, the enforcement constraint binds in a steady state. Second, with $\tau = 0$ and $\kappa = 0$, changes in ε have no effect on firms' labor and investment decisions. Thus, when $\tau = 0$ and $\kappa = 0$, business cycle fluctuations are driven only by productivity. The model becomes a real business cycle model, where firms are indifferent between debt and equity but still distinguish between hours per worker and employment choices.[26]

[26] It is not difficult to prove the equilibrium characterization from Equation 2.10 and Equation 2.14, see Jermann and Quadrini (2012).

2.4 Quantitative Analysis

The goal of this section is to evaluate the quantitative effects of the cyclical benefit costs mechanism and the financial conditions. Their macroeconomic impacts are captured by the responses of the model to estimated productivity and financial shocks. Results show that the cyclical benefit costs and financial conditions are crucial not only for employment volatility but also for its recent slow recoveries. Yet, the finding does not mean that other economic factors and shocks are not of significance to the U.S. employment dynamics.

2.4.1 Computation

I use numerical methods since the model cannot be solved analytically. I approximate the conditional expectations in Equations 2.4, 2.8, 2.9, 2.10 and 2.14 nonlinearly, with piecewise-linear functions that interpolate linearly between the grid points of a five-dimensional state space $(z, \varepsilon, k, n, b)$. Starting with initial guesses for the conditional expectations at each grid point, I can compute all variables of interest by solving a system of nonlinear equations, with the Garcia and Zangwill (1981) technique assuming that the enforcement constraint only binds occasionally.[27]

At the same time, I make sure that the system of the nonlinear equations at each grid point is truly solved by checking the reasons that the solving algorithm terminates. Once I have solved the equation system for all the grid points, I update the guesses for the conditional expectations through Gauss-

[27]With uncertainty, the constraint may not be always binding as in steady state, because the firm could reduce its borrowing in anticipation of future shocks.

Hermit Quadrature (z and ε are lognormal) and keep iterating until the changes in all policy functions convergence at 0.001. There are 10 grid points in total for each endogenous state of k, n and b, and 5 for each exogenous state of z and ε.[28]

2.4.2 Parameterization

The period in the model is a quarter from 1964Q1-2010Q4. Some parameters can be calibrated using steady-state targets, several of which are typical in the business cycle literature. The others, such as benefit cost function parameter g, stochastic shocks, and dividend adjustment cost parameter κ, cannot be calibrated using such targets, since they do not matter in a steady state.

I set $\beta = 0.9798$, implying that the annual steady-state market interest rate is 8.49 percent. Utility function parameter $\alpha = 1.2285$ is chosen to have steady-state per worker hours equal to $\frac{1}{3}$. Labor share in the production function is set to $\theta = 0.7213$. Within labor input, employment share $a = 0.8428$ and the elasticity parameter of the substitution between the hours and the employment is chosen to be $\gamma = -2$ so that steady-state employment is at $\frac{2}{3}$ and the per worker hours and the employment are complements (Konig and Pohlmeier, 1989). The depreciation rate $\delta = 0.0250$.

The tax wedge is set to $\tau = 0.3500$, which is also used by Jermann and Quadrini (2012). The mean value of the financial conditions $\bar{\varepsilon} = 0.1989$ is chosen to match a steady-state ratio of debt over quarterly GDP equal to about 4. This is the average ratio during the period 1964Q1-2010Q4 for the nonfinancial business sector based on the data from the Flow of Funds Accounts (for debt)

[28]Matlab R2012b and Fortran are used in the computation.

and National Income and Product Accounts (for GDP). At the same time, the steady-state ratio of capital stock over quarterly GDP equals to about 8 as in the data average for 1964Q1-2010Q4 as well.

Next, I calibrate parameters ϕ and g, which are unique and important to this model. It is clear that ϕ is the steady-state value of the benefit costs, or more precisely, the steady-state value of the quasi-fixed employment costs. Table A.2 summarizes the possible range for the quasi-fixed employment costs as a percentage of total wages.[29] The benefit cost data come from the same three sources as in Figure A.7: NIPA, Chamber of Commerce, and BLS. NIPA gives the minimum benefit cost share and BLS gives the highest for the pre-1990 and post-1990 periods in Table A.2. The average benefit cost shares are calculated as the average of all three sources. A more detailed description of the data sources is provided in the Appendix.

The training cost estimate for the pre-1990 period comes from Oi (1962) and Manning (2010, Table 2); and its post-1990 period estimate is from BLS (1995) and Manning (2010, Table 2). According to Oi (1962) and Manning (2010, Table 2), in 1951 the hiring and training costs in the U.S. equal about 5.4-7.3 percent of the wage cost, out of which 7 percent is directly used as the pre-1990 period training cost share in my Table A.2. Manning (2010)'s Table 2 also reports his training cost estimate from Barron, Berger and Black (1997), which is 34-156 percent of monthly pay for U.S. firms between 1980 and 1993. BLS's Reports on Employer-Provided Training for 1995 conclude that employees who work in establishments with 50 or more workers received an average of 44.5 hours of

[29]Notice they are not calculated in terms of total compensation, since once I include other quasi-fixed costs such as the training costs, it is more convenient to calculate the ratios in terms of wages, as the total compensation becomes less clearly defined.

training in the period May-October 1995.[30] Accordingly, I calculate the training cost to be 9 percent of the total wages by dividing BLS 44.5 hours by two quarters of hours worked, assuming 40 hours per week, and then multiplying two, which is assumed to be the relative cost of trainers' wage and trainees' opportunity cost over wage. Therefore, in Table A.2 for the post-1990 period, the minimum training cost share is my estimated 9 percent of the total wages from BLS, the maximum is 156 percent according to Manning (2010), and the average is calculated from all three numbers – 9 percent from BLS, and 34 percent and 156 percent from Manning (2010). The total quasi-fixed employment cost shares are the sums of the benefit costs and the training cost.

From the costs shown in Table A.2, this paper uses two sets of them, the average benefit costs and the maximum total, as the value of ϕ to put into the model. For the pre-1990 period, I take ϕ as the average benefit costs, 26 percent of total wages, and as the maximum quasi-fixed costs, 44 percent. For the post-1990 period, the average benefit costs of 33 percent of total wages and the maximum quasi-fixed costs of 194 percent are used for ϕ.[31] The larger ϕ for the post-1990 period reflects a higher steady-state benefit costs and hence a higher sensitivity of the benefit costs to employment changes during the time. This, in turn, will allow the benefit costs to affects the employment more significantly in the post-1990 period than before.

In addition, it remains to estimate the endogenous relationship between the cyclical components of employment growth and benefit costs to obtain the parameter value for g in the benefit cost function $\phi(\frac{n'}{n})^g$. I take the log form of the benefit cost function and make the following transformation:

[30] Accessed at http://www.bls.gov/news.release/sept.nws.htm on September 30th, 2012.

[31] DeLoach and Platania (2008) use 32.2 percent of total compensation, i.e., 47.5 percent of total wages, as the steady-state value of health insurance cost.

$$\log Benefit - \log \phi = g[\log(\frac{n'}{n}) - log(\frac{\overline{n}}{\overline{\overline{n}}})] \quad (2.18)$$

It is clear that the cyclical components of the benefit costs equal the cyclical part of employment growth multiplied by g. Therefore, to estimate g, I detrend logged real per worker benefit costs by HP filter, and plot it against the HP-filtered logged employment growth, then run a simple OLS to regress the former on the latter. Figure A.8 presents a good idea of how the two are related.

First, the detrended benefit costs are strongly positively associated with the detrended employment growth, as is the benefit function form I presumed earlier. Second, the relationship between the two indeed has changed over the past two decades. I estimate that before 1990 $g = 0.7016$ and after 1990 $g = 1.3523$. The larger g for the post-1990 period indicates that the benefit costs are more sensitive to the employment changes (consistent with Figure A.5) and in turn affects the employment more effectively than it did before 1990. One caveat is that since the benefit costs and the employment are endogenous, the OLS used here may be subject to the problem of endogeneity. However, I regressed the benefit costs on lagged employment growth, and the message remains the same, that is, g increased for the period after 1990. In order to match the model function form, I use the estimation results for g obtained from the original OLS regressions in Figure A.8.

For the productivity z, I follow the standard Solow residuals approach and compute the stochastic technology process using the log-linearized production function. To construct the financial conditions ε, I follow a similar procedure but use the enforcement constraint under the assumption that it is always binding, that is, $\varepsilon_t(k_{t+1} - \frac{b_{t+1}}{R_t}) = y_t$. The linearized version of this constraint can be written as $\hat{\varepsilon}_t = \phi_k \hat{k}_{t+1} + \phi_b \hat{Br}_{t+1} + \hat{y}_t$, where $Br_{t+1} = \frac{b_{t+1}}{R_t}$, $\phi_k = -\bar{\varepsilon}\frac{\bar{k}}{\bar{y}}$, and $\phi_b = \bar{\varepsilon}\frac{\overline{Br}}{\bar{y}}$.[32] The hat sign denotes percentage deviations from the deterministic trend, and the bar sign denotes the steady-state values. $\hat{\varepsilon}_t$ reflects firms' capacity to issue debt from their existing debt and output after deducting investment expenditure. Figure A.9 plots the financial conditions ε_t. The volatility of financial conditions does not change much for the entire period; but there has been more enduring financial tightening during the recovery periods following the post-1990 recessions.

After constructing the series of the productivity and the financial conditions, I estimate the autoregressive system:

$$\begin{pmatrix} \widehat{z_{t+1}} \\ \widehat{\varepsilon_{t+1}} \end{pmatrix} = A \begin{pmatrix} \hat{z}_t \\ \hat{\varepsilon}_t \end{pmatrix} + \begin{pmatrix} e_{z,t+1} \\ e_{\varepsilon,t+1} \end{pmatrix} \tag{2.19}$$

where $e_{z,t+1}$ and $e_{\varepsilon,t+1}$ are i.i.d. with standard deviations σ_z and σ_ε, respectively. At this point, it is only the dividend adjustment cost parameter κ that remains to be calibrated. It is chosen so that the standard deviation of model-generated equity-payout-to-output ratio is at least as large as that of the data over the period 1964Q1-2010Q4 (0.1057). In practice, the different values of ϕ used in this paper affect the standard deviation of model-generated equity-payout-to-output ratio, I use $\kappa = 5$ to have the standard deviations fall into the desired range according to the data.[33] The full set of parameters is reported in Table A.3.

[32] With steady-state targets, I determine the coefficients $\phi_k = -2.1128$ and $\phi_b = 1.1128$. I then use the above equation to construct the time series with empirical measurements for the end-of-period capital, $\widehat{k_{t+1}}$, the end-of-period liabilities, $\widehat{Br_{t+1}}$, and output $\hat{y}_t$, which can be easily obtained through detrending the data.

[33] Notice that the standard deviation of model-generated equity-payout-to-output ratio is actually larger than that of the data, which indicates the model has a potential to generate larger employment volatility.

2.4.3 Findings

Figure A.10 plots the model results for the post-1990 period using $g_{post90} = 1.3523$ and $\phi_{post90max} = 0.4527$, with cyclical employment data. To highlight the importance of the model mechanisms, the figure also reports the responses generated by the standard model without benefit costs or financial conditions, which is obtained by eliminating the dividend payout adjustment cost, the bond market and the benefit costs from my model. Clockwise, the first three subplots graph the results from my full model, from the model with the benefit costs but no financial conditions (i.e., only productivity shocks, $\tau = 0$, and $\kappa = 0$), and from the model with the financial conditions but no benefit costs, while the fourth subplot compares the results of all three model scenarios.[34] A quick glimpse of the plots tells us that both benefit costs and financial conditions have contributed significantly to the delayed employment recoveries and employment volatilities. The full model is able to generate a much closer match with the data in terms of both dimensions of the employment dynamics, than the standard model can.

From the subsequent subplot of *Benefit Cost Only* in Figure A.10, it is clear that the benefit cost mechanism alone has contributed significantly to the delayed timing of employment recoveries. The model-generated employment troughs for 2001 and 2007 recessions are in line with those of the data. This is due to the larger benefit cost increases at the beginning of the recent recoveries during the post-1990 period. Yet, Figure A.10 also shows that the benefit cost mechanism stimulates the employment volatility just as much as the standard

[34]In this section, to keep the terminology simple, I refer to the quasi-fixed employment costs as the benefit costs too. But keep in mind, ϕ_{max} actually represents the quasi-fixed employment costs, and ϕ_{ave} is the benefit costs.

model can. In fact, the benefit costs alone (with productivity shocks) explain 49 percent of employment volatility, marginally larger than the standard model can. To improve this, here comes the role of financial conditions.

Looking at the subplot of the results from the model with *Financial Conditions Only*, I find that the financial conditions drive the volatility of employment. However, they deliver too much fluctuations. This is because the large capital stock as a share of output has made financial conditions matter considerably. Hence, they deliver a big impact on employment. Moreover, the financial conditions have contributed to the delays of employment recoveries as well. Recall that there has been enduring financial tightening during the recovery periods following the post-1990 recessions. But, the slowness of employment recoveries caused by financial conditions themselves is not adequate without the benefit cost mechanism, especially following 1990 and 2001 recessions.

Now, comparing the results from the above *Three Model Scenarios*, we can clearly see that, benefit costs help smooth the employment volatility caused by financial conditions and extend the slow recovery of employment. This is because the benefit cost mechanism prevents firms from adjusting employment right away.[35] Together the two mechanisms allow this simple model to generate a very close match with cyclical employment movement, lining up with the cycle's turning points and explaining 76 percent of its volatility.

More specifically, at a time when the business cycle is moving towards a trough, financial constraint is tight, so employment is discouraged. At the same time, the benefit costs are below their trend. Hence, the employment decreases

[35] In the full model, per worker hours volatility as well is smaller than that in the model with financial conditions only, because hours and employment are complements in the model. Firms actually resort to more dividend adjustment in the full model.

but not right away as much as it would have without the relatively low benefit costs. The opposite occurs near peaks. When the financial constraint is loose, employment is encouraged; due to the above-trend benefit costs, however, the employment does not increase immediately as much as it would have otherwise.

Figure A.11 shows the same comparisons for the post-1990 period, except that the model results are computed using the average $\phi_{post90ave} = 0.0778$. Now, as the benefit costs are more moderate, their smoothing impact on employment volatility becomes weaker. This is because firms do not have to wait for longer time to make more dramatic employment changes. However, the contribution of the benefit costs to the delayed cyclical employment recoveries remains in Figure A.11, as well as the full model results.

To examine more closely the timing of aggregate employment recoveries (including both the employment trend and its cyclical components), Figure A.12 plots the cumulative employment growth generated by the model, as in the right panel of Figure A.1. Using the maximum $\phi_{post90max}$, the model is able to generate 3-to-7-quarter delays of employment recoveries relative to output recoveries. In the data, the delays are 3-6 quarters. Particularly, following the 1990 recession, employment recovery delayed for 4 quarters in the data and 3 quarters in my model; for 2001, it was 6 quarters in the data and 7 quarters in my model. The depth of employment declines has also been closely matched at about 1 percent from NBER business cycle trough level. For the Great Recession, the model generates deeper and longer employment drop than what is from the data. Yet, in terms of both recovery timing and decline depth, this paper has improved results comparing with those from Berger (2012), where the delays of employment recoveries are shorter at 3-4 quarters and the employment declines are shallow for the Great Recession. Compared with Bachmann (2009) where his model cannot explain the Great Recession, my model results match well with it, and generate better employment decline and recovery for the 1990 recession too.

Using the average ϕ, the more moderate estimate of benefit costs, the results with benefit cost mechanism alone are weakened. But they still generate jobless recoveries during the Great Recession, as well as nearly zero employment growth following the 1990 and 2001 recessions. With financial condition, the model is able to deliver the delayed employment recovery of 3-8 quarters, as well as deeper employment declines. Now we can conclude that the model results of jobless recoveries are not very sensitive to the calibration of ϕ. Overall, from Figure A.12, it is clear that both benefit costs and financial conditions have contributed to the delays, and that benefit costs smooth out and prolong the sharp changes in employment due to financial conditions.

In order to scrutinize how much the *cyclicality* of benefit costs have contributed to the slow employment growth, I also plot in Figure A.13 the results from a model with fixed benefit costs only (without financial conditions). We can see that fixed benefit costs cannot deliver jobless recoveries following the 1990 and 2007 recessions. In fact, there are two factors in the cyclicality that drive the slow employment recoveries, which cannot be captured by the fixed benefit costs. On the one hand, it is next period employment, n', that firms have to decide, with expectations about future. This embeds the idea that firms' hiring and firing decisions are subject to uncertainties in the economic environment. On the other hand, it is the increase of benefit costs (i.e., part of the marginal cost of employment) at the beginning of recoveries and its decrease during recessions that have further deterred employment adjustments. Both factors work for the employment impact of cyclical benefit costs to generate better results than fixed benefit costs can.[36]

Furthermore, impulse responses to one-time productivity and financial shocks are reported in Figure A.14 and Figure A.15, respectively. These results are based on the model for the post-1990 calibration with $\phi_{post90max}$, but are similar when using the other calibrated versions. From Figure A.14, we see that a negative productivity shock, indeed, delivers a significantly delayed employment recovery relative to the output recovery. Figure A.15 shows that a financial shock generates more volatility in employment and hours than a productivity shock can in the same model. Under the financial shock, employment growth is also slower than that of output.

Next, Figure A.16 plots the model-generated employment cycle using the maximum $g_{pre90} = 0.7016$ and $\phi_{pre90max} = 0.1027$ for the pre-1990 period. The model using the average $\phi_{pre90ave} = 0.0607$ generates almost the same results, as can be seen from Table A.5, column (2) and (3). For the sake of simplicity, only the plot with results using $\phi_{pre90max}$ is reported here. Because of the lower ϕ and smaller g estimated for the per-1990 period, i.e., a weaker relationship between the benefit costs and the employment growth, the benefit cost mechanism becomes much less efficacious regarding the delay in employment movement at this time. Financial conditions also have less impact since tight financial conditions did not continue into recessions during the pre-1990 period. It enables

[36]Between the two factors, n' has a larger effect. However, it is not because that, in the model formulation, firms deliberately decide next period employment. After all, it is only *one-quarter* delay by deliberation, but the model generates up to 7-quarter delays of employment recoveries. The key lies in firms' employment decisions under uncertainty.

the same model of mine to successfully generate no delay in the employment recoveries as in the data for the pre-1990 period. This can also be seen from Figure A.12: the pre-1990 results of employment recoveries have at most 1 quarter delay, as in the data. Moreover, benefit costs again help push employment movement due to financial conditions closer to the data. However, the model-generated employment volatility is neither as high as that of the data nor much different from that of the standard model.

Table A.4 and Table A.5 report the specific standard deviations of the data and the model results for output, employment, and per worker hours, respectively. My full model is able to explain more than 76 (using $\phi_{post90ave}$ or $\phi_{post90max}$) percent of post-1990 employment volatility in the data. However, the model does not do as well for pre-1990 employment volatility, where I can explain about 50 percent of the data fluctuation. In fact, the pre-1990 period experienced lower dividend payout volatility with a standard deviation of 0.0729, versus 0.1219 in the post-1990 period, and a larger capital-to-output ratio, which could have increased my model-generated pre-1990 employment volatility if I had distinguished the pre-1990 and post-1990 calibration targets for the dividend adjustment cost parameter κ and the steady state of capital-to-output ratio. But in order to focus on the changes brought by the benefit costs, I differentiate the values of only those parameters that are related to the benefit costs, i.e., ϕ and g. Additionally, output volatility has been matched well for the two periods. However, the fluctuation of per worker hours is larger than that of the data and that of employment in several cases, which needs correction in near future, potentially with the inclusion of overtime wage.

Last, it is important to investigate the model-generated employment recovery delays against not only the NBER business cycle troughs, as I did previously, but also the output and per worker hours produced by the model. Figure A.17 shows that indeed the model is able to deliver the lagging relationship between the model-generated output and employment for post-1990 recoveries.[37] Using either maximum ϕ or average ϕ does not alter the lagging relationship. Figure A.18 is attempting to convey the same message for the lagging relationship between the model-generated per worker hours and employment. However, it is less clear from the current results.

2.5 Conclusion

Are flexible hours, financial conditions, rising benefit costs and the cyclicality of those costs important for recent employment dynamics in the U.S.? The analysis of this paper suggests that they are. I propose a simple DSGE model that explicitly incorporates these factors, in which they each play an important role in generating business cycle labor market movements.

Using firms' financial conditions and dynamic employment benefit costs, I show that they are crucial for capturing not only the recent slow employment recoveries but also employment volatility. In particular, with the benefit costs alone, my model can deliver 1-to-6-quarter delays relative to NBER business cycle troughs for the employment recoveries after the 1990, 2001, and 2007 recessions. It can also generate about 49 percent of the volatility in the post-1990 employment data. Moreover, together with the financial conditions, the impacts of the two mechanisms enable my model to explain more than 76 percent

[37]Notice the difference between results here and those shown in Figure A.12. Figure A.12 uses the growth rates calculated from employment level with trend, not HP-filtered.

of the employment volatility in the data for the post-1990 period, a much higher percentage than that of existing literature. Also, they together generate 3-to-7-quarter delays of employment recoveries relative to NBER troughs during the post-1990 period, while generating no delay before that. This is consistent with the data that has scarcely been matched in the literature. My results match well with the cyclical movement of output too.

Having shown the significant employment impact of financial conditions and benefit costs, this paper does not intend to interpret the results such that they are the only drivers of the recent jobless recoveries and, as noted earlier, there are many other contributing factors. The main unique point of this paper is that they do have important effects on the tradeoff that firms face between adjusting hours per worker and employment, hence affecting employment volatilities and recovery timing. Also, this paper raises some important policy concerns that are related to firms' financial conditions and employment-based benefit systems and health insurance costs. On one hand, favorable financial conditions are crucial for timely employment recoveries; curtailing the financial condition's procyclical movement can significantly reduce employment fluctuations. On the other hand, although it is difficult to judge various options without a welfare analysis, according my results it is clear that the cyclical quasi-fixed employment costs delay employment recoveries and the costs' rising trend deepens employment declines. At the very least, it would be helpful to employment to reduce benefit costs and mitigate their cyclicality for private firms, especially to prevent them from rising at the beginning of a recovery. Furthermore, potential extensions based on my model can be made to evaluate various benefit system options and their impact on employment and welfare.

Several aspects of the current paper could be improved. First, the formulation of the benefit costs constrains the model's ability to match well with the volatility of the benefit costs' cyclical components in the data (0.0006 in the model, 0.0106 in data), although the directions of the fluctuations around the benefit costs' trend are consistent with the data. With a higher volatility of benefit costs, this model has potential to generate larger employment fluctuations. Hence, in this sense the paper's current results understate the employment impact of benefit costs. Incorporating heterogeneous workers (part-time, full-time; skilled, unskilled) in the model may be able to improve this dimension. Second, this model performs better for the post-1990 period than for the pre-1990 period in terms of the employment volatility, which could be improved by switching to period-tailored calibration targets for dividend volatility and capital-to-output ratio steady states.

Third, this model produces procyclical wages, whereas in the data the aggregate wages are acyclical or even counter-cyclical. Yet, it is shown that real wages in the microdata are indeed procyclical, but their procyclicality is merely obscured in the aggregate time series because of a composition bias: the aggregate statistics are constructed in such a way that gives more weight to low-skill workers during expansions than during recessions (Prasad and Keane, 1993; Solon, Barsky, and Parker, 1994; and Prasad, 1996). Therefore, an extension of my simple model can incorporate heterogeneously skilled workers to address this issue. Fourth, this paper has not considered overtime wages and the trade-off between the overtime wages and the employment benefit costs. It would be helpful for generating better per worker hours[38]. Last, I plan to incorporate

[38] An alternative to better per worker hours results is to use a general Cobb-Douglas production function $F(z, k, n, h_f) = zk^{\theta_1} n^{\theta_2} h_f^{\theta_3}$, so that hours per worker become a substitute to employment.

the benefit cost and financial condition mechanisms into a DSGE search model. This will enable the model to examine more dimensions of the labor market.

