ESSAYS ON UNCERTAINTY

A Ph.D. Dissertation

by
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To my husband and family

ESSAYS ON UNCERTAINTY

Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

SEÇİL YILDIRIM KARAMAN

In Partial Fulfillment of the Requirements For the Degree
of
DOCTOR OF PHILOSOPHY

in

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ANKARA

SEPTEMBER 2015

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Doctor of Philosophy in Economics.

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Supervisor

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ABSTRACT

ESSAYS ON UNCERTAINTY

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This dissertation consists of three essays on the real impacts of uncertainty shocks. The first essay develops a theoretical model to investigate the impact of financial market uncertainty on real economic downturns. The second and third essays empirically investigate the differences in the adverse impact of uncertainty shocks on real output for countries with different financial development levels and central bank characteristics.

The first essay investigates whether financial market volatility induces real downturns in a dynamic stochastic general equilibrium framework with heterogenous agents. In the model, an increase in the volatility of future stock price expectations of nonsophisticated agents causes an increase in the volatility of stock prices. In response to the increase in stock price volatility, the model generates reduction in consumption, investment, employment and output. The model contributes to the literature by modeling financial market volatility in a general equilibrium framework, highlighting the mechanisms through which the impact works, and providing estimates of its magnitude.

The second essay investigates whether financial development moderates the negative impact of uncertainty shocks on real economic activity. To test this conjecture, I compare the impact of macro level uncertainty as measured by stock market volatility on real GDP growth for countries with different financial development levels. To address potential endogeneity concerns, the estimation is made using Two Stage Least Squares technique where plausibly exogenous disaster shocks are used as instruments for stock market volatility. The estimation results based on a panel data set of 54 countries between 1971 and 2009 are consistent with the conjecture that uncertainty shocks hurt countries with developed financial markets less.

The third essay investigates the role of institutional characteristics of the central banks in moderating the negative consequences of uncertainty shocks using the same identification strategy as the second essay. The results provide strong evidence that central bank independence reduces the adverse effects of uncertainty shocks. As for the impact of central bank transparency, while in some specifications the results support its mitigating impact on the adverse effect of uncertanity, in others it doesn't have a significant moderating impact. In the light of the restrictions on the transparency data set which spans 44 countries between 1998 and 2009, more comprehensive studies may be needed to reach a stronger verdict for its impact.

Keywords: Uncertainty, Volatility Shocks, Financial Market Volatility, Business Cycles, Financial Development, Central Bank Independence, Central Bank Transparency.

ÖZET

BELİRSİZLİK ÜZERİNE MAKALELER

YILDIRIM KARAMAN, Seçil

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Tez Yöneticisi: Prof. Dr. Refet Soykan Gürkaynak

Eylül 2015

Bu çalışma belirsizlik şoklarının reel ekonomiye etkisini inceleyen üç makaleden oluşmaktadır. İlk makale, mali piyasalardan kaynaklanan belirsizlik şoklarının reel ekonomiye etkisini teorik bir model çerçevesinde incelemekte, ikinci ve üçüncü makaleler ise, belirsizlik şoklarının büyüme üzerindeki olumsuz etkisinin miktarını, farklı mali piyasa gelişme seviyeleri ve merkez bankası yapıları için ampirik olarak karşılaştırmaktadır.

İlk makale mali piyasalardaki volatilite artışının reel üretim üzerindeki etkisini hane halklarının heterojen olduğu bir dinamik stokastik genel denge modeli çerçevesinde incelemektedir. Modelde, rasyoneliteleri kısmi olan bireylerin hisse senedi fiyatlarına dair beklentilerinin volatilitesindeki artış mali piyasalarda volatilite artışına yol açar. Mali piyasa volatilitesindeki artış ise tüketim, yatırım, istihdam ve reel üretimde azalmaya yol açar. Bu makalenin literatüre katkısı mali piyasalar kaynaklı volatilite artışını genel denge içinde modellemek, mali piyasa volatilitesi artışının reel sektör üzerindeki etkisinin hangi mekanizmalar üzerinden işlediğini anlamak ve bu etkinin büyüklüğünü

ölçmektir.

İkinci makale, ampirik olarak, finansal gelişmişlik düzeyi yüksek ülkelerde, belirsizlik şoklarının reel büyüme üzerindeki olumsuz etkisinin daha düşük olacağı hipotezini inceler. Analizde, finansal gelişmişlik altı farklı değişken ile, genel belirsizlik seviyesi hisse senedi fiyatlarındaki volatilite ile ölçülür. Ekonometrik analizde ortaya çıkabilecek içsellik problemlerlerine karşı, analiz hisse senedi volatilesi için doğal felaket, terörist saldırı ve siyasi darbe ve devrimler araç değişken olarak kullanılarak yapılmıştır. 54 ülke için 1971 ve 2009 yılları arası için yapılan analiz, finansal olarak gelişmiş ülkelerde belirsizlik şoklarının üretime daha az zarar verdiği hipotezini güçlü şekilde destekler.

Üçüncü makale ise, merkez bankası bağımsızlığının ve şeffaflığının artmasının belirsizlik şoklarının büyüme üzerindeki olumsuz etkisini azaltacağı hipotezini ikinci makalede olduğu gibi araç değişken yöntemi ile inceler. 43 ülke ve 1972-2008 yılları için yapılan analiz, merkez bankası bağımsızlığının belirsizliğin üretime olumsuz etkisini azalttığı tezini güçlü şekilde destekler. Merkez bankası şeffaflığı üzerine 1998-2009 yıllarını kapsayan daha sınırlı bir veri setiyle yapılan analizde ise bazı sonuçlar belirsizliğin olumsuz etkisini azalttığını gösterirken, diğer sonuçlar şeffaflığın fark yaratmadığına işaret etmektedir. Veri setinin kısıtları göz önüne alındığında merkez bankası şeffaflığının rolü hakkında kesin bir sonuca varmak için daha geniş kapsamlı calışmalara gerek olacağı öngörülmektedir.

Anahtar Kelimeler: Belirsizlik, Volatilite Şokları, Mali Piyasalarda Volatilite, Konjonktür Dalgalanmaları, Finansal Gelişmişlik, Merkez Bankası Bağımsızlığı, Merkez Bankası Şeffaflığı

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CHAPTER 1

INTRODUCTION

This dissertation consists of one theoretical and two empirical essays on the real consequences of uncertainty shocks. The first essay investigates the causal impact of an exogenous uncertainty shock to financial markets on real output based on a theoretical model. The second and third essays try to understand the factors that determine the size of the adverse impact of uncertainty shocks on output.

The insight that volatility in financial markets may contribute to economic downturns is motivated by evidence from the Great Depression of 1929 and the Great Recession of 2008. In the build up to the Great Recession of 2008, a critical turning point was the collapse of Lehman Brothers. After Lehman failed, it created a widespread panic in financial markets about the possible bankruptcy of other financial institutions. The panic arguably increased the volatility in the financial markets, a feeling of uncertainty replaced economic optimism and this in turn played a role in the decision by consumers and firms to cut back their spending.

Historical evidence suggests that a similar mechanism was at work during the Great Depression of 1929. The US entered a mild recession in the summer of 1929, explained in the literature mainly by the monetary tightening of the Federal Reserve. The severe collapse in output, however, began in October 1929 after the stock market crash and the spike in financial volatility. Volatility stayed high for the next few years because of the concerns about the health of the banking system while real production continued to decline. This sequence of events has motivated Friedman and Schwartz (1971) and others to argue that the spike in the financial market volatility played an independent and important role in the real contraction during the Great Depression.

While it is difficult to disentangle the complex relationship between financial uncertainty and real variables and empirically establish causality during the recessions, these anecdotal accounts of the crises give strong reason to suspect and investigate the causal impact of financial uncertainty. Modeling this impact, however, has received relatively limited attention in the theoretical literature.

In the first essay of my thesis, I investigate the impact of financial volatility on real variables based on a New Keynesian model that works in two steps. First, the model offers a setup to understand how stock prices may persistently deviate from their fundamental values due to the shocks that originate in financial markets. Second, it identifies a mechanism for the causal impact of an exogenous increase in the volatility of stock prices on real downturns.