CHAPTER 3

TAXATION AND LEVERAGE IN INTERNATIONAL BANKING

3.1 Introduction

In most countries, firms can deduct interest expenses from their corporate tax base, but not equity returns. This causes a tax advantage of debt finance, the so-called debt bias of taxation. In the public finance literature, this debt bias has been intensively explored (see, e.g., Auerbach, 2002). More recently, the excessive leverage induced by corporate taxation has regained policy interest in the wake of the financial crisis. Indeed, while taxes are unlikely to have caused the crisis, the high indebtedness encouraged by the debt bias of taxation might have made firms more vulnerable to the negative shock and could well have deepened the crisis.[1]

A large number of studies have empirically estimated the relevance of the debt bias of taxation and report significant results (recently, e.g., Graham, 2003; De Mooij, 2011; Feld, Heckemeyer, and Overesch, 2011). Yet, there are almost no studies on debt bias in the banking sector. Indeed, studies on debt bias either eliminate data on financial firms or make no distinction between financial and non-financial companies. Conversely, studies on bank capital structures typically ignore taxation. Only in a recent paper, Keen and De Mooij (2012) analyze debt bias in banks. They point to two special features of banks that can

[1]This chapter is coauthored with Ruud de Mooij and Tigran Poghosyan at International Monetary Fund. An earlier version is published as IMF Working Paper No. 12/281. Disclaimer: This Working Paper should not be reported as representing the views of the IMF. The views expressed in this Working Paper are those of the author(s) and do not necessarily represent those of the IMF or IMF policy. Working Papers describe research in progress by the author(s) and are published to elicit comments and to further debate.

make debt bias different as compared to non-financial firms. First, banks face capital requirements that restrict their debt ratio choice. Second, banks face different agency costs due to regulation (such as deposit insurance) and implicit or explicit state insurance (e.g., due to too-big-to fail status). Using unconsolidated statements of over 14,000 commercial banks in 82 countries, they find that the sensitivity of banks' debt to taxation is very similar to that of non-financial firms. This outcome is important in light of the significant externalities associated with excessive bank leverage. Indeed, high bank leverage tends to increase the probability of a bank's default and, if the bank is systemic, contributes to the probability of a financial crisis. Although Keen and De Mooij (2012) do not look specifically at multinational banks, they do explore whether large banks (which are systemically the most important) differ from small banks and find that the former's leverage are notably less responsive to tax changes.

A relatively new strand of the debt bias literature looks into the behavior of multinational firms. Specific for them is the opportunity of international debt shifting. By the traditional debt bias channel described earlier, a firm or a subsidiary's leverage is affected by local tax levels. In contrast, international debt shifting entails a multinational choosing the financial structure of its subsidiaries in different countries partly on the basis of tax differences. At a high-tax location, debt finance is attractive because the interest costs can be deducted at a higher rate. In a low-tax location, equity finance is more attractive since the returns will be taxed at a lower rate with the repatriated dividends usually exempt for the parent. Thus, a tax-minimizing strategy of a multinational will involve relatively more debt in high-tax jurisdictions. Studies for the U.S. by Hines and Hubbard (1990), Collins and Shackelford (1992), Grubert (1998), Altshuler and Grubert (2002), Desai, Foley, and Hines (2004), and Mills and

Newberry (2004) all find that subsidiary debt ratios respond to international tax differences in the expected way. For European countries, Moore and Ruane (2005), Huizinga, Laeven, and Nicodeme (2008), Bttner and Wamser (2009), and Egger, Eggert, Keuschnigg, and Winner (2010) report similar results. This is an important message since international debt shifting erodes corporate tax bases in high-tax countries. Several high-tax countries have therefore taken measures to prevent base erosion, e.g., by restricting interest deductibility (see, e.g., Bttner, Overesch, Schreiber, and Wamser, 2008).

This paper combines the two strands of literature by exploring debt bias of taxation in multinational banks. Our analysis aims to shed light on how these banks respond to corporate taxation, through the traditional debt bias channel and international debt shifting. This paper's approach is closely related to that in Huizinga, Laeven, and Nicodeme (2008), who explore debt bias in multinational firms. However, their study excludes banks and is confined to European firms.[2] The debt bias analysis of multinational banks in this paper is particularly important for at least two reasons. First, multinational banks are often systemically important, not only within a country but also across countries. Exploring their leverage response to taxation is therefore critical to better understand the causes and consequences of financial crises and the role of taxation therein. Second, it is important to understand the nature and size of international debt spillovers of tax policy through the banking sector. Indeed, such spillovers raise several policy concerns regarding tax competition, policies to address debt shifting, and interactions with bank regulation, including through

[2]Cerutti, Dell'Ariccia, and Martinez Peria (2007) argue that the structures of multinational firms and banks are somewhat different. Unlike multinational firms, internationally active banks tend to operate through two types of affiliates: subsidiaries or branches. They show that local corporate taxes affect the mode of bank entry, with branches being a more preferred entry mode in countries that have higher tax rates. We do not consider branches in this empirical analysis and focus on taxation and leverage of subsidiaries.

capital requirements.

Using a novel data set for 558 commercial bank subsidiaries of the 86 largest multinational banks in the world, we find that corporate taxes matter significantly through both the traditional debt bias channel and international debt shifting. While the tax effects are statistically significant and large, the international debt shifting channel appears to be more robust and tends to be larger than the traditional debt bias. These results imply that taxation causes significant international debt spillovers through multinational banks, which has potentially important implications for tax policy.

The remainder of the paper is structured as follows. Section 2 sets out a simple theory to guide our empirical analysis. Section 3 presents the empirical methodology and data, while Section 4 discusses the estimation results. Section 5 concludes.

3.2 Theoretical Model

This section develops a model for the optimal capital structure of a multinational bank (or parent bank). The model follows the standard trade-off theory, in which each bank subsidiary entails a convex cost of debt finance that is associated with possible capital requirement violation and bankruptcy, and entails a tax advantage of debt finance, since the interest is deductible for corporate taxable profits while equity returns are not. This tax advantage, through the traditional debt bias channel, leads to a higher leverage of the subsidiaries, which is traded off against the law violation and bankruptcy cost. In addition, the parent bank rebalances the capital structure among its subsidiaries, depending on the relative tax rates of the host countries where the subsidiaries operate. In particular, it will have an incentive to finance subsidiaries in high-tax countries by (intra-company) debt since the interest paid is deductible against a high rate. Subsidiaries in low-tax countries will be more likely financed by equity since returns on equity are taxed in the host country and are typically exempt when repatriated to the parent. Meanwhile, the parent bank also faces its own capital requirement violation and bankruptcy cost that is associated with the leverage of the whole group.

The model predicts that the optimal debt-to-assets ratio of a subsidiary bank of a multinational will be positively related to the host country tax rate, as well as to the international tax difference between the host-country tax rate and the tax rates prevailing at other subsidiaries. As a subsidiary bank faces tighter capital requirements, the possible legal violation makes it costlier to increase leverage, resulting in a less sensitivity of the bank to tax changes.

The model is based on Albertazzi and Gambacorta (2010), with corporate income tax (CIT) bias, but is also substantially different from theirs, in that our model features a multinational bank setup and includes the convex cost of possible capital requirement violation and bankruptcy. It considers a multinational bank operating in m countries. The multinational has one subsidiary bank[3] in each host country i with total assets A_i assumed to be given. The subsidiary bank provides loans L_i yielding an interest rate l_i, and borrows B_i (including deposits and other debts) at interest rate r. The profit function for a subsidiary bank i is therefore given by:

[3]The model does not distinguish between subsidiaries and branches. We assume that the parent bank provides explicit or implicit credit guarantees for the debts of its subsidiaries. If there are multiple subsidiary banks in a country, we consider them as being one subsidiary. In the estimations, however, we allow multiple subsidiary banks of the same parent in one host country.

$$P_i = l_i L_i - rB_i \tag{3.1}$$

which is also the CIT base of the subsidiary bank.

Subsidiary bank i owns fixed assets, denoted by FA_i. Together with the outstanding loans, this forms the asset side of the balance sheet. On the liability side, E_i stands for the subsidiary bank's total equity. Hence, the balance sheet constraint of the subsidiary bank is given by:

$$A_i = L_i + FA_i = B_i + E_i. \tag{3.2}$$

As in Albertazzi and Gambacorta (2010), we assume that the subsidiary bank is partly owned by the parent bank and partly by outside investors. Denotes ki the proportion of the subsidiary bank owned by the outside investors, we assume the required net rate of return by them to be equal to the return on alternative investment options (n):

$$\frac{k_i P_i (1 - t_i)}{E_i - FA_i} - 1 = n. \tag{3.3}$$

The capital structure of both the parent (p) and its subsidiaries (i) are restricted by legal minimum capital requirements (r_E), which are set by the country in which the bank operates:

$$E_i \geq r_{Ei} L_i, E_p \geq r_{Ep} L_p. \tag{3.4}$$

The minimum capital requirement in Eq. 3.4 might be violated by either the subsidiary or the parent, at a certain legal cost. In addition, both the parent bank and its subsidiaries are at the risk of bankruptcy given their debt. We assume that the parent bank provides implicit credit guarantees for the possible bankruptcy and legal penalty in case of violating the capital requirements by its subsidiaries. Therefore, the parent bank takes account of not only the leverage of the multinational group as a whole, but also the leverage in its subsidiaries. The overall cost of debt finance, caused by both the possible bankruptcy and the possible violation of the capital requirement faced by the parent bank and its subsidiaries, is denoted by:

$$\sum_{i=1}^{m} C_i + C_p \tag{3.5}$$

where C_i is the cost of subsidiary bank i and C_p the cost of the parent bank.

Similar to Huizinga, Laeven, and Nicodeme (2008), the cost of the subsidiary is defined as $C_i = \frac{m_i(r_{Ei})A_i b_i^2}{2}$, where $b_i = B_i/A_i$ denotes the subsidiary's leverage ratio, in which the cost is convex, for the multinational recognizes that higher leverage increases the chance of bankruptcy. But different from their paper, the convexity here changes with capital requirement tightness, since $m_i(r_{Ei})$ is not a parameter but a positive and increasing function of the capital requirement faced by the subsidiary. All else equal, when the subsidiary faces a tighter capital requirement, it has a higher chance of violating the law, both the cost level C_i and the marginal cost of increasing leverage rise. Hence, the subsidiary's cost increases with its leverage and capital requirement, whose interaction also affects each other's impact on the cost.

The cost of the parent bank is defined as

$$C_p = \frac{g_p(r_{Ep})A_p(\frac{\sum_{i=1}^{m} B_i}{A_p})^2}{2}, \tag{3.6}$$

where $g_p(r_{Ep})$ is a positive and increasing function in the capital requirement faced by the parent bank. The group's total assets are denoted by $A_p = \sum_{i=1}^{m} A_i$, and the group's total leverage is the sum of all the subsidiaries' debts over the total group assets, i.e., $\frac{\sum_{i=1}^{m} B_i}{A_p}$. Likewise, the parent's cost increases with the group's overall leverage and its capital requirement. Conveniently, we further define each subsidiary's asset share in the group as $q_i = \frac{A_i}{A_p}$, so that we can rewrite $C_p = \frac{g_p(r_{Ep})A_p(\sum_{i=1}^{m} b_i q_i)^2}{2}$.

The multinational bank chooses E_i, L_i and B_i so as to maximize its overall post-tax profits, i.e., the sum of post-tax profits of all its subsidiaries minus the share that goes to outside investors and minus the overall cost of debt finance:

$$\max \sum_{i=1}^{m}(1-k_i)(1-t_i)P_i - \sum_{i=1}^{m} C_i - C_p \tag{3.7}$$

subject to constraints 3.1-3.3, and 3.5. Substituting those into the maximization problem 3.7 and rearranging yields:

$$\max \sum_{i=1}^{m}(1-t_i)(L_i[l_i - \frac{1+n}{1-t_i}] - B_i[r - \frac{1+n}{1-t_i}]) - \sum_{i=1}^{m} \frac{m_i(r_{Ei})A_i b_i^2}{2} - \frac{g_p(r_{Ep})A_p(\sum_{i=1}^{m} b_i q_i)^2}{2} \tag{3.8}$$

From the first-order condition of B_i (see Technical Appendix for derivation details), we find:

$$b_i = \lambda_{0i} + \lambda_{1i} t_i + \lambda_{2i} \sum_{j \neq i}^{m} (t_i - t_j) q_j + \lambda_{3i} \sum_{j \neq i}^{m} [b_j (m_j(r_{Ej}) - m_i(r_{Ei}))] q_j \tag{3.9}$$

where $\lambda_{0i} = \frac{1+n-r}{g_p(r_{Ep})+m_i(r_{Ei})}$, $\lambda_{1i} = \frac{r}{g_p(r_{Ep})+m_i(r_{Ei})}$, $\lambda_{2i} = \frac{g_p(r_{Ep})r}{m_i(r_{Ei})[g_p(r_{Ep})+m_i(r_{Ei})]}$, and $\lambda_{3i} = \frac{g_p(r_{Ep})}{m_i(r_{Ei})[g_p(r_{Ep})+m_i(r_{Ei})]}$.

Eq. 3.9 shows that the leverage of a subsidiary bank depends on two tax-related terms. First, the term $\lambda_{1i} t_i$ reflects the debt impact of local tax level at the subsidiary's host country. This quantifies the traditional debt bias channel. The coefficient λ_{1i} turns out positive here, indicating that a higher local CIT rate will increase bank leverage. Second, the term $\lambda_{2i} \sum_{j \neq i}^{m} (t_i - t_j) q_j$ reflects the debt impact of international tax differences. The coefficient λ_{2i} is also predicted to be positive in our theory, suggesting that as the CIT rate in the host country becomes relatively high compared to CIT rates in other host countries of the same multinational bank, the subsidiary bank's leverage rises. Thus, it measures the international debt shifting. Important for our empirical analysis is that in the second term the international tax differences $(t_i - t_j)$ are weighted by the asset shares of subsidiaries in all the other host countries, q_j.

The tax effects captured by the coefficients λ_{1i} and λ_{2i} in Eq. 3.9 depend on the capital requirements faced by both the parent bank and its subsidiaries. In particular, when the capital requirement becomes tighter, i.e., r_{Ei} and r_{Ep} get larger, the violation cost at the margin of holding debt rises. The higher marginal cost (benefit) of raising (lowering) leverage makes the bank less sensitive to tax changes. In the regressions, we will test whether this hypothesis is indeed valid.

The theory also offers some insights on the relative magnitudes of λ_{1i} and λ_{2i}, which measure the importance of the traditional debt bias channel as compared to the international debt shifting. In particular, if $g_p(r_{Ep}) > m_i(r_{Ei})$, then $\lambda_{1i} < \lambda_{2i}$, in this case, international tax difference exerts a larger effect on leverage than local tax, that is, the international debt shifting is a more important channel than the traditional debt bias. Intuitively, when the violation cost is larger for the parent bank, $g_p(r_{Ep})$, than for subsidiary bank, $m_i(r_{Ei})$, then the parent bank will find it relatively easy to shift debt across subsidiary banks, but costlier to modify the overall leverage level of the group, hence, the international debt shifting is dominating. However, if debt finance would be less costly for the multinational bank as a whole compared to for subsidiary banks, e.g., because unlike the parent bank, the subsidiaries do not enjoy the same protection against bank failure, then the opposite would hold. In the next section, we will explore these hypotheses empirically.

Summing up, the main predictions of the model are as follows:

1) Bank leverage depends positively on the local CIT level.

2) Bank leverage depends positively on the weighted average difference between the subsidiary host country's CIT rate and those of the other subsidiary host countries for the same maturational group. The weights are subsidiaries' asset shares.

3) The impact of traditional debt bias channel might be either smaller or larger than the impact of international debt shifting, depending on the capital requirement violation cost to the subsidiary versus to the parent bank.

4) As a host country's capital requirement becomes tighter, ceteris paribus, its bank leverage becomes less sensitive to the changes of both local tax and its

tax difference with other host countries.

3.3 Empirical methodology and data

3.3.1 Methodology

The strategy is to estimate a series of panel regressions of the general form:

$$leverage_{ikt} = \alpha + \lambda_1 tax_{it} + \lambda_2 itd_{it} + \beta\sigma_{ikt} + \delta\gamma_{it} + \mu_i + \varepsilon_{ikt} \tag{3.10}$$

where $leverage_{ikt}$ is total-liability-to-total-assets ratio for subsidiary bank k at host country i in year t, tax_{it} is the statutory CIT rate the subsidiary bank faces, itd_{it} is a variable measuring international tax difference (see below for details), σ_{ikt} is a vector of subsidiary-level controls, γ_{it} is a vector of host-country-level controls, and μ_i is host country fixed effect. Our attention focuses on the coefficients λ_1 and λ_2, which reflect the marginal impacts of the traditional debt bias channel and of the international debt shifting. In particular, the theory predicts that $\lambda_1 > 0$ and $\lambda_2 > 0$. Also, the tax elasticity of leverage is expected to be larger if a subsidiary bank holds more capital beyond its capital requirement (i.e., in the theory, λ_1 and λ_2 become larger as relevant capital requirements are loosened).

The measurement of international tax difference, itd_{it}, is the asset-weighted average of differences between the tax rate of subsidiary k in country i and those of other subsidiaries within the same parent bank, as in Huizinga, Laeven, and Nicodeme (2008). More specifically, it is computed as $\sum_{j \neq i}^{m}(tax_{it} - tax_{jt})q_{jt}$, where the parent bank has a total of m subsidiary banks, and weights q_{jt} reflect the subsidiary asset shares in the total assets of the multinational group, i.e., $q_{jt} = \frac{A_{jt}}{\sum_{j=1}^{m} A_{jt}}$. A positive value of this tax difference variable indicates that, on average, there is an incentive to shift debt into the subsidiary host country i; a negative value indicates the opposite.

To understand the calculation of the international tax difference variable, let us illustrate it with an example. Suppose there is a corporate group that consists of three ($m = 3$) subsidiaries in country A, B, and C, respectively, each having one third of the group's total assets. The international tax difference for the subsidiary in country A, itd_A, is then calculated as the asset-weighted differences between the tax rate in A, τ_A, and the tax rates in B and C, τ_B and τ_C, respectively: $itd_A = \sum_{j=A}^{m}(\tau_A - \tau_j)q_j = (\tau_A - \tau_B)\frac{1}{3} + (\tau_A - \tau_C)\frac{1}{3}$. If τ_A is 10 percent, and both τ_B and τ_C are 20 percent, then itd_A equals about -7 percent. As the subsidiary is located in a relatively-low-tax country A, there exists an incentive to decrease leverage. If τ_A increases to 50 percent, itd_A would rise to 20 percent, indicating that the subsidiary is located in a relatively-high-tax country and has an incentive to increase leverage.

The asset size of a subsidiary matters for the debt shifting incentive. Suppose the asset size of the subsidiary in country A increases to one half of the group's assets, while the subsidiaries in B and C are still of equal size (i.e. now $\frac{1}{4}$ of the group's assets). We assume that τ_A is 50 percent, while τ_B and τ_C are still 20 percent. The international tax difference for the subsidiary in country A now is: $itd_A = (\tau_A - \tau_B)\frac{1}{4} + (\tau_A - \tau_C)\frac{1}{4} = 15$ percent, instead of 20 percent in the previous example, implying a smaller incentive to shifting in debt. More generally, the larger a subsidiary's asset share is within the multinational, the smaller the leverage impact of a tax change through international debt shifting will be. Intuitively, large subsidiaries have more capacities in absorbing debts without increasing much of their leverage. Additionally, the smaller the assets held by other subsidiary banks abroad (other than in country A), the smaller the scope for debt to be shifting from them to A. Therefore, the international debt shifting channel is positively proportional to the asset share of subsidiaries in other countries, but negatively proportional to the asset share in the subsidiary's residing country. Likewise, international debt shifting effect is expected to be larger for the leverage of a subsidiary with a relatively small asset size.

Furthermore, we can rewrite the international tax difference as: $\sum_{j\neq i}^{m}(tax_{it} - tax_{jt})q_{jt} = tax_{it} - \sum_{i=1}^{m} tax_{it}q_{it}$. The rearranged equation reflects the tax difference between the subsidiary and the asset-weighted average tax rate of the group as a whole (or, the average tax faced by the parent bank). Since it contains the local tax level variable tax_i, already captured by the second term on the right-hand side of Eq. 3.10, we can redefine $itd_{it} = \sum_{i=1}^{m} tax_{it}q_{it}$, then the newly estimated $\lambda_1' = \lambda_1 + \lambda_2$ and $\lambda_2' = -\lambda_2$. In the empirical exercise, we also use alternative weights in the measurement of the international tax difference, such as liability weights and time-invariant asset weights (i.e., the average of the subsidiary-asset-weights across time) to eliminate a possible endogeneity problem arising from endogenous assets with leverage.

The bank-level controls in σ_{ikt} are those usually included in the capital structure literature (e.g., Rajan and Zingales, 1995; Frank and Goyal, 2009). First, we include the book value of a subsidiary bank's assets and its square to allow for non-linear size effect. This scaling variable reflects that larger banks have easier access to credit because they tend to be more diversified and less prone to bankruptcy (Rajan and Zingales, 1995). Moreover, large banks could benefit from a too-big-to-fail notion (e.g., De Haan and Poghosyan, 2011). Thus, we expect a positive relation between subsidiary bank size and its leverage.

Second, we include the pre-tax return on assets as a measurement of profitability. Theory suggests that its effect on leverage is ambiguous. On the one hand, profitable banks could be perceived to be less risky and face less financial distress, which would facilitate their access to external credit. Moreover, profitable banks could have more incentive to reduce tax payment by raising debt than loss-making banks that benefit less from tax deductibility. This would suggest a positive relation between profitability and leverage. On the other hand, higher profits add to equity if retained within the firm, directly reducing the leverage ratio, suggesting a negative relation between profitability and leverage. This is also consistent with the ”pecking order” theory developed by Myers and Majluf (1984), according to which in the presence of asymmetric information firms prioritize internal financing to the issuance of new debt.

Third, growing banks invest more, holding profitability constant, and could accumulate more debt over time. However, growth also decreases financial distress and places a greater value on the equity holder, thereby encouraging equity investment and reducing leverage. Overall, its effect on leverage is ambiguous. In terms of the measurement of bank growth, market-to-book-asset ratio is the most commonly used proxy. But since not all subsidiary banks in our sample are listed, we use the growth of total book assets.

Fourth, collateral can reduce costs of issuing both debt and equity. In empirical studies on the capital structure of non-banks, it is typical to find that collateral increases access to external funding so that firms can rely less on retained earnings. Thus, the leverage ratio tends to rise with collateral value. However, the very nature of the banking sector and the impact of regulation could change this for banks. We use the proportion of total security assets and non-earning assets out of total assets as a proxy for collateral.

Finally, DeAngelo and Masulis (1980) show that non-debt tax shields are a substitute for the tax benefits of debt financing. Hence, they should be negatively related to leverage. We measure non-debt tax shields by total-non-interest-expenses-to total-assets ratio.

We also control for subsidiary host country characteristics. First, we include GDP growth and inflation. High growth at the country level is expected to facilitate debt finance. An inflationary environment could lead to higher risk premiums and discourage debt supply. Yet, as nominal interest is deductible for the CIT, high inflation could also encourage debt demand as it lowers real borrowing costs. The overall impact of inflation on leverage is ambiguous. Second, if a country provides generous deposit insurance, depositors could be more willing to place their funds in banks without having to monitor their activities. We include a 0/1 dummy for the existence of deposit insurance and expect its debt impact to be positive. Third, we include the minimum capital requirement, which should have a negative impact on bank leverage. Finally, we add a financial crisis dummy from Laeven and Valencia (2010). A crisis could initially increase the leverage ratio due to the decline in equity values, but could also subsequently reduce leverage.