In the first step, financial market volatility is generated using mood shocks as an analytical device. In particular, there are two types of agents, sophisticated and nonsophisticated. The only difference between these two types of agents is that they price the risky asset, stock, differently. Sophisticated agents correctly discount future dividends. Nonsophisticated agents, on the other hand, are subject to first and second moment mood shocks. In other words, they misperceive the future stock price based on their incorrect beliefs. Both the level and the volatility of these beliefs are assumed to be stochastic which in turn cause both the level and volatility of stock prices to be stochastic.

The second step of the model investigates the real consequences of an exogenous increase in the volatility of stock prices. An increase in the stock market volatility impacts real sector through two channels. First, it causes an immediate decline in the stock prices which is a negative wealth shock. Second, an increase in stock price volatility increases the volatility of future income. This in turn causes agents to take precautions against higher uncertainty of their future income. In response to both effects, agents decrease their aggregate demand. Since the output is demand determined in the New Keynesian setup, output also declines.

By investigating the real consequences of financial volatility, this study fills a gap in the existing DSGE literature on business cycles. In the DSGE literature, the prevalent approach is to model volatility as originating from real sector. This modeling choice reflects the fact that modeling financial markets as an exogenous source of volatility is not straightforward when all agents are assumed to be rational. Hence, volatility is modeled as second moment shocks to the total factor productivity[1], household discount rates[2],

[1]See Bloom et al. (2012) and Basu and Bundick (2012).
[2]See Basu and Bundick (2012).

idiosyncratic productivity of the firms[3], or fiscal policy tools.[4] In these models an increase in real volatility in turn causes a contraction in output and induces endogenous volatility in asset prices.

The innovation in the current model is that it generates financial market volatility even in the absence of real shocks. In other words, in this model uncertainty shocks originate in the financial sector and are transmitted to real sector. The critical assumption for generating financial market volatility in the absence of real shocks is the existence of nonsophisticated agents in the model who are boundedly rational and have volatile expectations about future stock market performance. This modeling setup reflects the insight that financial markets might themselves be an independent source of uncertainty. This setup is particularly relevant for the recent Great Recession, considering the widespread consensus about the role of financial sector in instigating the crisis.

Going beyond modeling the negative impact of uncertainty on output, the second and third essays of the thesis turn to an empirical analysis of the determinants of the size of the impact. The empirical analysis of the factors that moderate the size of the negative impact of uncertainty shocks builds on the existing theoretical literature on the question. It is also a question with immediate and important policy implications.

The second essay investigates the moderating impact of financial development on the adverse effect of uncertainty on output. The conjecture that financial development has a moderating impact is motivated by a number of

[3]See Gilchrist et al. (2014), Christiano et al. (2013), and Arellano et al. (2010).

[4]See Fernández-Villaverde et al. (2011).

theoretical models in the literature that suggest that the adverse effect of uncertainty on output works through financial frictions. Accordingly, one strand in the literature argues that uncertainty shocks depress aggregate demand through creating precautionary motives for the agents.[5] A second strand suggests that higher uncertainty causes a decline in firms' investment through the liquidity constraints and an increase in the cost of borrowing.[6] In a third strand, uncertainty shocks distort resource allocation between more and less productive firms while optimal consumption smoothing mitigates the negative impact of the shocks.[7] As financial development level increases, precautionary savings are replaced by credit, liquidity problems are less serious, borrowing is less costly and resource allocation and consumption smoothing is more efficient. Consequently, I conjecture that financial development decreases the negative impacts of uncertainty shocks

The main contribution of this study is to investigate this conjecture throughly using an extensive data set and a clear identification strategy that builds on Baker and Bloom (2013). In the empirical analysis, the dependent variable is real GDP growth. The main independent variable of interest is uncertainty (as measured by stock market volatility) interacted with financial development. The data on real GDP growth and stock market is based on Baker and Bloom (2013), whereas for financial development, I use six different indices of financial development including measures of financial depth, access and stability developed by Čihák et al. (2013). The conjecture that financial development mitigates the negative impact of uncertainty shocks implies that the coefficient

[5] See Basu and Bundick (2012) and Fernández-Villaverde et al. (2011).

[6] See Gilchrist et al. (2014), Christiano et al. (2013) and Arellano et al. (2010).