3.3.2 Data

Data of the subsidiaries of 100 largest multinational banks in the world are collected from Bankscope database, compiled by Bureau Van Dijk.[4] The database provides accounting data on banks around the world, including information about ownership relations. This latter information allows us to match the subsidiaries with their multinational parents.[5] In our analysis, we focus on commercial banks and we do not consider branches. We define a bank as a subsidiary if more than 50 percent of it is owned by a parent bank. If a subsidiary bank owns its own subsidiaries, then the data we use can be from either consolidated or unconsolidated statements, whichever is available in the database. The consolidated statement reflects the activities of the subsidiary bank itself and all the subsidiaries it owns. The unconsolidated statement, in contrast, reflects only the accounts of the subsidiary bank itself. In our sample, 36 percent of the subsidiaries report consolidated accounts and 64 percent report unconsolidated statements.

Table B.1 shows detailed information about variable constructions and data sources. Starting from the raw data, we first drop all inactive subsidiary banks. We also drop subsidiary banks with a leverage ratio larger than 99 percent, or with a pre-tax profit-to-asset ratios smaller than -20 percent or larger than 250 percent, or with negative total non-interest expenses, or with non-earning-

[4] In our regressions, we use only data of subsidiaries, not those of their parents. This is because we want to look at how multinational banks place leverages across their subsidiaries due to host countries' taxes, adding parent banks may complicate the results. Also, our partial equilibrium model does not include a parent bank either, so the empirical exercises are consistent with the theory.

[5] The data we have from Bankscope do not report historical ownership. Therefore, our analysis is based on the latest ownership information, implicitly assuming that ownership has not changed for banks in our sample. A robustness check based on the data for last two years yields qualitatively similar results on the debt impact of taxes, providing indirect support to our results.

assets-to-total-assets ratio larger than 99 percent, or with total assets growth larger than 150 percent, or with effective tax rates smaller than zero, or with missing total assets or CIT rates. Doing so, we end up with a sample of 558 commercial bank subsidiaries (both domestic and foreign), owned by 86 largest multinational commercial banks in the world. The parents are headquartered in 25 countries, while their subsidiaries are located in 66 different host countries. The sample spans through 1998-2011 period. Table B.2 provides summary statistics of main variables of interest, such as leverage, statutory CIT rates, international tax differences, and control variables. Table B.3 displays the correlations between variables. Figure B.1 shows the distribution of bank leverage in the sample.

Table B.4 presents information on the number of parent banks and subsidiaries (both domestic and foreign) in different countries. We see that many parent banks reside in France, Germany, Spain, the U.K., and the U.S. A relatively large number of subsidiaries are hosted in France, Luxemburg, Russia, the U.K., and the U.S. Table B.5 provides information on average financial leverage and CIT rates in subsidiary countries. The average financial leverage ranges from 69.3 percent in Argentina to 94.9 percent in Spain. CIT rates are the highest in Japan and the lowest in Bosnia and Herzegovina. The international tax difference variable suggests that subsidiaries in Germany, Thailand, and Zambia should have the largest debt levels in light of their relatively high tax, while subsidiaries in Albania, Bosnia and Herzegovina, and Ireland, should have the lowest debt ratios.

3.4 Results

Table B.6 reports our baseline results, where we regress subsidiary bank leverage on tax variables and bank-level variables, first without and then with country-level variables. Tables B.6-B.10 show various robustness checks, using alternative estimators, samples, and specifications. Finally, Table B.11 partitions observations by capital tightness of the subsidiary banks.

3.4.1 Baseline Regressions

Results in Table B.6 are based on OLS regressions with subsidiary host country fixed effects. For each variable we indicate between brackets the predicted sign of the coefficient. Regression (1) contains local tax level and bank-level variables, excluding international tax difference variable and host country controls. We see that the local tax coefficient is close to 0.3 and statistically significant. It supports hypothesis (1), namely that a higher tax in the host country increases the debt ratio of its residing subsidiaries. The coefficient of 0.3 means that an increase in the statutory CIT rate by 10 percentage points will increase subsidiaries' leverage ratio by 3 percentage points (= 0.3 10). The size of the effect is close to the coefficient of 0.26 found for non-financial firms in Huizinga, Laeven, and Nicodeme (2008), and in the analysis of De Mooij (2011). It is also very similar to the coefficient of 0.27 for banks found by Keen and De Mooij (2012). This evidence supports the traditional debt bias channel.

Bank-level control variables are also important. Table B.6 confirms that larger banks have higher leverage ratios. Higher profitability reduces the leverage ratio. While theory is ambiguous about the impact of bank growth on leverage, our estimations suggest that faster growing banks accumulate more debt. The collateral variable has a negative coefficient, again consistent with that for non-financial firms in Huizinga, Laeven, and Nicodeme (2008). Even though collateral is generally expected to have a positive effect on financial leverage, it can also make equity issuance less costly with lower asymmetric information (Rajan and Zingales, 1995). For our sample, this positive impact on equity appears to be dominant. Finally, non-debt tax shields substitute for the tax benefits of debt financing and reduce leverage, as suggested by DeAngelo and Masulis (1980).

Regression (2) adds international tax difference variable. We see that the estimated coefficient for this variable is statistically significant and positive. It supports the theory that subsidiary bank leverage is affected by the international tax differences with multinational banks, consistent with our hypothesis (2). Note that the local CIT rate level enters both in the first and in the second term in the regression. The first term, whose effect is measured by coefficient λ_1, captures the effect of local taxation on the leverage of banks through traditional debt bias channel. We see that this effect is smaller than in the first regression, because part of the impact is now captured by the second term. With a coefficient of 0.25, however, the traditional debt bias channel remains important. The second term, whose impact is measured by coefficient λ_2, captures the international tax difference effect on leverage. Its value of 0.12 suggests that this second effect appears smaller than the first channel in this specification.

Regressions (3) and (4) augment regressions (1) and (2) with an additional set of host-country controls. The GDP growth variable enters the regressions positively, as expected. However, all the other host country controls are not statistically significant, except that in column (4) the financial crisis variable enters with a weakly significant negative coefficient. The estimated coefficient for the CIT rate in regression (3) is very similar to that in column (1), although slightly smaller in size. It again confirms hypothesis (1).

In regression (4) the estimated coefficient for the local CIT is reduced to 0.16, much smaller than in column (2). The coefficient for the international tax difference is positive and significant, consistent with hypothesis (2). Compared to column (2) the coefficient is much larger at 0.18. Comparing the two tax channels in column (4), we find that the international tax difference is slightly more important than the traditional debt bias channel. This would be consistent with the case in which the capital requirement violation cost for the multinational group is larger than that for a single subsidiary. However, the difference between the two channels' importance is not statistically significant, with the F-test of coefficient equality p-value of 0.69. Hence, column (4) suggests that the traditional debt bias channel and the international debt shifting are both relevant in explaining the impact of the CIT rates on the leverage ratio of subsidiary banks.

To illustrate the findings in columns (3) and (4) further, we use an example of a hypothetical U.S. multinational bank. On average, in our sample a U.S. multinational bank has about 10 subsidiaries around the world. Suppose that our hypothetical U.S. parent bank owns 10 subsidiaries with equal asset size. We consider a tax cut by 10 percentage points in country A where one of the subsidiaries resides, while keeping the tax rates in all other countries unchanged. In this case, there are two channels through which the leverage ratio of subsidiary banks in country A can be affected. One is the traditional debt bias channel, due to the change of tax level; the other is the international debt shifting channel, due to the change of relative tax differences. When we use the results in regression (3), the two effects are combined and measured by the coefficient of the CIT rate level. The 10 percent CIT rate reduction in country A will reduce the leverage ratio of its subsidiaries by 2.5 percent. When we use regression (4) results, the two channels are distinguished. Through the traditional debt bias channel, the leverage ratio drops by 1.59 percentage points. Through the international debt shifting channel, the leverage ratio declines by 1.62 percentage points (= $0.18 \times 10 \times 0.9$). The overall impact is then 3.21 percentage points (= 1.59 + 1.62).

Suppose now instead, the statutory CIT rate declines by 10 percentage points in all the other countries, except for country A. In regression (3), there is no effect on leverage, since foreign tax rates are not included in the regression and international debt shifting effect cannot be captured. In regression (4), however, the international tax difference rises by 9 percent (= 0.9×10). This increases the leverage ratio of the subsidiary banks in country A by 1.62 percentage points ($9\times$ 0.18). Hence, international debt spillovers associated with relative tax changes can only be quantified by regression (4).

Overall, the results in Table B.6 suggest significant and sizeable effects of taxation on bank leverage. If we look at the size of the subsidiary banks in the data, the mean value of total assets is USD 2.8 billion while the median is USD 2.1 billion. This is larger than the banks analyzed in Keen and De Mooij (2012). In their data, only 5 percent of the banks exceed an assets size of USD 1.2 billion. While Keen and De Mooij (2012) find very small tax responses for their

5 percent group of largest banks, our sample containing relatively large banks reports considerably larger effects. In column (4), we see that a considerable part of the tax effect originates from international debt shifting. Hence, our results suggest that large subsidiary banks are as responsive as the average banks are found in Keen and De Mooij (2012), but that the impact on debt is for more than half explained by international debt shifting.

3.4.2 Robustness Checks

Tables B.7-B.10 present robustness checks, taking regression (4) in Table B.6 as our benchmark specification. In Table B.7, regressions (5)-(7) correct standard errors by clustering observations across parent banks, host countries, and subsidiaries, respectively. The estimated coefficients for the two tax variables are unchanged by the clustering, but standard errors increase. Nevertheless, the tax coefficients remain statistically significant at either the 1 percent or 5 percent level. Regression (8) uses the Driscoll and Kraay (1998) standard errors, which are robust to heteroskedasticity and autocorrelation in the error structures up to a certain lag (or where errors are correlated between groups). Again, the traditional debt bias remains statistically significant at the 5 percent level, but the international debt shifting loses significance slightly, now significant at 10 percent.

In Table B.8, regressions (9)-(11) adopt alternative measurements for the international tax difference variable. Given that the construction of international tax difference variable includes an element of local tax rate, it is positively correlated with the local tax variable (with a correlation coefficient of 0.68 in Table

B.3). In regression (9) we exclude the local tax rate from the second term in our specification. Thus, the coefficient for the CIT rate captures the overall impact of a change in local taxation on subsidiary leverage, both through the traditional debt bias channel and international debt shifting. The coefficient for the international tax difference captures only the impact of a change in foreign tax rates, reflecting international debt shifting channel. As expected, regression (9) shows that (i) the coefficient for the CIT rate is now larger (reflecting both channels), and (ii) the foreign tax has a negative coefficient: higher foreign taxes in other host countries reduce the leverage of subsidiaries in this country. In fact, the coefficients of this regression are directly linked to those in regression (4), in that $\lambda'_1 = \lambda_1 + \lambda_2$ and $\lambda'_2 = -\lambda_2$, as predicted in Section 3.1.

Regression (10) eliminates the time variation in asset weights by using constant asset weights in the calculation of the asset-weighted international tax difference. The constant asset weights are calculated as the average of the asset weights across time for each subsidiary bank. This can help to reduce potential endogeneity issues arising from endogenous assets with leverage.[6] The coefficients remain significant in this regression for our two core tax variables. In fact, the international debt shifting effect becomes larger, while the traditional debt bias channel becomes weaker. In column (11), we use leverage shares rather than asset shares to compute the weights for international tax difference variable. The results are very similar to those in column (4) of Table B.6.

Next, regression (12) takes short-term debt ratio as the dependent variable rather than total leverage. Short-term debt is calculated as total leverage minus

[6]We also ran regressions for a dynamic specification using the system GMM estimator as in Keen and De Mooij (2012). The instruments should help to reduce possible endogeneity. However, the results turned out to be very sensitive to the choice of instruments and are therefore not reported.

long-term funding ratio. While both tax variables enter again with a positive coefficient, the local tax coefficient is larger than before, implying that long-term debt (such as customer saving deposits) is less responsive to tax than short-term liabilities. Interestingly, regression (12) also shows that the deposit insurance variable reduces short-term debt. Considering that the variable has an insignificant effect for total leverage, our result suggests that deposit insurance exerts a positive effect on long-term funding. This is intuitively appealing as the debt covered by deposit insurance tends to be of a long-term nature.

In Table B.9, regression (13) employs quantile regression instead of OLS to address the possible impact of the skewed distribution of bank leverage. Quantile regressions approximate the conditional median instead of the mean of a dependent variable, which reduces the impact of outliers. Thus, its estimates should be more robust, if the response measurements are highly skewed. Figure B.1 shows that the distribution of bank leverage in our sample is indeed highly skewed to the right. Therefore, quantile regressions should be helpful in our case. Regression (13) suggests that using quantile regressions the two tax effects remain statistically significant, as before, but their magnitudes become smaller. Since quantile regressions give less weight to sample outliers, the result suggests that for our outliers, i.e., subsidiary banks with very low debt-to-asset ratios, their leverage could be more affected by taxes. This is consistent with our later results in Section 4.3, where we find that the leverage of banks with more abundant capital is more affected by tax changes. Regression (14) in Table B.9 contains a host-country-specific trend variable that captures the declining trend of statutory CIT rates worldwide. Now we see that the traditional debt bias channel becomes statistically insignificant, and the international debt shifting effect remains significant and large.

Table B.10 exploits the regression specification as in (4) but for various subsamples. In regression (15) we restrict the sample to subsidiaries for which we have data from unconsolidated statements. This reduces the number of observations from 3905 to 2569. The results for core tax variables are the same, although the impact of the international debt shifting is larger than before. Regression (16) considers only subsidiary banks with positive profits. We expect taxes to have a larger effect for profitable banks, since the value of interest deductions is smaller for loss-making banks (as costs can only be used against future profits, if at all). The coefficients for λ_1 and λ_2 are indeed larger than the ones in the baseline estimation, consistent with our expectation.

Furthermore, regression (17) limits the sample to subsidiaries residing in advanced countries. The advanced countries are defined as countries where the domestic credit provided by the banking sector as a share of GDP is higher than the sample average. We expect the international debt shifting channel to be more pronounced for these countries where banks use more sophisticated products that could facilitate capital transfers globally. Indeed, relative to the benchmark regression, the value of international tax difference coefficient, λ_2 , is much larger in magnitude at 0.47 than in the benchmark (0.18). However, we find no significant effect of the traditional debt bias channel. Note that regression (17) also reports a positive impact of inflation on leverage and a negative impact of capital requirements.[7] Finally, regression (18) confines the sample to the period before the latest global recession by excluding observations between 2009 and 2011. The tax effects are similar to the baseline estimates, with a larger

[7]For deposit insurance there is weakly significant negative coefficient. This contrasts with our expectations. However, it might be that in the absence of deposit insurance governments in advanced countries offer implicit insurance to banks, e.g., through the expectation of public bail out at times of distress. Hence, the presence of explicit deposit insurance could actually imply lower insurance through other implicit channels, consistent with the finding of Gropp and Vesala (2001).

coefficient for the international debt shifting. We also see that inflation is negatively associated with bank leverage.

3.4.3 Extension: Capital Tightness

In Section 2, our theory shows that banks that are regulated under tight capital requirement are less responsive to tax. Intuitively, capital-tight banks, i.e., those that hold capital close to the requirement level, will be more constrained in adjusting leverage ratios due to the cost of violating capital requirement. The conjecture is therefore that banks' responsiveness to tax declines with their capital ratio relative to the minimum capital requirement they face.

To test this hypothesis, we calculate capital tightness as follows. For each subsidiary bank we compute its capital ratio relative to the legal capital requirement prevailing in its residing host country. We then divide subsidiary banks into three equal-sized groups: banks with most abundant capital relative to their capital requirements, an intermediate group, and a group of banks with the tightest capital. We run regressions for the first and last groups, respectively.

Table B.11 presents the results. Comparing columns (19) and (20) we find that taxes exert a larger impact on the leverages of the capital-abundant banks through both the traditional debt bias channel (with its coefficient equal 0.28) and the international debt shifting (with its coefficient equal 0.35). For capital-tight banks, however, the coefficients are much smaller at 0.05 and -0.02, respectively, whereby the latter is statistically insignificant. Hence, when the host country's capital requirement becomes tighter, we expect banks to become less sensitive to tax changes. This is consistent with our theoretical hypothesis (4) and also with the findings in Keen and De Mooij (2012).

3.5 Conclusions

This paper analyzes the sensitivity of multinational bank capital structures to taxation. Using a sample of 558 commercial bank subsidiaries of 86 largest multinational banks in the world over 1998-2011 period, we find that a bank's leverage depends on corporate income taxes in two ways: (i) the traditional form of the debt bias channel, measured by the debt impact of the local tax level in the host country of a subsidiary; and (ii) international debt shifting, measured by the debt impact of the international tax difference vis-a-vis other bank subsidiaries in the same multinational parent bank. While the tax effects are statistically significant and large, the international debt shifting effect appears to be more robust and is often larger in our empirical studies than the traditional debt bias channel. It implies that tax policies around the world induce significant international debt spillovers through their impacts on multinational bank behavior.

The results raise a number of policy concerns. First, international debt spillovers could intensify the incentives for tax competition by governments, which could lead to inefficient policies. From this perspective our results strengthen the case for international tax coordination. Second, countries could seek measures to remedy international debt shifting, such as, by imposing thin capitalization rules that restrict the deductibility of interest on intra-company loans. These measures, however, generally do not apply to banks and raise the issue of specific bank regulation and bank taxation. More fundamentally, countries could consider eliminating debt bias altogether by neutralizing the tax treatment of debt and equity, e.g., by introducing an allowance for corporate equity?as Belgium, Italy, and Latvia have done. In principle, such an allowance could be applied specifically to the banking sector alone. Finally, capital requirements can play a role for the impact of taxation. The results in this study, for instance, suggest that banks become less responsive to tax changes if their equity is closer to the minimal capital requirement. The interaction of bank taxation and regulation is thus important for developing appropriate policy responses to debt bias.

CHAPTER 4

A TALE OF TWO COUNTRIES: SOVEREIGN DEFAULT, EXCHANGE RATES, AND TRADE

4.1 Introduction

Establishing a theoretical link between sovereign default and international trade is important, not only because the empirical literature has often noted that trade is affected by sovereign default through mechanisms upon which economists still lack consensus, but also because in return default occurrences can be influenced by trade ties too (Rose, 2005). In principle, the reduction in trade following a debt default could come from restrictive measures imposed by the country of residence of the investors. This is the assumption often made by the theoretical debt literature. However, there is little historical record of countries imposing quotas or embargoes on a country that falls into default (Tomz, 2007). In addition, Borensztein and Panizza (2008) show in their empirical analysis that despite trade and trade credit are negatively affected by default as in Kaletsky (1985), controlling for trade credit does not modify the effect of default on trade.

This paper argues that a currency crisis (or drastic exchange rate depreciation) frequently coincides with default[1], and it is a major reason for trade changes. In default, the country's terms of trade deteriorates, which means that more domestic production is diverted towards exports in exchange for the same amount of imports. My model captures the following feature of the external sector in default: rising exports and declining imports so that households of default

[1] Reinhart (2010) shows most time inflation crises company defaults; Reinhart and Rogoff (2011) finds that in merging markets the correlation of the share of countries with inflation and currency crises is about 75 percent during 1950-2009.

country consume less. Moreover, if a sovereign government internalizes its citizens' desire for imported goods, averting the currency depreciation caused by default motivates the country to keep its debt service on time. Hence, international trade ties matter to sovereign default.

Additionally, this paper finds that currency depreciation during default periods is also the main cause for output loss upon default. As shown in Figure C.1, during Iceland's default in 2007, at most one third of the post-default output loss actually comes from reduced production activities. This is also true for the default episodes in the Philippines, Indonesia, Argentina, Mexico, and so on. For some of the default countries, GDP volume actually had positive growth. Only because of exchange change depreciations, their output value declined (e.g., Brazil).

However, quantitative models typically treat sovereign default in isolation of a currency crises or other crises. In those models, default triggers restrictions to access to international credit and an output loss. While the assumption of post-default restricted access to international credit is reasonable, it is unclear in those models the output loss is due to currency depreciation or decreased production volume. Those models do not incorporate exchange rates. In this spirit, I introduce a two-open-economy model with exchange rate and international goods trade, in which default does not affect domestic production volume but national income and relative price making imported goods more expensive.

This paper sets out to make three main contributions. First, new insights into how sovereign defaulters are punished are proposed in this paper, that is through exchange rate depreciation. This is particularly important because there is no codified rule for dealing with defaulters. It is ambiguous in the literature that trade sanctions and reputation penalty could explain default occurrence and post-default phenomena. However, frequently currency crises and inflation accompany sovereign defaults due to capital flight. The resulting exchange rate and trade changes can be significant sources of penalty to defaulters in a connected world. Second and subsequently, through the analysis of post-default exchange rate changes, we can understand how a countrys preferences for imports and foreign demand for its exports affect its propensity to default. Past research suggests that less outward-oriented sovereigns might be more willing to default. By changing the relative preference for imported goods, researchers can begin to consider how a country revolt with a reduced desire for foreign goods might spur default.

Third, empirical evidence has pointed to the trade impacts of sovereign defaults, but little has been done theoretically, especially with explicit export and import preferences and welfare analysis of two countries. This paper intends to make some progress along this dimension. I develop a dynamic stochastic general equilibrium (DSGE) model of two open economies trading goods and capital with each other with endogenous default risk. The model helps us to gain insights about the relationship between international capital and goods flows in an incomplete market.

I find that upon occurrence of default, defaulting country suffers from negative exchange rate shocks, its domestic goods consumption drops slightly and imports (i.e. creditor country's exports) decline more drastically due to worsened terms of trade. Creditor country's domestic goods consumption also drops slightly and imports (i.e. defaulting country's exports) increase, but overall the creditor country's welfare decreases.

This paper proceeds first by reviewing the literature briefly, then examining the empirical data on exchange rates and goods trade, and lastly presenting a two-open-economy model and examining the implications of its results.

4.1.1 Literature

This study starts off from earlier work on sovereign default in a small economy. At its root, the model follows the tradition of Eaton and Gersovitz (1981) and Arellano (2008), in which a borrowing country's income can only be buffered by defaultable bonds. However, this paper differs from the aforementioned in three aspects. First, taking away income in default is motivated by empirical findings that output value often falls upon default. In previous works the typical default penalty is a simple output loss without distinguishing volume loss or value loss.[2] In my model, terms of trade deteriorate upon default, reducing defaulter's total income (i.e. output value not volume) and import purchasing power at the same time. This is consistent with data.

Second, I study how default may affect international goods trade through the exchange rate channel, as well as the creditor's welfare. Previous models have no explicit role for the international flow of goods; because there is no demand for international goods, only international borrowing, financial autarky only hurts the defaulter, leaves no harm on the creditor, which is not the case in reality.

[2] In Arellano (2008), default is punished by losing a fixed percentage of output up to a threshold.

4.1.2 Patterns of Exchange Rates in Default

In Popov and Wiczer (2009) Table 1, the authors present the gross changes over a year for default countries' nominal effective exchange rate (NEER) and real effective exchange rate (REER). They show that countries in default suffer a consistent depreciation of around 10 percent, no matter it is NEER or REER. They also find that even at high frequency, the depreciation is abrupt upon default. In Figure C.2, I use REER dynamics in Iceland as an example. According to Reinhart (2010), Iceland defaulted from 2007-2010, and at that time they have been having a free floating exchange rate regime. Upon default, its REER depreciated significantly for about 30 percent.