[7] See Bloom et al. (2012).

of the interaction term between stock market volatility and financial development should be positive and significant. To address the potential endogeneity of stock market volatility and return, in a Two Stage Least Squares estimation, they are instrumented by plausibly exogenous natural disasters, terrorist attacks, political coups and revolution shocks.

The results of the empirical analysis provides strong support for the conjecture that as financial development level increases, the adverse effect of uncertainty on output decreases. Using a quarterly panel data set for the period between 1971 and 2009 for 54 countries, the regression results find significant coefficients for the interaction between uncertainty and various proxies of financial development. More specifically, the regression results show that a greater financial depth, access and stability all decrease the negative impact of uncertainty on economic growth. The finding is robust when various country characteristics, including population, real GDP, per capita real GDP, country and time fixed effects are controlled for.

The third essay investigates the conjecture that a transparent and independent central bank mitigates the adverse impact of uncertainty shocks on real economic activity. Central bank transparency refers to the degree to which central bank shares information about the procedures for its decision making, its policy decisions and objectives, the implementation of its policies and the economic variables relevant for the state of the economy. I conjecture that when an uncertainty shock hits the economy, the transparency of the central bank works to reduce the policy uncertainty, undercuts precautionary incentives and mitigates the negative consequences of uncertainty shocks.

Independence, on the other hand, refers to the degree of autonomy a central bank has in choosing and implementing its policies. Under uncertainty shocks, central bank independence matters, because it restricts political interference and the additional ambiguity it introduces to policy making. Consequently, it increases the credibility of the central bank's policies and goals in the eyes of the public and reduces the destabilizing effects of the uncertainty shocks on output.

In testing the two conjectures summarized above, I adopt an empirical strategy similar to the one employed in the second essay. The dependent variable in the analysis is real GDP growth. The independent variable of interest is uncertainty (as measured by stock market volatility) interacted with central bank independence in the first set of regressions and central bank transparency in the second set. The conjectures that central bank independence and transparency mitigate the negative impact of uncertainty shocks implies that the coefficient of these interaction terms should be positive and significant. The model is estimated using Two Stage Least Squares Method, where stock market volatility and return are instrumented by various exogenous shocks.

The results of the empirical analysis are consistent with the conjectured impact for central bank independence. Using the index constructed by Bodea and Hicks (2015), the analysis of 43 countries between years 1972-2009 finds strong support for the mitigating impact of central bank independence on the adverse effect of uncertainty. This finding is robust after controlling for country and year fixed effects, the interaction of volatility with population, real GDP, real GDP per capita and political regime. When financial development indicators are included in the regression together with Central Bank independence, the mitigating impact of both remain significant, suggesting both have independent impacts.

The evidence on transparency is mixed. In some specifications, the coefficient of the interaction term is positive and significant suggesting that transparency reduces the adverse impact of uncertainty and in others its impact is insignificant. This ambiguous result can partly be a consequence of the data limitations, as the data set by Dincer and Eichengreen (2014) used in the analysis is restricted to the years between 1998 and 2009 and transparency is an attribute that is inherently more difficult to measure compared to other variables included in the analysis. In this respect, reaching a more conclusive result requires further research with more comprehensive data or alternative proxies.

CHAPTER 2

UNCERTAINTY IN FINANCIAL MARKETS AND BUSINESS CYCLES

This essay investigates whether uncertainty originating in financial markets affects real variables and helps drive business cycles. The impact of uncertainty is investigated based on a New Keynesian model with two types of agents, sophisticated and nonsophisticated, who price the risky asset, stock, differently. In the model, an increase in volatility of future stock price expectations of nonsophisticated agents increases the volatility of current stock prices. The stock price volatility, in turn, reduces consumption, investment, employment and output. The model contributes to the literature by modeling financial market volatility in a general equilibrium framework, establishing its causal impact on real variables, highlighting the mechanisms through which the impact works, and providing estimates of its magnitude.

The study departs from existing literature on uncertainty in the source of uncertainty in the model. In the existing literature, the prevalent approach is to model uncertainty as originating from real sector. For example, uncertainty is modeled as volatility shocks to the total factor productivity[1], household discount rates[2], idiosyncratic productivity of the firms[3], or fiscal policy tools.[4] In these models an increase in real uncertainty in turn causes a contraction in output and induces endogenous fluctuations in asset prices.