There could be multiple reasons for the coinciding currency depreciation. For instance, foreign capital may flee when a country defaults, causing depreciation. My model does not include how exchange rate depreciation happens following a default, but takes it as an exogenous shock. The focus of this paper is to study the trade impact of default via this exchange rate channel, as well as a country's default incentive given the trade tie.

4.1.3 Patterns of Trade in Default

Sovereign default also brings adjustments to trade, in terms of both volume and a percentage of GDP. Rose (2005) documents that defaults reduce real bilateral trade value by 8 percent for an extended period after the event. However, it does not take into account exchange rate fluctuations. I show in Figure C.3 that the export and import status in Iceland after defaults. A clear pattern emerges: export volume rise and import volume decline (at least during the first year of default). This can be related to exchange rate changes from last subsection. Due to the post-default currency depreciation, domestic households substitute away from imports; whereas foreign households find defaulting country's exports become cheaper than before, thus exports increase. Moreover, when looking at trade values, Figure C.3 shows that both exports and imports decline, so now we know the decrease in exports is due to exchange rate depreciation.

4.2 Model

My model characterizes the equilibrium outcome of trading interactions between two risk-averse countries. It starts off from Arellano (2008), but extends the commodity space to domestic and foreign goods and two countries. Consider a world with two open economies with endowments: a natural lender and a natural borrower. Each country can produce only one type of goods, so there exist two types of goods in the model. Consumers in each country enjoy both types of goods, they trade what they can produce for the goods they can't make. Specifically, country 1 is endowed with goods 1, country 2 goods 2. These goods are imperfect substitutes with constant elasticity.

Non-contingent debt denominated in good 1 is traded. The borrower country 2 could default on its debt repayment obligations to country 1. Lender country 1 is larger than country 2, and is considered to be safe and may borrow occasionally but never defaults.[3] The bond contracts reflect default probabilities that are endogenous to the borrower's incentives to default and its fundamental. Hence, the equilibrium interest rate that the borrower faces is linked

[3]If differences in size are large, then country 1 may never have an incentive to default.

to its default risk. Default can happen along the equilibrium because the asset structure is incomplete, as it includes only bonds that pay a non-contingent face value. With non-contingent assets, the risk-averse lender country is willing to offer debt contracts that in some states may result in default by charging a higher interest rate on these loans. Default entails an output cost due to currency depreciation (rather than volume decrease) and temporary exclusion from the international financial markets, but there is no punishment otherwise (i.e. no sanction on international goods trade).

C_i stands for country i's total consumption index. c_{ij} stands for country i's consumption of good j. e_j stands for total endowment of good j. p_j stands for good j's price, and let $p_1 = 1$. b^i stands for country i's assets. Both governments internalize their citizens' preferences over domestic goods and imports. α is risk aversion parameter. I also assume that each country's consumers purchase relatively larger share of their own goods, i.e., home bias; in calibration $\theta_1 > 0.5$ and $\theta_2 < 0.5$.

$$U(C_i) = \frac{C_i^{1-\alpha}}{1-\alpha} \tag{4.1}$$

Country 1:

$$C_1 = [\theta_1(c_{11})^\rho + (1-\theta_1)(c_{12})^\rho]^{\frac{1}{\rho}} \tag{4.2}$$

Country 2:

$$C_2 = [\theta_2(c_{21})^\rho + (1-\theta_2)(c_{22})^\rho]^{\frac{1}{\rho}} \tag{4.3}$$

Since only country 2 has the possibility of defaulting, it is particularly important to examine its default decision. Country 2 compares its value of repaying debt and that of default and chooses the option that gives a bigger value:

$$V_{2x}(s, b_2) = \max\{V_{2c}(s, b_2), V_{2d}(s)\} \tag{4.4}$$

where V_{2c} is country 2's optimized value under open financial market as below:

$$V_{2c}(s, b_2) = \max_{b_2', c_{21}, c_{22}} \{U(c_{21}, c_{22}) + \beta E \max[V_{2c}(s', b_2'), V_{2d}(s')]\} \tag{4.5}$$

subject to

$$p_2 e_2 + b_2 = c_{21} + p_2 c_{22} + q b_2'. \tag{4.6}$$

However, in the event of default, both countries go into financial autarky, that is, no bond is traded within a certain period of time. It is only with probability *re* that they start trading bonds again. Their goods trade continues regardless of the financial autarky. However, the defaulting country's currency will be forced to depreciate by a certain percent from its zero-bond level in each income state, i.e., $p_{2d} = p_2(s, 0) * (1 - loss)$. One can think of this as capital flight out of the country, hence the depreciation is exogenous to this current model. With this exchange rate depreciation imposed, only goods 1 market can not be cleared between the two countries. Creditor country 1 will have to save or export a small part of its product to somewhere else. Now, country 2's default value follows as:

$$V_{2d}(s) = \max_{c_{21}, c_{22}} \{U(c_{21}, c_{22}) + \beta E[re V_{2x}(s', 0) + (1 - re) V_{2d}(s')]\} \tag{4.7}$$

subject to

$$p_{2d} e_2 = c_{21} + p_{2d} c_{22}. \tag{4.8}$$

Hence, country 2 compares the value of repaying debt V_{2c} and that of default V^{2d} to choose the better value. I define the default set D is a collection of states and debt levels when country 2 will strategically choose to default to maximize its own value:

$$\mathcal{D}(s, b^2) = \{s \in S : V_{2c}(s, b_2) < V_{2d}(s)\} \tag{4.9}$$

Because no one knows which state the world is going to be in tomorrow but state transition probabilities, default probability is the sum of all the probabilities of tomorrow's occurrence of the states when country 2 may choose to default:

$$\pi_2(s', b_2') = \int_{s' \in \mathcal{D}(s', b_2')} prob(s')ds' \tag{4.10}$$

In the other half of the world, with open financial markets, country 1 maximizes its own value, taking into account country 2's possibilities of repayment or default, subject to its budget constraint:

$$V_{1c}(s, b_1) = \max_{b_1', c_{11}, c_{12}} \left\{ U(c_{11}, c_{12}) + \beta[\int_{s' \notin \mathcal{D}(s', b_2')} V_{1c}(s', b_1')dF(s'|s) + \int_{s' \in \mathcal{D}(s', b_2')} V_{1d}(s')dF(s'|s)] \right\} \tag{4.11}$$

subject to

$$e_1 + b_1 = c_{11} + p_2 c_{12} + q b_1'. \tag{4.12}$$

where

$$q(s', b_2') = \beta \int_{s' \notin \mathcal{D}(s', b_2')} \frac{\frac{\partial U}{\partial C_1'} \frac{\partial C_1'}{\partial c_{11}'}}{\frac{\partial U}{\partial C_1} \frac{\partial C_1}{\partial c_{11}}} dF(s'|s) \tag{4.13}$$

It also has to undergo financial autarky when country 2 chooses to default on sovereign debt.

$$V_{1d}(s) = \max_{c_{11}, c_{12}} \{U(c_{11}, c_{12}) + \beta E[reV_{1x}(s', 0) + (1 - re)V_{1d}(s')]\} \tag{4.14}$$

where $V_{1x} = [V_{1c}(s, b_1)$ or $V_{1d}(s)|$country 2 defaults or not].

Finally, both goods and financial (if not in financial autarky) markets clear at the end:

$$e_j(s) = c_{1j} + c_{2j}, \quad j = 1, 2. \tag{4.15}$$

$$b_1{}'(s, b_1) + b_2{}'(s, b_2) = 0. \tag{4.16}$$

Definition 1. *A recursive competitive equilibrium is defined as a set of functions for (i) borrowing and lending government-households' consumption policy c and savings policy b'; (ii) the two governments' value V at default and repayment; and (iii) law of motion for the aggregate states, such that: (i) the borrowing and lending government-households' policies satisfy the problem's first order conditions; (ii) the two governments' V satisfies Bellman's Equations; (iii) the p_2 and q clear the goods and bond markets during nondefault periods; and (v) the law of motion is consistent with the stochastic processes of e_2.*

4.3 Computation and Calibration

This paper applies a nonlinear approach and solves the optimization problems for the two countries as functions of a two-dimensional state vector (s, b) through collocation representations. For now, I use 5 grid points for state variable $b = b^1 = -b^2$ and 3 states for s (3 endowment states for borrower country 2). Starting with initial guesses for b', two countries' consumptions, term of trade and default risk, I compute all variables of interest by solving a system of nonlinear equations. New values for b', two countries' consumptions, term of trade, default risk, value functions are produced, updated and iterated until collocation coefficients convergence to changes smaller than 0.001. This problem's computational difficulty lies in the strong nonlinearity of both countries' policy functions given possible defaults, as well as calculating default probabilities. Table C.1 gives the parameter values I use in the current exercise. Note that the two countries are of different size: lender country 1 has a slightly larger economy.

4.4 Quantitative Results

This section analyzes results for the calibrated model. Figure C.4 shows the savings function and bond price schedule faced by the potential default country (country 2) in the model for two income shocks that are 5 percent above and below trend, respectively. The left panel of Figure C.4 presents the savings policy function $b'(b, e_2)$ conditional on not defaulting as a function of assets b for a high and a low income shock. Savings b' and assets b are reported as a percentage of mean output. As borrowing becomes larger, country 2 can borrows more in high income state than in low income state. This is consistent with the results from Arellano (2008).

The right panel of Figure C.4 plots the price schedule, which determines the set of contracts $q(b_2'(b_2, e_2), e_2), b_2'$ that the borrower can choose from every period. Bond prices are an increasing function of assets, making larger levels of debt carry higher interest rates. Importantly, higher income is associated with more generous financial contracts, as the interest rate charged for every loan size is lower. More interestingly, since country 2 has default possibility while country 1 does not, the latter's financial contract is much more lenient than the former's. That is, country 2's bond price becomes significantly lower than country 1's as each of their borrowing increases.

Figure C.5 plots default country's exchange rate and model generated international trade. Upon default, country 2's exchange rate depreciates, by 10 percent from the calculated currency value at zero borrowing or assets for each income state. Its export volume slight increases, while imports volume decreases more drastically. This is consistent with what we see in the data. Figure C.6 reports trade value and it as a percentage of GDP. Both export and import values decline after default, because of decreased imports and exchange rate despite of risen exports. This is consistent with the data. But as a percentage of GDP, the rise of imports is not as in the data. I also notice that high income state comes with higher trade-to-GDP ratio, this is in line with the results earlier that high income state comes with higher trade volume. Last but not least, in this model, the more a country exports the less it has to save.

The default also affects creditor country 1, whose welfare function is plotted in Figure C.7 with respect to its own asset level b_1. We can see that as country 1 accumulates asset, at first the welfare goes up for no default has happened yet, but then goes down upon the other country's default.

4.5 Conclusion

This paper models the trade impact of endogenous default in a stochastic dynamic framework of two open economies that features incomplete markets and currency crisis. In the model, exchange rate collapses due to default, therefore affecting trade. It predicts post-default deteriorating imports and rising exports, which is consistent with the data. It also can be used to study creditor country's welfare, which can be affected by default at the meantime. This is the first paper incorporating both international incomplete capital markets and international goods markets in a two-risk-averse-economy setting. Next steps in this research program include exploring quantitatively the predictions of the model in explaining the real dynamics observed during past defaults.

APPENDIX A

APPENDIX FOR CHAPTER 2

Data Sources

Employment: Total private, all employees, quarterly averages, seasonally adjusted. From Bureau of Labor Statistics (BLS) Current Employment Statistics Survey (National) (CES). 1964Q1-2012Q3.

Per worker hours: Total private, average weekly hours, production/nonsupervisory employees, quarterly averages, seasonally adjusted. From BLS CES. 1964Q1-2012Q3.

Hourly wage: Total private, average hourly earnings of production/nonsupervisory employees, 1982-84 dollars. From BLS CES. 1964Q1-2012Q2.

Consumption and investment: Chained 2005 dollars, seasonally adjusted. From Bureau of Economic Analysis (BEA) National Income and Product Accounts (NIPA) Table 1.1.6. 1964Q1-2012Q2.

GDP: seasonally adjusted at annual rates. From BEA NIPA Table 1.3.5. 1964Q1-2012Q2.

Price index: 2005=100, seasonally adjusted. From BEA NIPA Table 1.3.4. 1964Q1-2012Q2.

End-of-period debt stock (b_{t+1}/R_t): Initial debt stock (1951Q4, from LA144104005.Q) + Nonfinancial business; credit market instruments; liability (LA144104005.Q) + its net increase (FA144104005.Q). From Federal Reserve System, Flow of Funds Accounts. 1964Q1-2012Q2.

Dividends: Farm business; net dividends paid (FA136121073.Q) + Nonfinancial corporate business; net dividends paid (FA106121075.Q) - Nonfinancial noncorporate business; proprietors' equity in noncorporate business (net worth) (FA112090205.Q) - Nonfinancial corporate business; corporate equities; liability (FA103164103.Q). From Federal Reserve System, Flow of Funds Accounts. 1964Q1-2012Q2.

Capital stock: Initial capital stock (1951Q4, from NIPA Table 5.7.5A + NIPA Table 6.1) + Nonfinancial business; total capital expenditures (FA145050005.Q) - Nonfinancial business; consumption of fixed capital, equipment, software, and structures, current cost basis (FA146300005.Q). From NIPA, and Federal Reserve System, Flow of Funds Accounts. 1964Q1-2012Q2.

Federal funds effective rate: Quarterly. From Federal Reserve System, data series H15/H15/RIFSPFF N.M. 1964Q1-2012Q2.

Bond yield: Bank of America Merrill Lynch US Corporate Master Effective Yield, daily. Available at http://research.stlouisfed.org/fred2/data/BAMLC0A0CMEY.txt. Together with the Federal funds effect rate, I estimate the annual bond interest rate to be about 8.49 percent. December 31st 1996-October 9th 2012.

Overtime: Manufacturing, average weekly overtime, production/nonsupervisory employees, quarterly averages, seasonally adjusted. From BLS CES. 1964Q1-2012Q2.

Benefit costs: (1) NIPA Table 7.8 Supplements to Wages and Salaries 1929-2011, total benefit costs per year; (2) Chamber of Commerce Employee Benefits

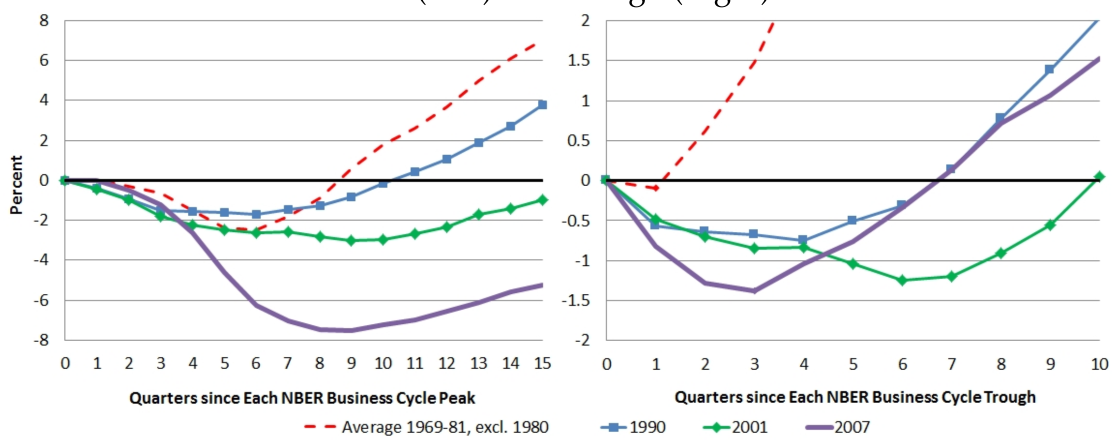
Study 1963-2007, per worker benefit costs per year; (3) BLS Employer Costs for Employee Compensation (ECEC) 1986-2011, per hour benefit costs, all workers, private industry, annual data; (4) BLS Employment Cost Index (ECI) 1980Q1-2012Q2, per hour benefit costs. All series are converted to per worker benefit costs by the author with the BLS employment and per worker hours data.

Training cost: (1) Oi (1962), with the 1951 study by the International Harvester Company, (2) Manning (2010) Table 2, and (3) BLS 1995 Survey of Employer Provided Training (Employee Results) at http://www.bls.gov/news.release/sept.nws.htm.

Credit market tightness: The measures of credit market tightness used to construct panels in Figure A.3 are from Federal Reserve Board and CEIC database. In particular, the left panel data are from the Net Percentage of Domestic Respondents Tightening Standards for Commercial and Industrial Loans for Small and Large Firms obtained from the Senior Loan Officer Opinion Survey on Bank Lending Practices from the Federal Reserve Board. The right panel data are from CEIC's data series 57229201, U.S. Quarterly Seasonally Adjusted Nonfinancial Business Corporate Debt Flow, and data series 211484102, U.S. Quarterly Seasonally Adjusted Nominal GDP.

Figure A.1: Cumulative Employment Growth since Each NBER Business Cycle

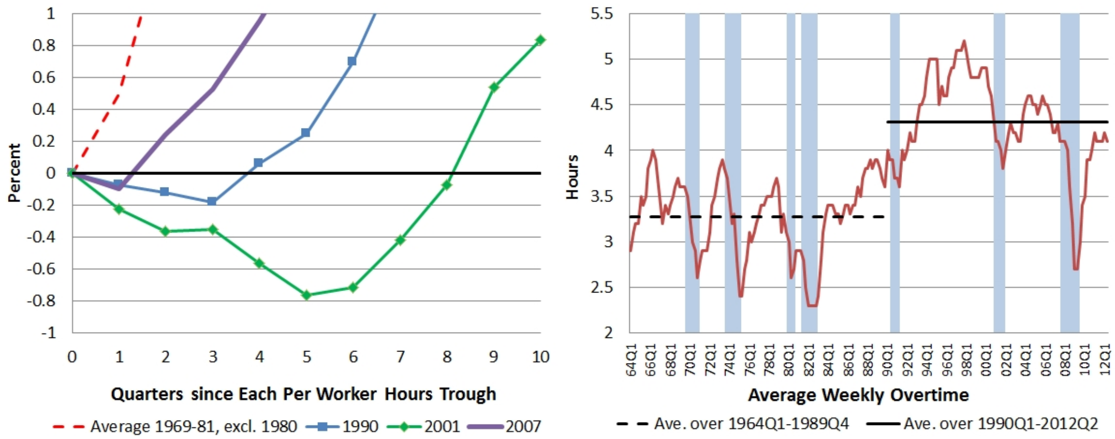
Peak (Left) and Trough (Right)



Source: Bureau of Economic Analysis (BEA), National Income and Product Accounts (NIPA), Bureau of Labor Statistics (BLS) Current Employment Statistics Survey (National) (CES), and author's calculations.
Takeaway: Left: employment dropped more deeply in the last recession and recovered more slowly following all of the post-1990 recessions, than the pre-1990 period. Right: employment recovered 3-6 quarters later relative to output recoveries during the post-1990 period, different from before.

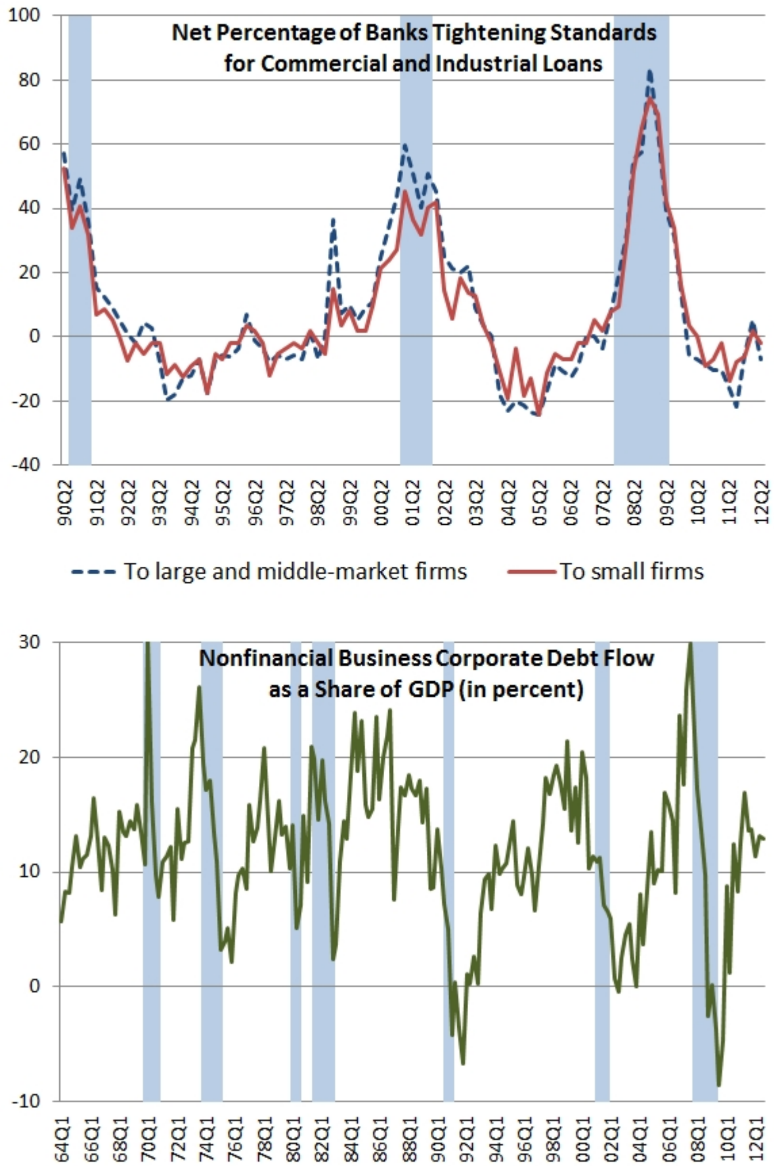
Figure A.2: Left: Cumulative Employment Growth since Per Worker Hours Troughs

and Right: Average Weekly Overtime (1964Q1-2012Q2, Quarterly)



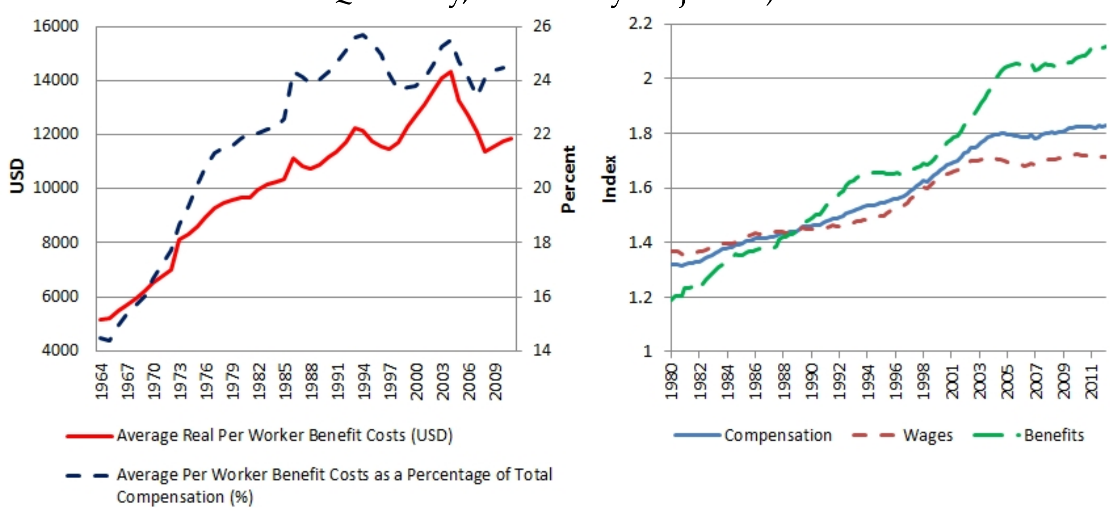
Source: Left panel: NIPA, CES, and author's calculations. Right panel: BLS, NIPA, and author's calculations.
Takeaway: Left: employment recovered 1-5 quarters later relative to per worker hours recoveries following all of the post-1990 recessions. Right: average weekly overtime has trended up since 1990, implying a changed tradeoff between employment and hours.

Figure A.3: Financial Conditions (Seasonally Adjusted)



Source: Senior Loan Officer Opinion Survey on Bank Lending Practices from the Federal Reserve Board, and CEIC.
Takeaway: (1) Top panel shows credit supply, which tightens during recessions and gradually loosens in recent recoveries. (2) The bottom panel depicts for longer period de-facto procyclical credit conditions through debt flows as a percentage of GDP, which have recovered relatively slowly after 1990 and 2001 recessions.

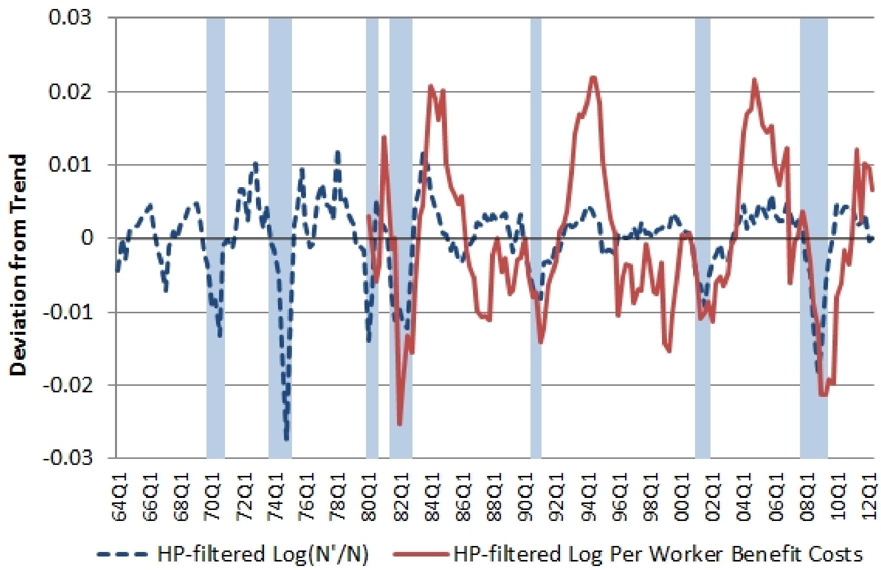
Figure A.4: Left: Real Per Worker Benefit Costs (1964-2011, Annual) and Right: Real Employment Cost Index (Private Sectors, 1980Q1-2012Q2, Quarterly, Seasonally Adjusted)



Source: Left panel: NIPA Table 7.8 Supplements to Wages and Salaries 1929-2011, Chamber of Commerce Employee Benefits Study 1963-2007, BLS Employer Costs for Employee Compensation (ECEC) 1986-2011, and author's calculations. Right panel: BLS Employment Cost Index (ECI) and author's calculations.
Note: Left panel: Real per worker benefit cost series are calculated by the author using NIPA, Chamber of Commerce, and BLS data, respectively, deflated by the NIPA GDP price index, and then averaged over the three series. NIPA's wage and salary data is used in producing per worker benefit costs as a percentage of total compensation. Right panel: Real employment index is deflated by NIPA GDP price index.
Takeaway: Left: benefit costs have been trending up. Right: benefit costs have been growing faster than wage has.

Figure A.5: Employment Changes and Real Per Worker Benefit Costs

(1964Q1-2012Q2, Seasonally Adjusted, HP-filtered)



Source: NIPA, CES, BLS Employment Cost Index (ECI), and author's calculations.
Note: Benefits data starts from 1980Q1. N is employment while N' is next period employment. Throughout this paper, Hodrick-Prescott (HP) filter uses a smoothing parameter of 1600.
Takeaway: (1) Benefit costs have cyclical components; they increase at the beginning of recoveries and decrease during recessions. (2) The cyclical components of benefit costs and employment growth are positively correlated. (3) Their correlation has changed since 1990, that is, given the same percentage increase of the benefit costs above their trend, employment growth has become smaller.

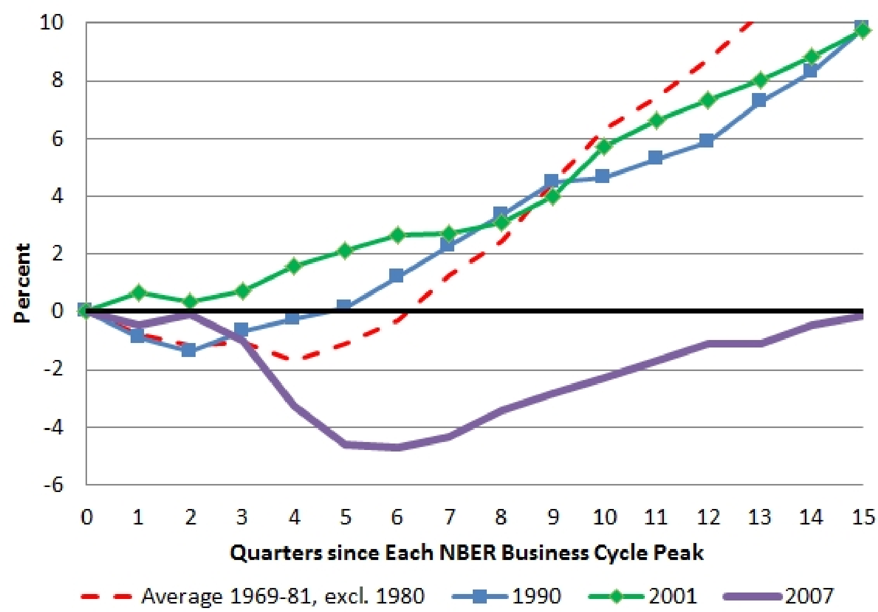
Table A.1: Employment-Based Benefits as a Percentage of Total Compensation

(Private Industries, in Percent, 2012)

Legal required payments	**8.3**
Social security	4.7
Medicare	1.2
Workers' compensation (for work related illness)	1.5
Unemployment insurance*	0.9
Retirement	**3.6**
Employment costs based on benefit formulas (defined benefit plans)*	1.5
Employer costs proportional to earnings (defined contribution plans)	2.1
Insurance (medical, life)*	**8.2**
Paid vacations, holidays, sick and personal leave*	**6.8**
Others	**2.9**
Total	**29.8**

Source: BLS, "Employer Costs for Employee Compensation - December 11, 2012," Table 5, news release USDL-12-2404.
Note: Items with a superscript asterisk are considered purely quasi-fixed, about 60 percent of total benefit costs (Ehrenberg and Smith, 2012).

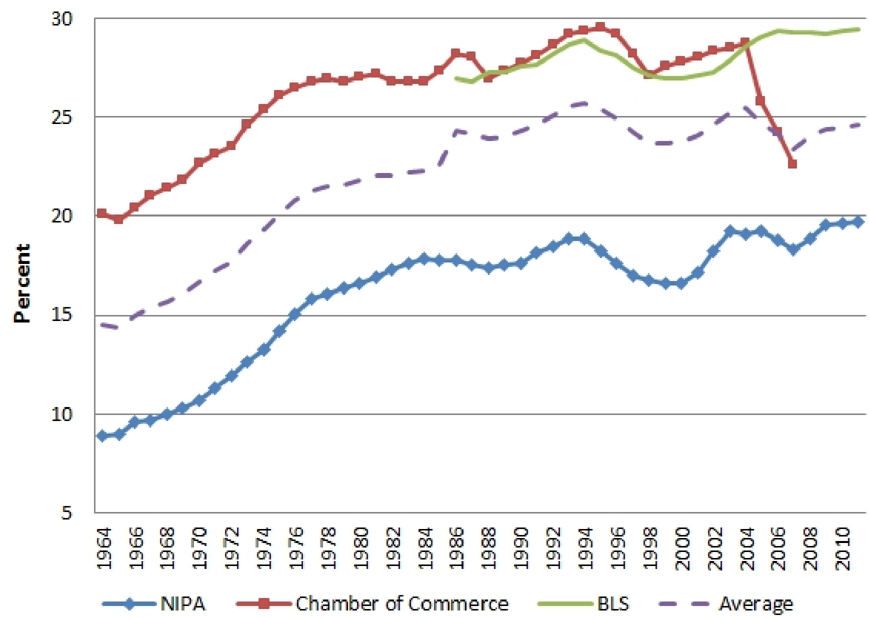
Figure A.6: Cumulative Output Growth since Each NBER Business Cycle Peak



Source: NIPA, BLS CES and author's calculations.
Takeaway: Only following the Great Recession, output has recovered much more slowly than the pre-1990 period; the 1990 and 2001 output recoveries were just as fast. But all post-1990 recessions were followed by slower employment recoveries than before. This implies that output-employment relationship has changed since then.

Figure A.7: Per Worker Benefits as a Percentage of Total Compensation

(1964-2011, Annual)



Source: NIPA Table 7.8 Supplements to Wages and Salaries 1929-2011, Chamber of Commerce Employee Benefits Study 1963-2007, Bureau of Labor Statistics (BLS) Employer Costs for Employee Compensation (ECEC) 1986-2011, and author's calculations.
Note: Real per worker benefit cost series are calculated by the author using NIPA, Chamber of Commerce, and BLS data, respectively, deflated by the NIPA GDP price index, and then averaged over the three series. NIPA's wage and salary data is used in producing per worker benefit costs as a percentage of total compensation.

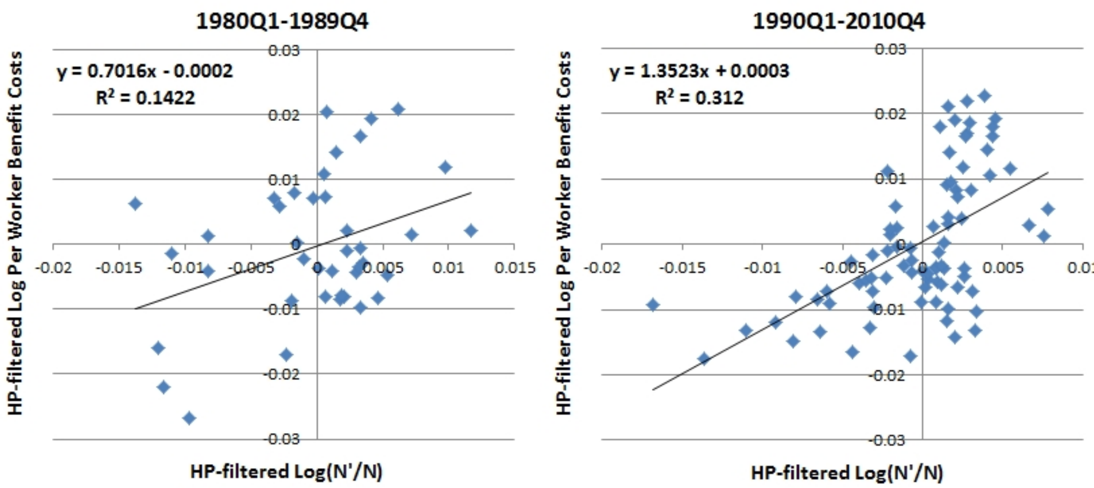
Table A.2: Quasi-fixed Employment Costs as a Percentage of Total Wages $\phi/(\overline{w}\overline{h})$

	Pre-1990			Post-1990		
	Min	Ave.	Max	Min	Ave.	Max
Benefits	16	26	37	22	33	38
Training	7	7	7	9	66	156
Total	23	33	44	31	99	194

Source: Oi (1962) with the 1951 study by the International Harvester Company; Manning (2010) Table 2; BLS 1995 Survey of Employer Provided Training (Employee Results) at http://www.bls.gov/news.release/sept.nws.htm; and author's calculations.
Note: See the Parameterization section for the calculation details. The average benefits and the maximum total for the pre-1990 and the post-1990 periods are the values used in the model simulations.

Figure A.8: Scatter Plots of HP-filtered Log Benefit Costs

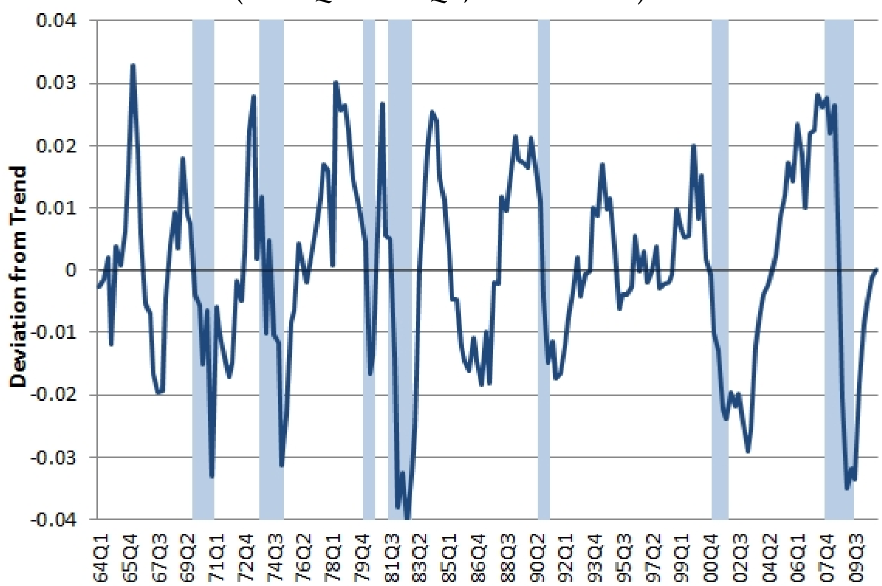
and HP-filtered Log Employment Growth



Source: NIPA, CES, BLS ECI, and author's calculations.
Note: N is employment while N' is next period employment.
Takeaway: The relationship between the cyclical components of benefit costs and employment growth indeed has changed since 1990, that is, given the same percentage increase of the benefit costs above their trend, employment growth has become smaller, i.e., g becomes larger.

Figure A.9: Financial Conditions ε_t

(1964Q1-2010Q4, HP-filtered)



Source: Author's calculations.
Note: See the Parameterization section for the calculation details.
Takeaway: Tight financial conditions have prolonged progressively into recent recoveries.

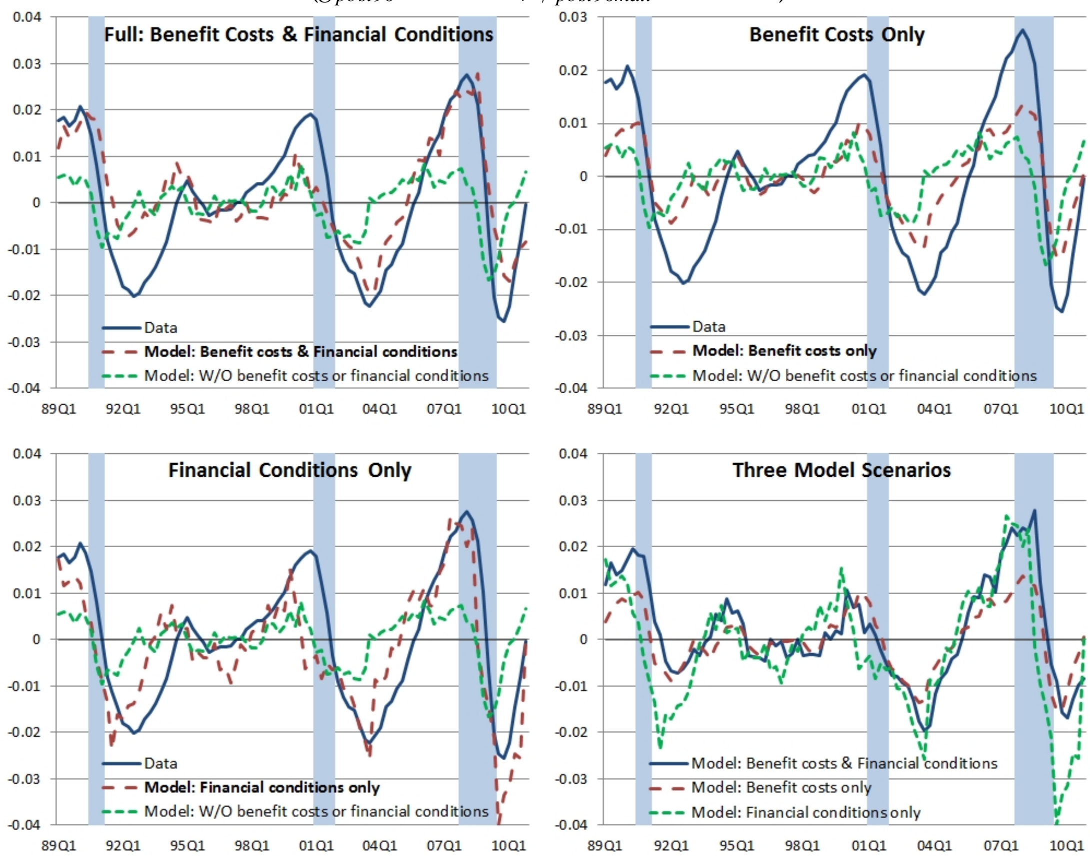
Table A.3: Parameterization

Description	
Discount factor	$\beta = 0.9798$
Utility parameter	$\alpha = 1.2285^{*}$
Labor share	$\theta = 0.7213$
Employment share	$a = 0.8428^{*}$
Elasticity of substitution parameter	$\gamma = -2$
Depreciation rate	$\delta = 0.0250$
Tax advantage	$\tau = 0.3500$
Steady-state Financial Condition	$\bar{\varepsilon} = 0.1989$
Steady-state average benefit costs before 1990	$\phi_{pre90ave} = 0.0607$
Steady-state maximum quasi-fixed costs before 1990	$\phi_{pre90max} = 0.1027$
Steady-state average benefit costs after 1990	$\phi_{post90ave} = 0.0778$
Steady-state maximum quasi-fixed costs after 1990	$\phi_{post90max} = 0.4527$
Benefits-employment relationship before 1990	$g_{pre90} = 0.7016$
Benefits-employment relationship after 1990	$g_{post90} = 1.3523$
Financial structure adjustment cost parameter	$\kappa = 5$
Standard deviation of the productivity shock	$\sigma_z = 0.0086$
Standard deviation of the financial shock	$\sigma_\varepsilon = 0.0108$
Matrix for the shock process	$\begin{pmatrix} 0.8283 & 0.0146 \\ -0.0896 & 0.9170 \end{pmatrix}$

Source: See the Parameterization section for the calibration details.
Note: The parameters with $*$ vary slightly with the different values of ϕ. The Values reported in this table are the ones used for the regime where $g_{post90} = 1.3523$ and $\phi_{post90max} = 0.4527$. The shock process matrix's eigenvalue modulus is 0.8471, thus the shock process is stationary.

Figure A.10: Employment Cycle Results, Post-1990

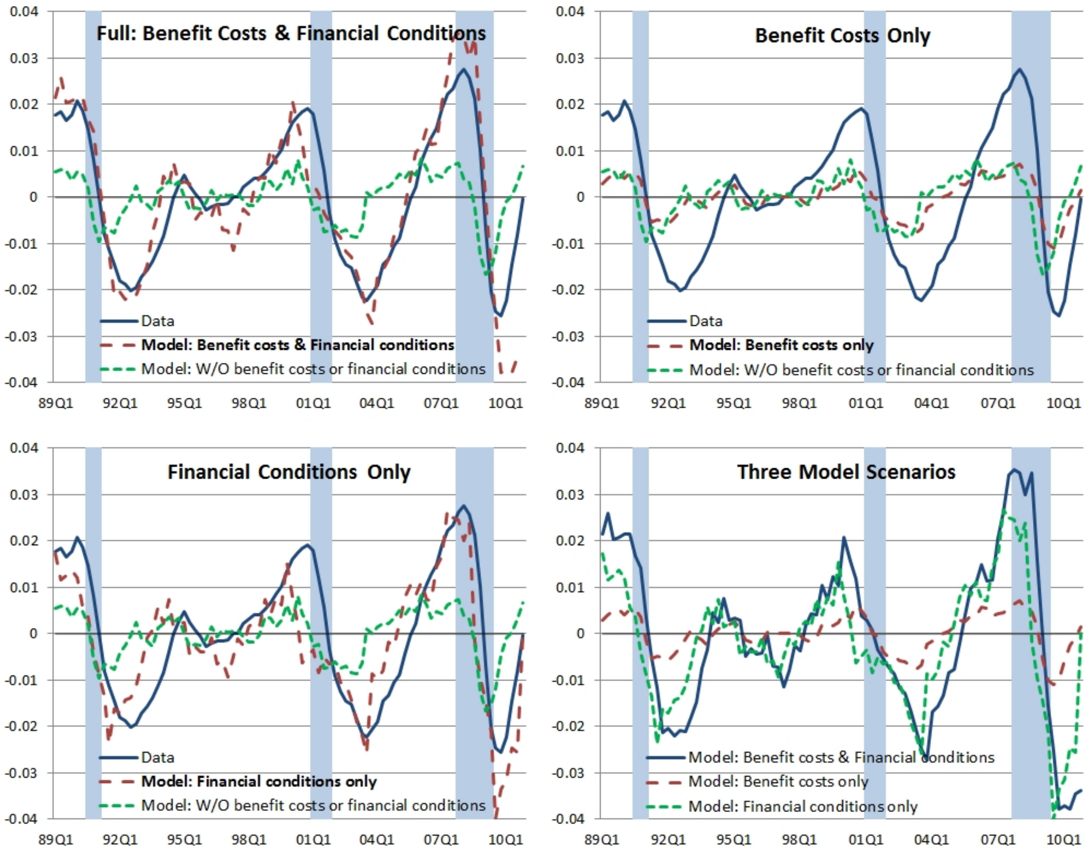
$(g_{post90} = 1.3523, \phi_{post90max} = 0.4527)$



Source: BLS, and author's calculations.
Note: The data is HP-filtered. All results include productivity shocks.
Takeaway: My full model results with both benefit cost and financial condition mechanisms best match with the employment data. The model results with only benefit costs match well with the timing delay of employment recoveries, but not as well for employment volatility. The volatility is improved by further including financial conditions and thus the interactions between the two mechanisms.

Figure A.11: Employment Cycle Results, Post-1990

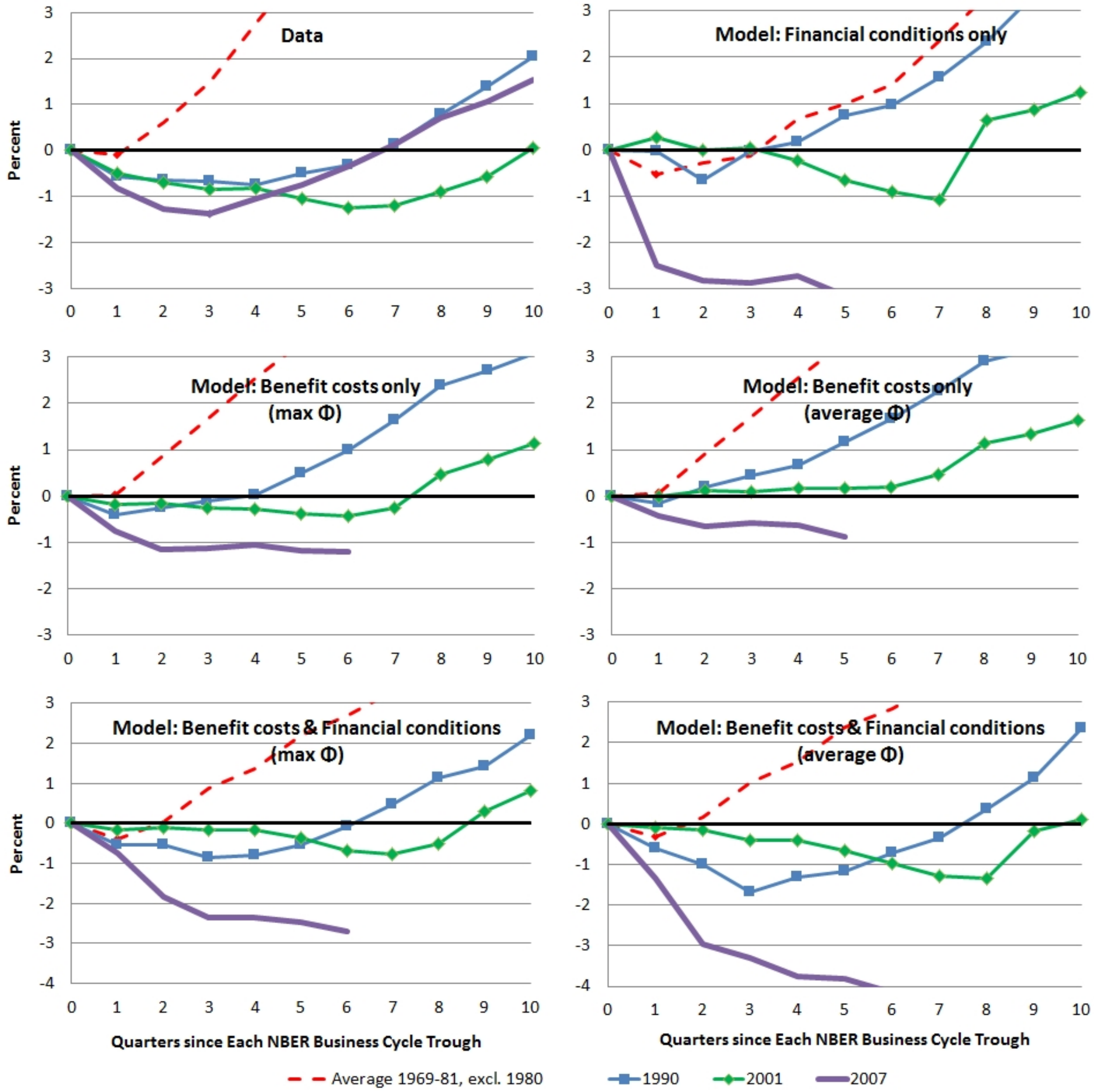
$(g_{post90} = 1.3523, \phi_{post90ave} = 0.0778)$



Source: BLS, and author's calculations.
Note: The data is HP-filtered. All results include productivity shocks.
Takeaway: The model results are marginally affected by a more moderate estimate of benefit costs.

Figure A.12: Cumulative Employment Growth Results

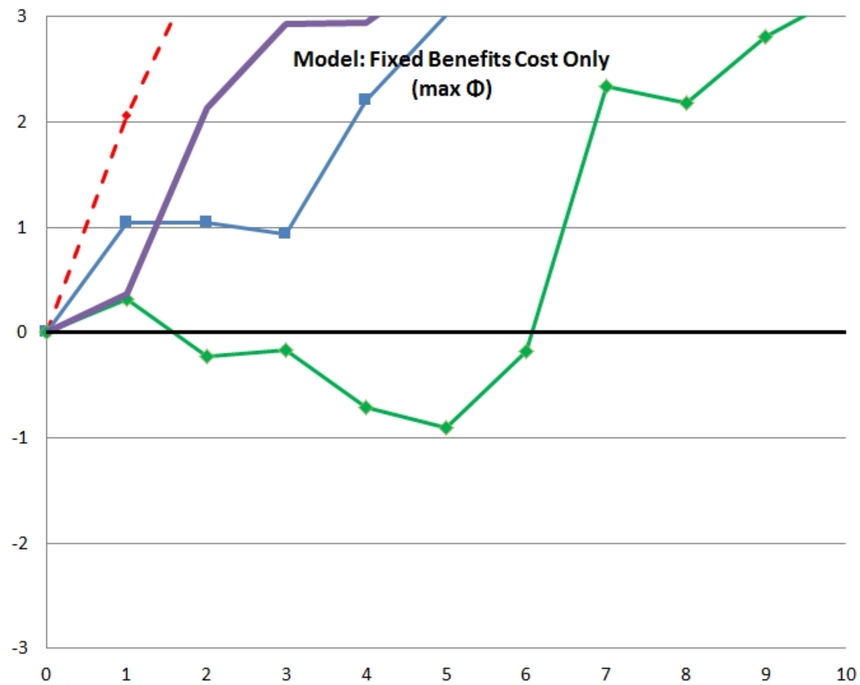
since Each NBER Business Cycle Trough



Source: BLS, and author's calculations.
Note: Employment growth results are based on the modeled employment which is calculated by adding the data trend to the model-generated cyclical components of employment. For the model results with maximum ϕ, the pre-1990 results use $\phi_{pre90max} = 0.1027$ and the post-1990 results use $\phi_{post90max} = 0.4527$. For the model results with average ϕ, the pre-1990 results use $\phi_{pre90ave} = 0.0607$ and the post-1990 results use $\phi_{post90ave} = 0.0778$. All results include productivity shocks.
Takeaway: The delays of employment recoveries are driven by both benefit cost mechanism and financial conditions in this model. With $\phi_{post90max}$, the model generates 3-to-7-quarter delays, very close to 3-6 quarters in the data. With $\phi_{post90ave}$, the model results remain, even though the delays are slightly shortened and volatility is weakened.

Figure A.13: Cumulative Employment Growth Results

since Each NBER Business Cycle Trough



Source: BLS, and author's calculations.
Note: Employment growth results are based on the modeled employment which is calculated by adding the data trend to the model-generated cyclical components of employment. In this plot, the model results use maximum ϕ, the pre-1990 results use $\phi_{pre90max} = 0.1027$ and the post-1990 results use $\phi_{post90max} = 0.4527$. All results include productivity shocks, particularly the results here do not include financial conditions nor use $n\prime$.
Takeaway: Cyclical benefit costs generate much better results than fixed benefit costs.

Figure A.14: Impulse Responses to One-Time Productivity Shock

$(g_{post90} = 1.3523, \phi_{post90max} = 0.4527)$

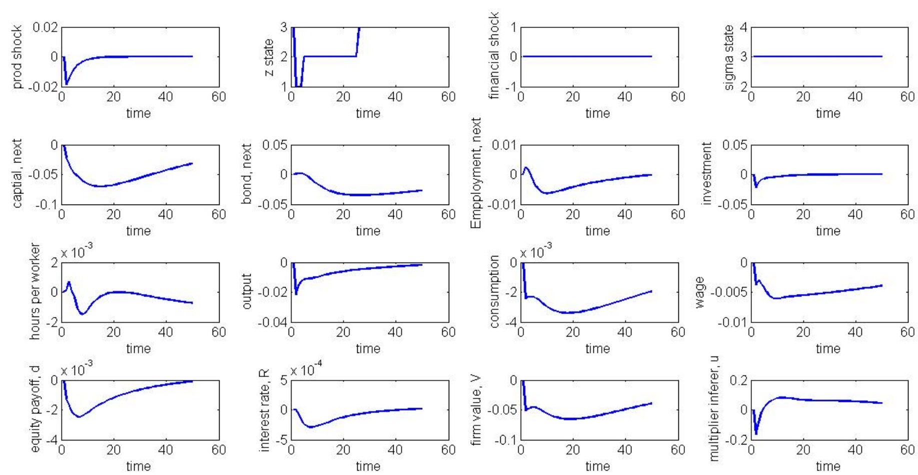


Figure A.15: Impulse Responses to One-Time Financial Shock

$(g_{post90} = 1.3523, \phi_{post90max} = 0.4527)$

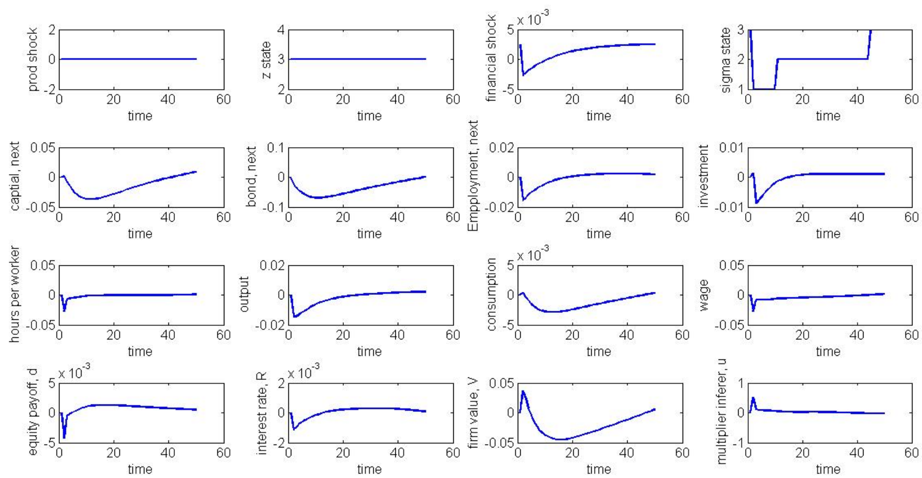
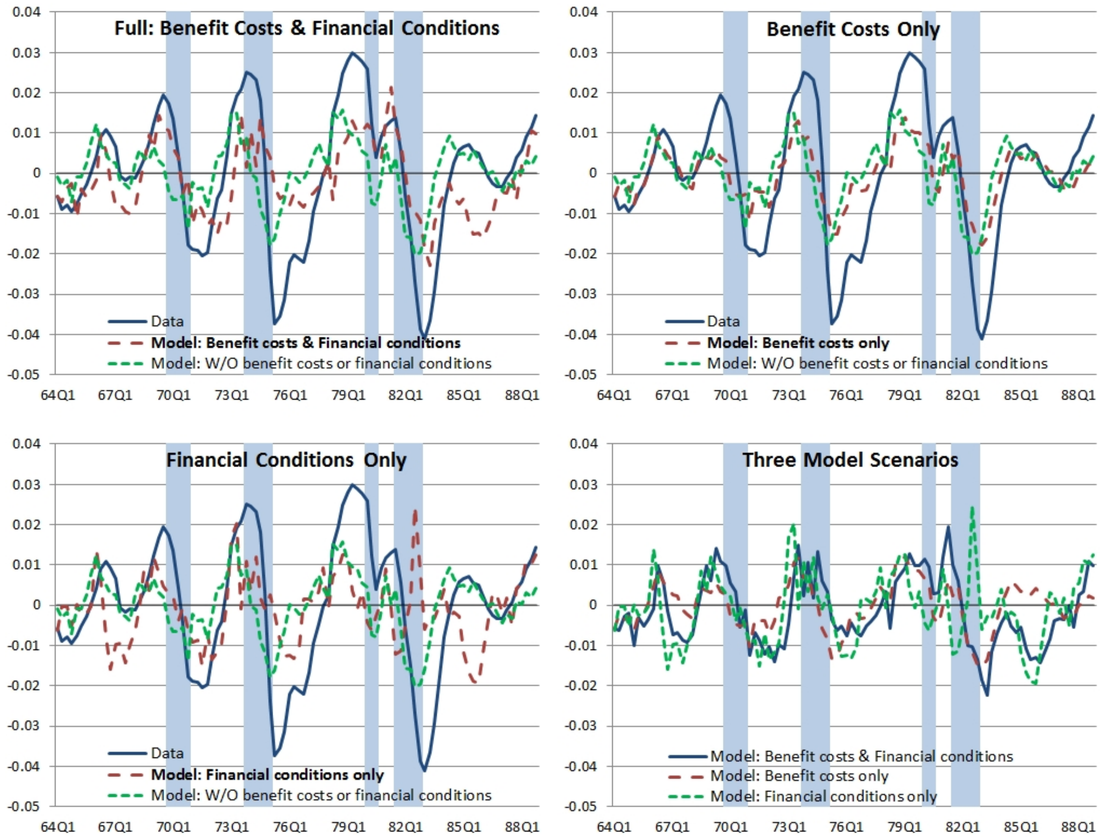


Figure A.16: Employment Cycle Results, Pre-1990

($g_{pre90} = 0.7016$, $\phi_{pre90max} = 0.1027$)



Source: BLS, and author's calculations.
Note: The data is HP-filtered. The model using average $\phi_{pre90ave} = 0.0607$ generates very similar results. All results include productivity shocks.

Table A.4: Business Cycle Standard Deviations, 1990-2010

		Model		
	(1) Data	(2) Full (ϕ_{max})	(3) Full (ϕ_{ave})	(4) No Friction
Output	0.0149	0.0186	0.0235	0.0161
Employment	0.0142	0.0133	0.0172	0.0054
Per Worker Hours	0.0042	0.0103	0.0236	0.0054

Source: BLS, and author's calculations.
Note: No Friction refers to the standard model without benefit costs or financial conditions. The data is HP-filtered.

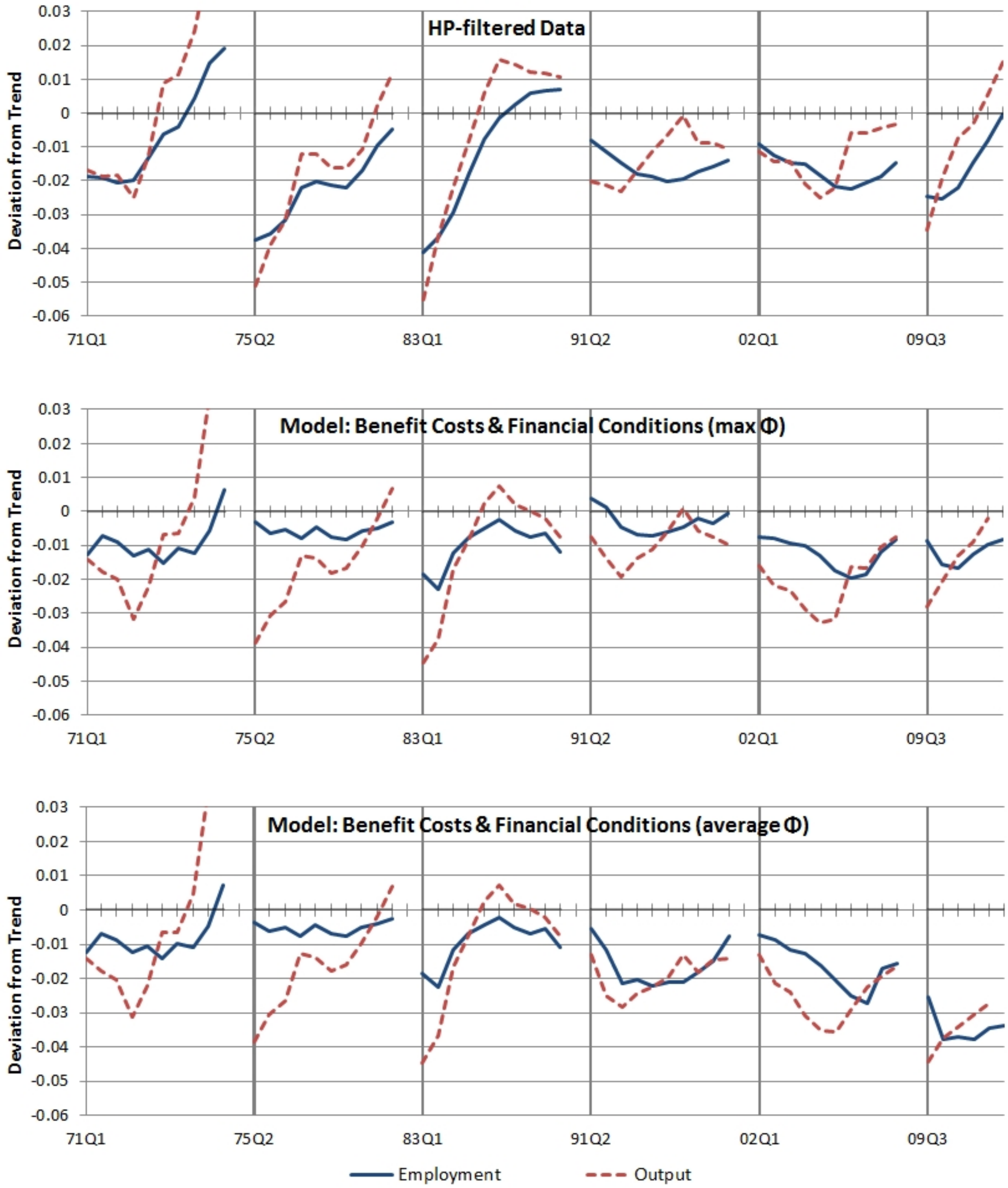
Table A.5: Business Cycle Standard Deviations, 1964-1989

		Model		
	(1) Data	(2) Full (ϕ_{max})	(3) Full (ϕ_{ave})	(4) No Friction
Output	0.0235	0.0201	0.0201	0.0229
Employment	0.0166	0.0093	0.0088	0.0076
Per Worker Hours	0.0047	0.0154	0.0146	0.0076

Source: BLS, and author's calculations.
Note: No Friction refers to the standard model without benefit costs or financial conditions. The data is HP-filtered.

Figure A.17: Employment and Output Cycle Results,

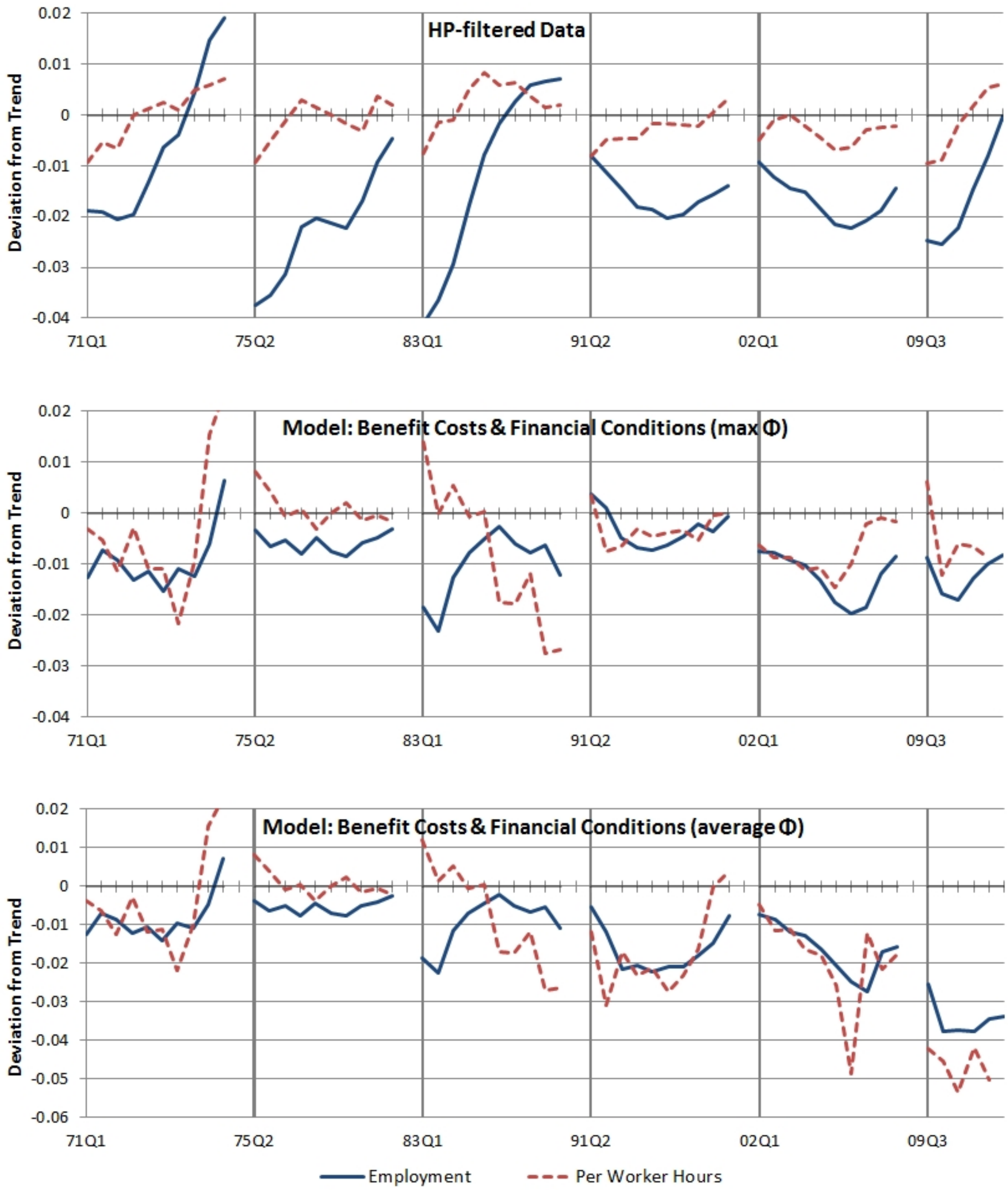
10 Quarters since Each NBER Business Cycle Trough



Source: BLS, NIPA, and author's calculations.
Note: For the model results with maximum ϕ, the pre-1990 results use $\phi_{pre90max} = 0.1027$ and the post-1990 results use $\phi_{post90max} = 0.4527$. For the model results with average ϕ, the pre-1990 results use $\phi_{pre90ave} = 0.0607$ and the post-1990 results use $\phi_{post90ave} = 0.0778$. All results include productivity shocks.

Figure A.18: Employment and Per Worker Hours Cycle Results,

10 Quarters since Each NBER Business Cycle Trough



Source: BLS, and author's calculations.

Note: For the model results with maximum ϕ, the pre-1990 results use $\phi_{pre90max} = 0.1027$ and the post-1990 results use $\phi_{post90max} = 0.4527$. For the model results with average ϕ, the pre-1990 results use $\phi_{pre90ave} = 0.0607$ and the post-1990 results use $\phi_{post90ave} = 0.0778$. All results include productivity shocks.

APPENDIX B

APPENDIX FOR CHAPTER 3

Technical Details

Consider a multinational bank operating in m countries. The multinational has one subsidiary bank in each of its host country i with total assets A_i, A_i is assumed to be given. The parent bank maximizes the sum of post-tax profits of its subsidiaries:

$\max \sum_{i=1}^{m}(1-k_i)(1-t_i)P_i - \sum_{i=1}^{m} C_i - C_p$

s.t. $P_i = l_i L_i - rB_i$,

where L_i is subsidiary-bank-made loans to borrowers with interest rate l_i and rB_i is its interest expenses from debt B_i with interest rate r; $C_i = \frac{m_i(r_{Ei})A_i b_i^2}{2}$, in which $b_i = B_i/A_i$, and $m_i(r_{Ei})$ is positive and an increasing function of the subsidiary bank's capital requirement; $C_p = \frac{g_p(r_{Ep})A_p(\sum_{i=1}^{m} b_i q_i)^2}{2}$, where $g_p(r_{Ep})$ is positive and an increasing function in the capital requirement faced by the parent bank, the parent asset $A_p = \sum_{i=1}^{m} A_i$, and $q_i = A_i/A_p$; $A_i = L_i + FA_i = B_i + E_i$, where A_i is given thus A_p is given too.

Finally, the outside owners of subsidiary bank, possessing k_i share of the subsidiary bank, require return n: $\frac{k_i P_i(1-t_i)}{E_i - FA} - 1 = n$.

Substituting constraints into parent bank's maximization problem, we can rewrite the problem as below. Parent bank maximizes with respect to L_i and B_i:

$\max \sum_{i=1}^{m}(1-t_i)L_i[l_i - \frac{1+n}{1-t_i}] - B_i[r - \frac{1+n}{1-t_i}] - \sum_{i=1}^{m} \frac{m_i(r_{Ei})A_i b_i^2}{2} - \frac{g_p(r_{Ep})A_p(\sum_{i=1}^{m} b_i q_i)^2}{2}.$

From the first order condition for B_i, we have:

$-(1-t_i)[r - \frac{1+n}{1-t_i}] - m_i(r_{Ei})b_i - g_p(r_{Ep}) \sum_{i=1}^{m} b_i q_i = 0,$

$m_i(r_E i)b_i = -(1-t_i)r + (1+n) - g_p(r_{Ep}) \sum_{i=1}^{m} b_i q_i.$

Since $\sum_{i=1}^{m} b_i q_i = b_i - \sum_{j \neq i}^{m}(b_i - b_j)q_j$, we can rewrite the above equation as:

$m_i(r_{Ei})b_i = t_i r - r + (1+n) - g_p(r_{Ep})[b_i - \sum_{j \neq i}^{m}(b_i - b_j)q_j],$

$[g_p(r_{Ep}) + m_i(r_{Ei})]b_i = t_i r - r + (1+n) + g_p(r_{Ep}) \sum_{j \neq i}^{m}(b_i - b_j)q_j.$

And because $m_i(r_{Ei})b_i - m_j(r_{Ej})b_j = (t_i - t_j)r$, thus we have:

$b_i - b_j = \frac{(t_i - t_j)r}{m_i(r_{Ei})} + b_j[\frac{m_j(r_{Ej})}{m_i(r_{Ei})} - 1].$

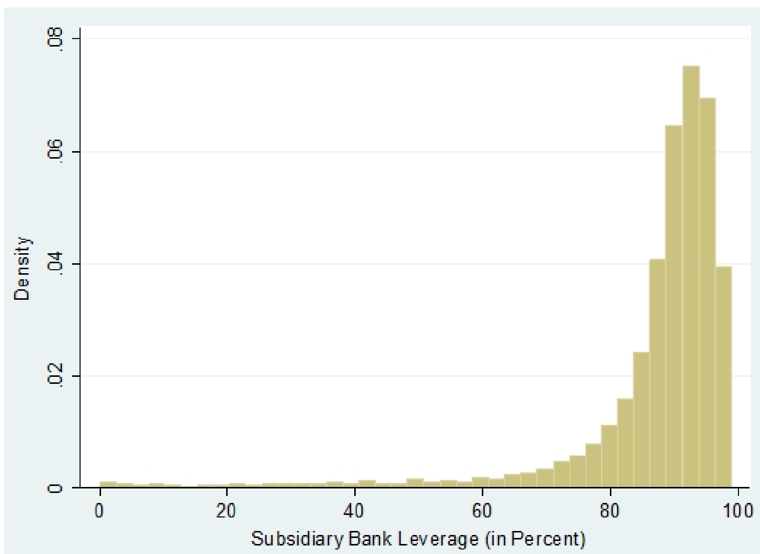
Therefore, $[g_p(r_{Ep}) + m_i(r_{Ei})]b_i = t_i r - r + (1+n) + \frac{g_p(r_{Ep})r}{m_i(r_{Ei})} \sum_{j \neq i}^{m}(t_i - t_j)q_j + \frac{g_p(r_{Ep})}{m_i(r_{Ei})} \sum_{j \neq i}^{m}[b_j(m_j(r_{Ej}) - m_i(r_{Ei}))]q_j$, and

$b_i = \lambda_{0i} + \lambda_{1i}t_i + \lambda_{2i} \sum_{j \neq i}^{m}(t_i - t_j)q_j + \lambda_{3i} \sum_{j \neq i}^{m}[b_j(m_j(r_{Ej}) - m_i(r_{Ei}))]q_j,$

where $\lambda_{0i} = \frac{1+n-r}{g_p(r_{Ep})+m_i(r_{Ei})}$, $\lambda_{1i} = \frac{r}{g_p(r_{Ep})+m_i(r_{Ei})}$, $\lambda_{2i} = \frac{g_p(r_{Ep})r}{m_i(r_{Ei})[g_p(r_{Ep})+m_i(r_{Ei})]}$, and $\lambda_{3i} = \frac{g_p(r_{Ep})}{m_i(r_{Ei})[g_p(r_{Ep})+m_i(r_{Ei})]}$.

Because λ_{1i} and λ_{2i} are positive, b_i increases with t_i and $\sum_{j \neq i}^{m}(t_i - t_j)q_j$. Moreover, since $m_i(r_{Ei})$ and $g_p(r_{Ep})$ are positive and increasing functions of r_{Ei} and r_{Ep}, respectively, the impacts of taxes on b_i, i.e. λ_{1i} and λ_{2i}, are negatively related with r_{Ei} and r_{Ep}.

Figure B.1: Subsidiary Bank Leverage Histogram



Source: Bankscope and authors' calculations.
Note: This figure presents the distribution of subsidiary bank leverage in our sample. The leverage is calculated as total-liability-to-total-assets ratio (in percent). The distribution is highly skewed to the right. Therefore, quantile regressions that give less weight to outliers should help accounting for the skewness.

Table B.1: Variable Constructions and Sources

Variable	Construction	Source
Leverage	Total liabilities ($LIAB_{it}$) / total assets (A_{it})	Bankscope
Short-term leverage	Leverage – long-term funding / Total assets	Bankscope
CIT rate	Statutory corporate tax rate	From a combined source of KPMG Corporate Tax Survey (1993-2012), OECD Tax Database (2012), and Mintz and Weichenrieder (2009).
Effective tax rate	Taxes/ Pre-tax Profit.	Bankscope
Capital tightness	(1-leverage ratio)-capital ratio requirement	Bankscope
International tax difference	$\sum_{j\neq i}^{m}(tax_{it} - tax_{jt})q_{jt} = tax_{it} - \sum_{i}^{m} tax_{it}q_{it}$, and $q_{it} = \frac{A_{it}}{\sum_{i=1}^{m} A_{it}}$	Bankscope, and see CIT rate sources
Alt.: Asset-weighted average tax	$\sum_{i}^{m} tax_{it}q_{it}$, and $q_{it} = \frac{A_{it}}{\sum_{i=1}^{m} A_{it}}$	Bankscope, and see CIT rate sources
Alt.: International tax difference with time-invariant asset-weights	$\sum_{j\neq i}^{m}(tax_{it} - tax_{jt})q_{j} = tax_{it} - \sum_{i}^{m} tax_{it}q_{i}$, and $q_{i} = mean(\frac{A_{it}}{\sum_{i=1}^{m} A_{it}})$	Bankscope
Alt.: International tax difference with liability-weights	$\sum_{j\neq i}^{m}(tax_{it} - tax_{jt})q_{jt} = tax_{it} - \sum_{i}^{m} tax_{it}q_{it}$, and $q_{it} = \frac{LIAB_{it}}{\sum_{i=1}^{m} LIAB_{it}}$	Bankscope
Log total assets	Log(total assets)	Bankscope
Square log of total assets	$[\text{Log(total assets)}]^2$	Bankscope
Profitability	Pre-tax profit / total assets	Bankscope
Total assets growth	Annual percentage change of total assets	Bankscope
Collateral	(Total security assets + total non-earning assets) / total assets	Bankscope
Non-debt tax credit	Total non-interest expenses / total assets	Bankscope
GDP growth	Annual percentage change of real GDP	IMF World Economic Outlook (WEO)
Inflation	Annual percentage change of CPI index	IMF WEO
Capital requirement	Survey item 3.1 (Minimum total capital-to-assets ratio). The database only has 2000, 2003 and 2008. In our data, 1998-2000 are the same as 2000; 2001-2003 are the same as 2003; and 2004-2011 are the same as 2008.	World Bank Regulation Survey
Deposit insurance	Dummy variable. Survey item 8.1 and 8.5, if a country has an explicit deposit insurance scheme or has any deposits not explicitly covered by deposit insurance at the time of the failure compensated when the bank failed (excluding funds later paid out in liquidation procedures), then this country's deposit insurance observation=1; otherwise 0. The database only has 2000, 2003 and 2008. In our data, 1998-2000 are the same as 2000; 2001-2003 are the same as 2003; and 2004-2011 are the same as 2008.	World Bank Regulation Survey
Financial crises	Dummy variable, with financial crisis=1.	Banking Crisis Database in Laeven and Valencia (2010)

Source: Various, see above.
Note: The sample consists of 558 subsidiary commercial banks of 86 largest multinational banks in the world for 1998-2011. The frequency of the sample is annual.

Table B.2: Summary Statistics for Subsidiaries of Multinational Banks

Variable	Obs.	Mean	St. Dev.	Min	Median	Max
Leverage (in percent)	3,905	86.74	14.70	0.52	90.70	98.98
Short-term leverage (in percent)	3,131	80.55	17.06	0.09	85.87	98.79
CIT rate (in percent)	3,905	30.78	7.55	10.00	30.00	56.05
International tax difference (in percent)	3,905	-2.13	6.53	-28.04	-0.04	23.65
Alt.: Asset-weighted average tax (percent)	3,905	32.91	5.74	15.07	33.72	56.05
Alt.: International tax difference with time-invariant asset-weights (percent)	3,905	-1.79	6.15	-28.56	-0.13	21.87
Alt.: International tax difference with liability-weights (percent)	3,905	-2.16	6.54	-28.06	-0.04	23.68
Log total assets	3,905	14.86	2.28	7.94	14.58	21.82
Square log of total assets	3,905	226.14	70.60	63.08	212.72	476.09
Profitability (in percent)	3,905	1.73	3.81	-18.46	1.26	85.81
Total assets growth (in percent)	3,905	14.22	26.79	-86.91	9.50	149.50
Collateral (in percent)	3,905	27.29	20.46	0.05	23.76	98.87
Non-debt tax credit (in percent)	3,905	4.41	10.71	0.00	2.63	321.51
GDP growth (in percent)	3,905	2.82	3.69	-17.73	2.95	21.18
Inflation (in percent)	3,905	4.20	5.17	-1.68	2.67	61.13
Capital requirement (in percent)	3,905	8.54	1.13	7.00	8.00	12.00
Deposit insurance	3,905	0.94	0.24	0.00	1.00	1.00
Financial crises	3,905	0.22	0.42	0.00	0.00	1.00

Source: See Table B.1.
Note: This table presents the summary statistics of the subsidiary bank leverage, tax variables, and other subsidiary-level and host-country-level variables. See Table 1 for the description of variables. Note that some observations have lower capital ratio (inverse of the leverage) than the minimum capital requirement; it is because we calculate leverage using total assets, instead of risk-weighted assets due to data availability. The sample consists of 558 subsidiary commercial banks of 86 largest multinational banks in the world for 1998-2011. The frequency of the sample is annual. The total number of subsidiary-year observations is 3,905.

Table B.3: Correlations among Variables

	Leverage	CIT rate	International tax difference	Alt.: Asset-weighted average tax	Alt.: International tax difference with time-invariant asset-weights	Alt.: International tax difference with liability-weights	Log total assets	Square log of total assets	Profitability
Leverage	1								
CIT rate	-0.0363	1							
International tax difference	0.0650	0.6764	1						
Alt.: Asset-weighted average tax	-0.1217	0.5454	-0.2486	1					
Alt.: International tax difference with time-invariant asset-weights	0.0728	0.7113	0.9406	-0.1350	1				
Alt.: International tax difference with liability-weights	0.0654	0.6773	0.9997	-0.2469	0.9391	1			
Log total assets	0.4228	0.0483	0.0557	0.0001	0.0218	0.0589	1		
Square log of total assets	0.3885	0.0657	0.0637	0.0139	0.0297	0.0668	0.9944	1	
Profitability	-0.3574	0.0115	-0.0697	0.0944	-0.0704	-0.0696	-0.1320	-0.1326	1
Total assets growth	0.072	-0.1113	-0.0728	-0.0635	-0.0880	-0.0721	-0.0465	-0.0510	0.0433
Collateral	-0.1256	0.0658	-0.0399	0.1319	-0.0530	-0.0383	0.1337	0.1474	0.1242
Non-debt tax credit	-0.2627	-0.0237	-0.0352	0.0089	-0.0339	-0.0361	-0.2180	-0.2029	0.2067
GDP growth	0.0145	-0.0728	-0.1057	0.0245	-0.1189	-0.1059	-0.1308	-0.1397	0.1106
Inflation	-0.0529	-0.1726	-0.1036	-0.1090	-0.1129	-0.1046	-0.2062	-0.2035	0.0896
Capital requirement	-0.0498	-0.3536	-0.2800	-0.1463	-0.2842	-0.2805	-0.1442	-0.1494	0.0345
Deposit insurance	-0.0181	0.0538	0.0517	0.0119	0.0660	0.0511	0.0915	0.0978	-0.0195
Financial crises	-0.0051	-0.0417	0.0872	-0.1541	0.0548	0.0875	0.1695	0.1788	-0.0528

	Total assets growth	Collateral	Non-debt tax credit	GDP growth	Inflation	Capital requirement	Deposit insurance	Financial crises
Total assets growth	1							
Collateral	-0.0086	1						
Non-debt tax credit	-0.0414	0.0208	1					
GDP growth	0.2341	0.0641	-0.0331	1				
Inflation	0.2165	0.0489	0.0825	0.0996	1			
Capital requirement	0.1427	0.1016	0.0997	0.1275	0.2637	1		
Deposit insurance	-0.0241	-0.041	0.0099	-0.1456	-0.0657	-0.0504	1	
Financial crises	-0.107	-0.0472	0.0774	-0.4095	-0.0601	-0.1317	0.0902	1

Source: See Table B.1.
Note: See Table B.1 for the description of variables.

Table B.4: Number of Banks in Each Country, 1998-2011

Residing Country	No. of Parent Banks	No. of Sub. Banks		Residing Country	No. of Parent Banks	No. of Sub. Banks	
		Domestic	Foreign			Domestic	Foreign
Albania	0	0	3	Kenya	0	0	3
Argentina	0	0	8	Korea	2	3	0
Armenia	0	0	2	Latvia	0	0	4
Australia	3	5	0	Lithuania	0	0	3
Austria	3	30	16	Luxembourg	0	0	37
Belarus	0	0	4	Malaysia	0	0	11
Belgium	2	23	7	Mexico	1	3	9
Bosnia and Herzegovina	0	0	4	Mozambique	0	0	1
Brazil	3	13	24	Netherlands	1	1	4
Bulgaria	0	0	3	Nigeria	0	0	2
Canada	4	24	0	Norway	1	8	5
Chile	0	0	4	Panama	0	0	4
China	3	7	14	Paraguay	0	0	3
Colombia	0	0	6	Peru	0	0	6
Costa Rica	0	0	4	Philippines	0	0	1
Croatia	0	0	7	Poland	0	0	18
Czech Republic	0	0	9	Portugal	0	0	2
Denmark	1	4	4	Romania	0	0	7
Egypt	0	0	4	Russia	3	15	31
El Salvador	0	0	2	Singapore	3	8	0
Estonia	0	0	1	Slovenia	0	0	3
Finland	0	0	2	Spain	3	37	7
France	5	95	47	Sweden	4	23	1
Germany	7	43	28	Switzerland	2	16	20
Hong Kong	2	4	0	Thailand	0	0	3
Hungary	0	0	8	Tunisia	0	0	1
India	3	12	7	Turkey	4	8	4
Indonesia	0	0	14	Ukraine	0	0	10
Ireland	0	0	4	United Kingdom	5	48	36
Italy	5	27	0	United States	11	71	60
Jamaica	0	0	3	Uruguay	0	0	4
Japan	5	30	11	Venezuela	0	0	1
Kazakhstan	0	0	4	Zambia	0	0	3
				TOTAL	**86**	**558**	**558**

Source: See Table B.1.
Note: This table lists the number of parent banks and subsidiaries in the sample. Intermediate companies, which are both parents and subsidiaries, are counted as subsidiaries only. Domestic subsidiary banks are those whose home country is also the residing country; foreign subsidiary banks are those whose home country is not the residing country.

Table B.5: Sample Averages of Bank Leverage and Tax Variables, 1998-2011

Host Country	Bank leverage	CIT rate	Intl. tax difference	Host Country	Bank leverage	CIT rate	Intl. tax difference
Albania	89.0	12.9	-17.6	Latvia	91.1	16.5	-9.6
Argentina	69.3	35.0	1.3	Lithuania	92.1	15.9	-11.6
Armenia	80.7	20.0	-5.7	Luxembourg	93.8	31.9	-1.8
Austria	90.1	28.0	0.5	Malaysia	87.6	27.2	-5.4
Belarus	88.1	25.5	0.1	Mexico	87.9	31.5	-2.4
Belgium	93.8	36.1	2.3	Mozambique	91.0	32.0	1.0
Bosnia and Herzegovina	79.5	10.0	-17.6	Netherlands	90.9	30.9	-3.6
Brazil	81.2	34.2	-0.7	Nigeria	79.5	30.0	-3.4
Bulgaria	86.2	12.0	-13.6	Norway	94.0	28.0	0.3
Chile	90.5	18.5	-11.0	Panama	90.0	31.2	-4.0
China	87.1	25.8	-4.0	Paraguay	87.9	20.8	-13.4
Colombia	87.1	34.2	0.9	Peru	89.3	29.8	-3.2
Costa Rica	88.0	30.6	-1.8	Philippines	86.3	33.0	2.6
Croatia	89.5	22.2	-5.0	Poland	89.1	19.3	-11.8
Czech Republic	92.3	24.9	-3.4	Portugal	88.2	26.7	-6.7
Denmark	86.2	26.2	-3.0	Romania	82.6	21.1	-9.3
Egypt	92.5	31.4	-1.1	Russia	82.1	22.5	-6.1
El Salvador	91.1	25.0	-10.5	Slovenia	91.1	23.8	-3.1
Estonia	89.4	22.9	-5.2	Spain	94.9	31.4	-1.0
Finland	93.7	26.0	0.1	Sweden	88.8	28.0	3.2
France	92.1	35.8	1.2	Switzerland	76.5	23.2	-9.7
Germany	87.2	39.0	3.8	Thailand	79.1	30.0	5.8
Hungary	91.3	18.2	-10.0	Tunisia	93.6	31.7	0.9
India	94.2	35.6	0.2	Turkey	83.1	22.4	-10.6
Indonesia	84.3	29.5	-2.9	Ukraine	88.8	25.9	-6.7
Ireland	89.2	15.0	-18.4	United Kingdom	85.3	29.1	-2.7
Jamaica	85.4	33.3	3.0	United States	78.7	39.3	2.4
Japan	93.0	40.2	0.6	Uruguay	91.0	29.8	-3.7
Kazakhstan	85.7	25.6	-2.6	Venezuela	88.9	34.0	-0.5
Kenya	89.5	30.5	-1.5	Zambia	88.6	35.0	3.8
				TOTAL	86.7	30.8	-2.1

Source: See Table B.1.
Note: See Table B.1 for the description of variables.

Table B.6: Baseline Estimation Results

Variables	(1) Only Tax Level	(2) Add Tax Differences	(3) Add Country Variables	(4) Add Country Variables and Tax Differences
CIT rate	0.2992***	0.2454***	0.2505***	0.1590***
(+)	(6.899)	(5.648)	(5.226)	(3.329)
International tax difference		0.1169***		0.1846***
(+)		(3.336)		(4.919)
Lag of log of total assets	14.2128***	14.1763***	15.0575***	15.0102***
(+)	(12.859)	(12.831)	(13.105)	(13.131)
Lag of square log of total assets	-0.3728***	-0.3720***	-0.3955***	-0.3941***
(-)	(-10.953)	(-10.935)	(-11.200)	(-11.221)
Lag of profitability	-1.1102***	-1.0972***	-1.0916***	-1.0738***
(?)	(-9.619)	(-9.632)	(-8.859)	(-8.938)
Lag of total assets growth	0.0426***	0.0426***	0.0437***	0.0435***
(?)	(5.697)	(5.686)	(5.357)	(5.341)
Lag of Collateral	-0.0786***	-0.0764***	-0.0806***	-0.0770***
(?)	(-5.667)	(-5.414)	(-5.485)	(-5.180)
Lag of non-debt tax credit	-0.0782**	-0.0780**	-0.0565**	-0.0548**
(-)	(-2.529)	(-2.491)	(-2.090)	(-1.993)
GDP growth			0.1650***	0.1721***
(+)			(3.304)	(3.416)
Inflation			0.0198	0.0229
(?)			(0.444)	(0.504)
Capital requirement			0.0346	0.1073
(-)			(0.041)	(0.126)
Deposit insurance			-1.0984	-1.3074
(+)			(-1.255)	(-1.482)
Financial crises			-0.8492	-1.1383*
(-)			(-1.430)	(-1.938)
Constant	-38.1776***	-44.9677***	-42.5385***	-46.4542***
	(-4.088)	(-4.629)	(-3.580)	(-3.737)
Observations	4,453	4,436	3,919	3,905
R-squared	0.467	0.468	0.469	0.472

Source: Authors' calculations.
Note: This table reports OLS regression results for subsidiary bank leverage, estimated over the 1998-2011 period. The dependent variable is bank leverage, defined as total-liability-to-total-assets ratio of a subsidiary bank. We use subsidiary-asset-weighted average tax differences between a subsidiary and the other subsidiaries of the same parent as a measure for International tax difference variable. See Table B.1 for the description of other independent variables included in the regressions. In column (1) we show regression with only local tax level and bank specific variables, and column (2) we add the International tax difference variable. Column (3) includes country-specific variables in addition to the variables included in column (1), and column (4) further add the International tax difference variable. Column (4) is our benchmark regression. Host country fixed effects are included in all specifications. Expected signs are in parentheses beneath each variable, robust t-statistics are in parentheses beneath each coefficient; *, **, *** denote significance at the 10, 5, and 1 percent level, respectively.

Table B.7: Robustness Check Estimation Results: Standard Errors

Variables	(5) Cluster Parent	(6) Cluster Host Country	(7) Cluster Subsidiary	(8) Driscoll & Kraay
CIT rate	0.1590**	0.1590***	0.1590***	0.1479**
(+)	(2.551)	(2.677)	(2.633)	(2.717)
International tax difference	0.1846**	0.1846**	0.1846**	0.1774*
(+)	(1.997)	(2.080)	(2.353)	(2.073)
Lag of log of total assets	15.0102***	15.0102***	15.0102***	15.1020***
(+)	(6.156)	(5.047)	(6.093)	(17.781)
Lag of square log of total assets	-0.3941***	-0.3941***	-0.3941***	-0.3927***
(-)	(-5.218)	(-4.393)	(-5.261)	(-16.065)
Lag of profitability	-1.0738***	-1.0738***	-1.0738***	-0.7520***
(?)	(-7.013)	(-8.350)	(-7.437)	(-4.838)
Lag of total assets growth	0.0435***	0.0435***	0.0435***	0.0166***
(?)	(5.751)	(4.968)	(5.121)	(3.557)
Lag of Collateral	-0.0770***	-0.0770***	-0.0770**	-0.0852***
(?)	(-4.594)	(-3.288)	(-2.513)	(-4.456)
Lag of non-debt tax credit	-0.0548	-0.0548	-0.0548	-0.0942
(-)	(-1.066)	(-1.059)	(-1.091)	(-1.576)
GDP growth	0.1721***	0.1721***	0.1721***	0.1408***
(+)	(4.175)	(3.926)	(4.093)	(3.387)
Inflation	0.0229	0.0229	0.0229	-0.0273
(?)	(0.580)	(0.256)	(0.463)	(-0.306)
Capital requirement	0.1073	0.1073	0.1073	-0.8087
(-)	(0.134)	(0.106)	(0.126)	(-0.821)
Deposit insurance	-1.3074	-1.3074	-1.3074	-0.5052
(+)	(-1.635)	(-1.095)	(-1.338)	(-0.840)
Financial crises	-1.1383	-1.1383	-1.1383*	-1.1186
(-)	(-1.620)	(-1.190)	(-1.693)	(-1.583)
Constant	-46.4542**	-46.4542**	-46.4542**	-42.2655***
	(-2.161)	(-2.227)	(-2.104)	(-8.071)
Observations	3,905	3,905	3,905	4,208
R-squared	0.472	0.472	0.472	0.436

Source: Authors' calculations.
Note: This table reports OLS regression results for subsidiary bank leverage, estimated over the 1998-2011 period. The dependent variable is bank leverage, defined as total-liability-to-total-assets ratio of a subsidiary bank. We use different standard error correction techniques to check the robustness of our results. See Table B.1 for the description of independent variables included in the regressions. Column (5)-(7) specify that the standard errors allow for intragroup correlation, relaxing the usual requirement that the observations are independent. That is, the observations are independent across clusters but not necessarily within them. Column (5)-(7) designate the clusters to be multinational banks (i.e., the parents of subsidiary banks), the host countries of subsidiary banks, and subsidiary banks, respectively. Column (8) employs Driscoll and Kraay standard errors, which are robust to heteroskedasticity and autocorrelation in the error structures. Host country fixed effects are included in all specifications. Expected signs are in parentheses beneath each variable, corrected t-statistics are in parentheses beneath each coefficient; *, **, *** denote significance at the 10, 5, and 1 percent level, respectively.

Table B.8: Robustness Check Estimation Results: Alternatives

Variables	(9) Only Ave. Tax	(10) Time Invariant	(11) Leverage Weights	(12) Short Term Leverage
CIT rate	0.3436***	0.1179**	0.1588***	0.3074***
(+)	(6.183)	(2.479)	(3.325)	(3.453)
International tax difference				0.1763***
(+)				(2.883)
Alt.: Asset-weighted average tax	-0.1846***			
(-)	(-4.919)			
Alt.: International tax difference with time-invariant asset-weights		0.2469***		
(+)		(5.543)		
Alt.: International tax difference with liability-weights			0.1825***	
(+)			(4.888)	
Lag of log of total assets	15.0102***	15.0326***	14.9911***	10.7582***
(+)	(13.131)	(13.173)	(13.135)	(8.150)
Lag of square log of total assets	-0.3941***	-0.3945***	-0.3935***	-0.2893***
(-)	(-11.221)	(-11.251)	(-11.224)	(-7.065)
Lag of profitability	-1.0738***	-1.0701***	-1.0744***	-1.1988***
(?)	(-8.938)	(-8.960)	(-8.947)	(-5.762)
Lag of total assets growth	0.0435***	0.0440***	0.0436***	0.0299***
(?)	(5.341)	(5.412)	(5.358)	(2.647)
Lag of Collateral	-0.0770***	-0.0747***	-0.0767***	-0.0488**
(?)	(-5.180)	(-5.008)	(-5.171)	(-2.181)
Lag of non-debt tax credit	-0.0548**	-0.0554**	-0.0548**	-0.1653***
(-)	(-1.993)	(-2.021)	(-1.992)	(-3.599)
GDP growth	0.1721***	0.1841***	0.1729***	0.2174***
(+)	(3.416)	(3.641)	(3.432)	(2.695)
Inflation	0.0229	0.0255	0.0227	0.0372
(?)	(0.504)	(0.561)	(0.500)	(0.429)
Capital requirement	0.1073	0.1337	0.1183	-0.1289
(-)	(0.126)	(0.158)	(0.140)	(-0.151)
Deposit insurance	-1.3074	-1.3639	-1.3316	-4.7074***
(+)	(-1.482)	(-1.537)	(-1.517)	(-3.009)
Financial crises	-1.1383*	-1.1492*	-1.1396*	-2.3441***
(-)	(-1.938)	(-1.947)	(-1.942)	(-2.734)
Constant	-46.4542***	-39.8849***	-40.5278***	-4.0262
	(-3.737)	(-3.373)	(-3.421)	(-0.328)
Observations	3,905	3,919	3,919	3,131
R-squared	0.472	0.473	0.472	0.296

Source: Authors' calculations.

Note: This table reports OLS regression results for subsidiary bank leverage using alternative measures of variables, estimated over the 1998-2011 period. The dependent variable in column (9)-(11) is bank leverage, defined as total-liability-to-total-assets ratio of a subsidiary bank; whereas, the dependent variable is short-term leverage in column (12), defined as total leverage minus long-term-funding-to-total-assets ratio. In column (9)-(11), we use three alternative measures for international tax difference. Column (9) employs subsidiary-asset-weighted average tax rate for a multinational bank. Column (10) uses a similar international tax difference measure as in Table 6, that is the subsidiary-asset-weighted tax differences between a subsidiary and the other subsidiaries of the same parent, except here the asset-weights are equal to the average of the subsidiary-asset-weights across time. Using time-invariant weights helps eliminating a possible endogeneity problem between asset-based weights and leverage. In column (11), time-varying subsidiary-liability-weights are used instead. See Table B.1 for the description of other independent variables included in the regressions. Host country fixed effects are included in all specifications. Expected signs are in parentheses beneath each variable, robust t-statistics are in parentheses beneath each coefficient; *, **, *** denote significance at the 10, 5, and 1 percent level, respectively.

Table B.9: Robustness Check Estimation Results: Leverage Skewness and Tax Trend

Variables	(13) Quantile	(14) Trend
CIT rate	0.0645***	
(+)	(2.845)	
Detrended CIT rate		-0.1089
(+)		(-1.106)
International tax difference	0.0518*	0.2313***
(+)	(1.830)	(6.019)
Lag of log of total assets	7.4148***	14.8930***
(+)	(12.063)	(13.085)
Lag of square log of total assets	-0.1996***	-0.3913***
(-)	(-11.070)	(-11.172)
Lag of profitability	-0.7538***	-1.0718***
(?)	(-7.105)	(-8.991)
Lag of total assets growth	0.0083***	0.0433***
(?)	(5.007)	(5.320)
Lag of Collateral	-0.0176***	-0.0761***
(?)	(-2.709)	(-5.116)
Lag of non-debt tax credit	-0.1071	-0.0552**
(-)	(-1.231)	(-1.999)
GDP growth	0.0432	0.1803***
(+)	(1.588)	(3.588)
Inflation	-0.0203	0.0379
(?)	(-0.394)	(0.844)
Capital requirement	-0.1255	-0.0211
(-)	(-0.215)	(-0.025)
Deposit insurance	0.0143	-1.8621**
(+)	(0.019)	(-2.135)
Financial crises	-0.6970***	-1.4374**
(-)	(-3.582)	(-2.470)
Constant	27.1517***	-39.4211***
	(4.303)	(-3.352)
Observations	4,208	3,905
R-squared	-	0.471

Source: Authors' calculations.

Note: This table reports quantile regression and OLS regression results for subsidiary bank leverage, estimated over 1998-2011 period. Column (13) uses a quantile regression that approximates the conditional median instead of the mean of the dependent variable, which reduces the impact of outliers. Thus, its estimates should be more robust than OLS regressions, given that bank leverage is highly skewed, as shown in Fig. B.1. Variance estimates of the quantile regression are obtained via bootstrapping. Column (14) contains a host-country-specific trend variable that captures the declining trend in statutory CIT rates worldwide. See Table 1 for the description of independent variables included in the regressions. Host country fixed effects are included in all specifications. Expected signs are in parentheses beneath each variable, robust t-statistics are in parentheses beneath each coefficient; *, **, *** denote significance at the 10, 5, and 1 percent level, respectively.

Table B.10: Robustness Check Estimation Results: Subsamples

Variables	(15) Unconsolidated	(16) Profitable	(17) Adv. Econ	(18) Before Crisis
CIT rate	0.1454**	0.1739***	0.1210	0.1363**
(+)	(2.315)	(3.669)	(1.310)	(2.494)
International tax difference	0.3219***	0.1961***	0.4657***	0.2248***
(+)	(5.587)	(5.012)	(6.222)	(5.049)
Lag of log of total assets	17.3983***	14.3880***	18.5307***	14.4828***
(+)	(10.538)	(11.929)	(13.111)	(11.538)
Lag of square log of total assets	-0.4602***	-0.3768***	-0.4859***	-0.3840***
(-)	(-8.334)	(-10.167)	(-11.712)	(-9.896)
Lag of profitability	-1.0525***	-1.1727***	-1.1777***	-1.0836***
(?)	(-8.168)	(-8.123)	(-6.907)	(-7.104)
Lag of total assets growth	0.0374***	0.0408***	0.0475***	0.0397***
(?)	(3.773)	(4.454)	(3.120)	(4.007)
Lag of Collateral	-0.0917***	-0.0608***	-0.0809***	-0.0779***
(?)	(-4.725)	(-4.128)	(-3.485)	(-4.984)
Lag of non-debt tax credit	-0.0441	-0.0242	-0.0132	-0.1311*
(-)	(-1.609)	(-1.044)	(-0.271)	(-1.747)
GDP growth	0.1785**	0.1529***	0.0993	0.0188
(+)	(2.081)	(2.755)	(0.864)	(0.187)
Inflation	0.0743	0.0433	0.9330***	-0.1047**
(?)	(1.124)	(1.045)	(2.828)	(-1.995)
Capital requirement	-0.2308	0.6107	-8.4484***	0.3969
(-)	(-0.183)	(0.758)	(-4.030)	(0.429)
Deposit insurance	0.7417	-1.4056	-2.9782*	-0.8291
(+)	(0.552)	(-1.506)	(-1.824)	(-0.893)
Financial crises	-1.3515	-0.9438	-2.0520**	0.2032
(-)	(-1.606)	(-1.543)	(-2.185)	(0.272)
Constant	-59.5663***	-45.8512***	-1.6650	-37.9602***
	(-3.688)	(-3.789)	(-0.096)	(-2.933)
Observations	2,569	3,556	1,771	2,961
R-squared	0.504	0.478	0.504	0.487

Source: Authors' calculations.
Note: This table reports OLS regression results for subsidiary bank leverage using different subsets of our entire sample, estimated over 1998-2011 period, except for column (18). Column (15) uses data from unconsolidated bank statements only. Column (16) excludes subsidiary banks with zero or negative profit. Column (17) contains subsidiary banks that reside in advanced countries, which are defined as countries where domestic credit provided by the banking sector as a share of GDP is higher than the sample average. Column (18) excludes the data from 2009 to 2011. See Table B.1 for the description of independent variables included in the regressions. Host country fixed effects are included in all specifications. Expected signs are in parentheses beneath each variable, robust t-statistics are in parentheses beneath each coefficient; *, **, *** denote significance at the 10, 5, and 1 percent level, respectively.

Table B.11: Estimation Results: Capital Tightness

Variables	(19) Abundant Capital	(20) Tight Capital
CIT rate	0.2780*	0.0545***
(+)	(1.861)	(5.100)
International tax difference	0.3460***	-0.0187*
(+)	(4.260)	(-1.901)
Lag of log of total assets	14.1896***	0.4363*
(+)	(6.416)	(1.789)
Lag of square log of total assets	-0.3413***	-0.0101
(-)	(-4.460)	(-1.391)
Lag of profitability	-0.7994***	-0.2331***
(?)	(-6.937)	(-5.120)
Lag of total assets growth	0.0506***	0.0039**
(?)	(3.512)	(2.289)
Lag of Collateral	-0.1602***	0.0066***
(?)	(-5.559)	(3.253)
Lag of non-debt tax credit	-0.0143	-0.0733**
(-)	(-0.473)	(-2.228)
GDP growth	0.3336***	0.0112
(+)	(2.847)	(0.995)
Inflation	0.0484	0.0248**
(?)	(0.575)	(2.002)
Capital requirement	0.5059	-0.0613
(-)	(0.371)	(-0.272)
Deposit insurance	0.2323	0.0484
(+)	(0.154)	(0.167)
Financial crises	0.3287	-0.0369
(-)	(0.224)	(-0.357)
Constant	-53.2262***	85.1981***
	(-2.623)	(26.591)
Observations	1,346	1,350
R-squared	0.446	0.585

Source: Authors' calculations.

Note: This table reports OLS regression results for subsidiary bank leverage using two subsamples, estimated over 1998-2011 period. We start with dividing subsidiaries banks into three equal-size groups: banks with abundant capital, median capital, and tight capital, relative to the capital requirement they face. Dropping the middle group, we regress bank leverage using the observations with most abundant capital in column (19) and tightest capital in column (20), respectively. More specifically, capital-abundant banks at each date are those with a ratio of equity-to-total-assets exceeding the minimum capital requirement by 3 percentage points, while capital-tight banks at each date are those with the ratio less than the minimum capital requirement by 1.2 percentage points. In our sample, it is possible for a bank to have equity ratio less than the minimum capital requirement because equity is divided over total assets instead of risk-weighted assets due to data availability. See Table B.1 for the description of independent variables included in the regressions. Host country fixed effects are included in all specifications. Expected signs are in parentheses beneath each variable, robust t-statistics are in parentheses beneath each coefficient; *, **, *** denote significance at the 10, 5, and 1 percent level, respectively.

APPENDIX C

APPENDIX FOR CHAPTER 4

Data Sources

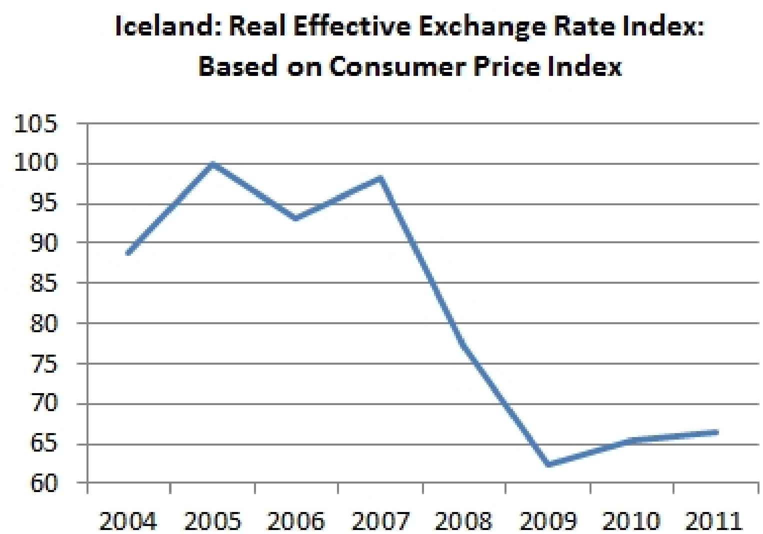
Default events: Reinhart (2010)

Exchange rates, trade, GDP: CEIC database

Figure C.1: Iceland GDP Growth upon Default (2007-2010)

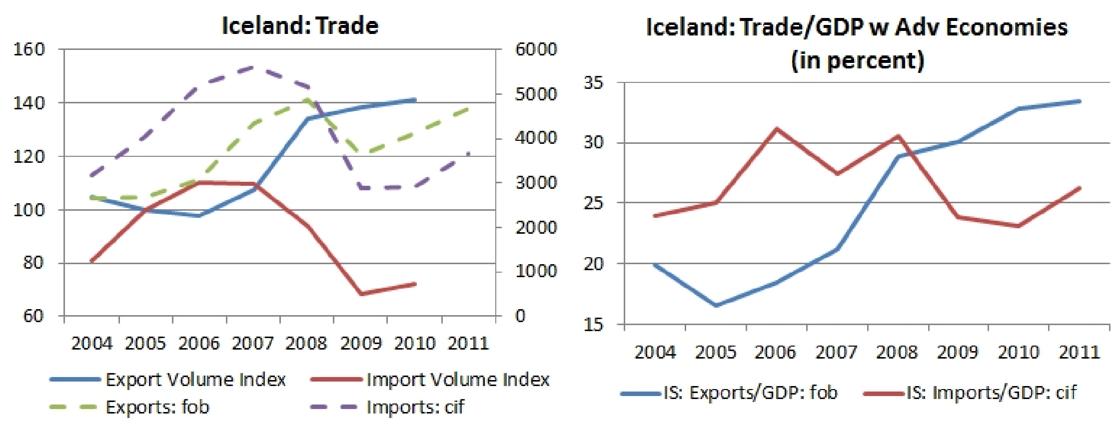
Source: Author's calculations.
Note: According to Reinhart (2010), Iceland defaulted from 2007-2010.
Takeaway: At most one third of the post-default output loss actually comes from reduced production activities.

Figure C.2: Iceland Real Exchange Rates upon Default (2007-2010)



Source: Author's calculations.
Note: According to Reinhart (2010), Iceland defaulted from 2007-2010. Here that I pick Iceland is because it has been having free floating exchange rate regime at the time of defaults. Certainly, there are other countries that can be presented too, Iceland only serves as an example here for now.
Takeaway: REER depreciated about 30 percent upon defaults in Iceland.

Figure C.3: Iceland Trade upon Default (2007-2010)

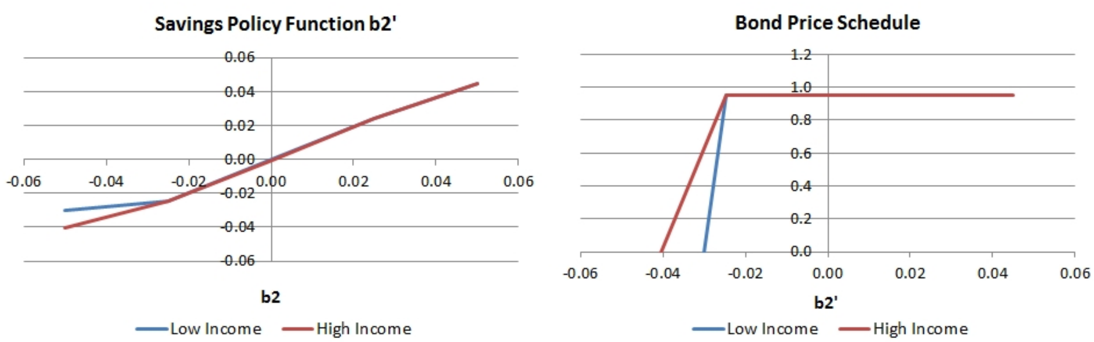


Source: Author's calculations.
Note: According to Reinhart (2010), Iceland defaulted from 2007-2010.

Table C.1: Parametrization

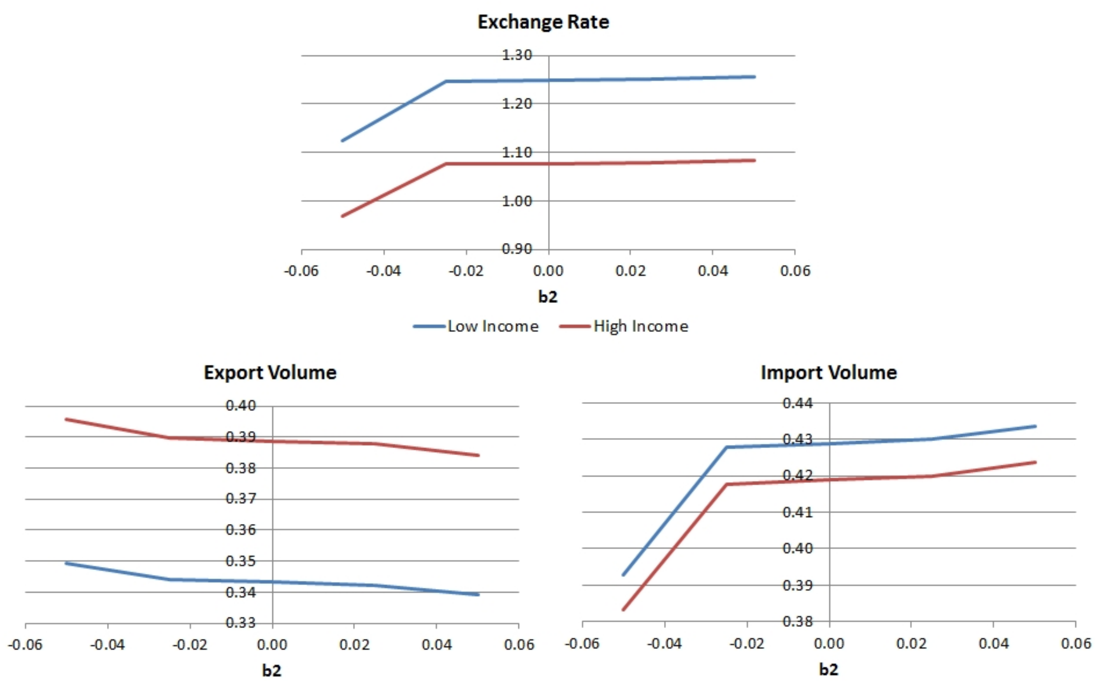
Discount factor	$\beta = 0.953$
Risk aversion	$\alpha = 2.000$
Elasticity of substitution parameter	$\rho = -0.350$
Home/foreign goods share	$\theta^1 = 1 - \theta^2 = 0.667$
Financial market re-entry probability	$re = 0.800$
Country 2's currency depreciation upon its default	$loss = 0.100$
Stochastic structure of country 2's output	$corr = 0.945$, $std = 0.025$

Figure C.4: Savings Function and Bond Price



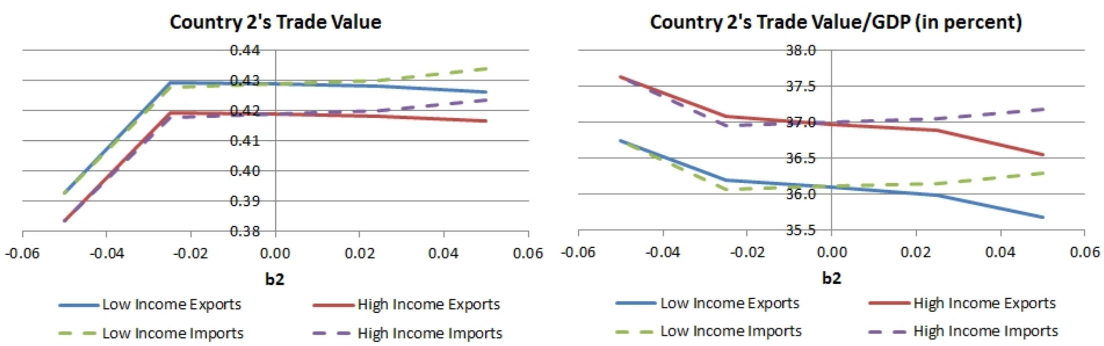
Source: Author's calculations.
Note: Different states are distinguished by default country's endowment shocks.

Figure C.5: Exchange Rate and Trade



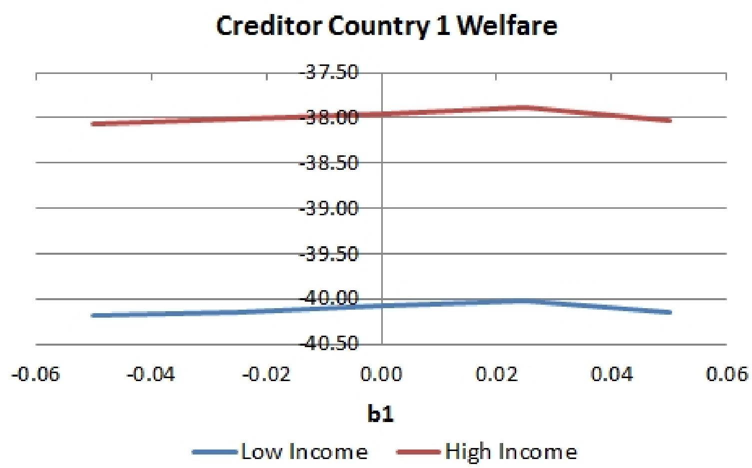
Source: Author's calculations.
Note: Different states are distinguished by default country's endowment shocks.

Figure C.6: Trade



Source: Author's calculations.
Note: Different states are distinguished by default country's endowment shocks.

Figure C.7: Creditor Country 1′s Welfare



Source: Author′s calculations.
Note: Different states are distinguished by default country′s endowment shocks.

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