The innovation in this study is that uncertainty shocks instead originate in the financial sector and are transmitted to real sector. This modeling setup reflects the insight that financial markets might themselves be an independent source of uncertainty. Theoretically and empirically, there is a large body of work that suggests behavioral and informational shocks might lead financial volatility to increase over and above volatility due to fundamental shocks.[5] In this respect, this essay identifies a mechanism both for the exogenous increase in financial uncertainty caused by nonfundamental factors and its transmission to real industry. This independent impact of financial uncertainty might be working together with real uncertainty shocks emphasized in the literature and help understand the severity of the resulting downturns.

The model formalizes the impact of financial uncertainty on real variables based on a model that works in two steps. The first step generates financial uncertainty as the outcome of "mood" shocks to agents. In particular, there are two types of agents, sophisticated and nonsophisticated, who price the risky asset, stock, differently. Sophisticated agents correctly discount future dividends. Nonsophisticated agents, on the other hand, are subject to "mood" shocks which change their level of "pessimism" about the future performance

[1]See Bloom et al. (2012) and Basu and Bundick (2012).
[2]See Basu and Bundick (2012).
[3]See Gilchrist et al. (2014), Christiano et al. (2013), and Arellano et al. (2010).
[4]See Fernández-Villaverde et al. (2011).
[5]See De Long et al. (1990), Barberis et al. (1998), Baker and Wurgler (2006).

of the stock, and cause their valuation to deviate from sophisticated agents' valuation. The "mood" of nonsophisticated agents is subject to both level and volatility shocks causing the level and the volatility of the stock prices to be stochastic.

The second step in the model, the main focus of the essay, captures the impact of greater stock price volatility on real variables. The impact works as follows. First, because agents are risk averse, when future stock price volatility increases, demand for stocks and equilibrium stock price falls, and because agents hold stocks, there is a negative wealth shock. Second, the increase in stock price volatility implies an increase in volatility of future income, which induces agents to take precautionary measures. In response to both the wealth shock and precautionary motives, agents cut back on consumption and increase their labor supply. On the firm side, under the New Keynesian assumptions of monopolistic competition and sticky prices, lower wages increase markup, and higher markup contracts labor demand. Under plausible parameter values, labor demand contracts more than the increase in labor supply, and so equilibrium employment and output fall. Higher markup and lower employment also decrease marginal return on capital and in turn investment. All in all, equilibrium employment, consumption, investment and output decrease.

In the model outlined above, uncertainty in financial markets is generated by "mood" shocks. The model, however, can be interpreted more broadly, as a general model of uncertainty shocks that spread from financial sector to real sector. Uncertainty in financial markets can also go up, for example, if the quantity and quality of available information changes (Ross (1989), Andersen

(1996)). Whatever the ultimate exogenous source of financial uncertainty is, the mechanisms of its impact on real variables, identified in the second step of the model, are still at work.

The negative causal effect of financial uncertainty on real output in the model is consistent with empirical evidence from both older and more recent economic downturns. For example, Romer (1988) finds that doubling of stock market volatility, which is measured by historical variation in stock prices, reduces durable consumption goods output significantly. She also argues that 1929 stock market crash led to a recession, but 1987 crash did not, because in the 1929 crisis volatility was much higher. Choudhry (2003) investigates the impact of stock market volatility on real production, consumption and investment using an error-correction model under the assumption that volatility follows a nonstationary stochastic process. His results suggest that stock market volatility has adverse effects on consumption and investment.

The sequencing of events during the recent and earlier financial crises also provide evidence for the negative impact of financial market volatility on real production. Figure 2.1 and 2.2 show the negative correlation between financial market volatility and real production respectively for the Great Recession of 2008 and Great Depression of 1929. In both instances, at the outset of the real downturn, there was a significant spike in stock market volatility. The spike was partly a consequence of a turn for worse in the real variables. Arguably, in addition to these real shocks, market panic and informational asymmetries also contributed to volatility. Since stock market plays a central role in the economic decisions of both firms and households, it is only plausible that the

Figure 2.1: Real GDP and Implied Volatility during the Great Recession

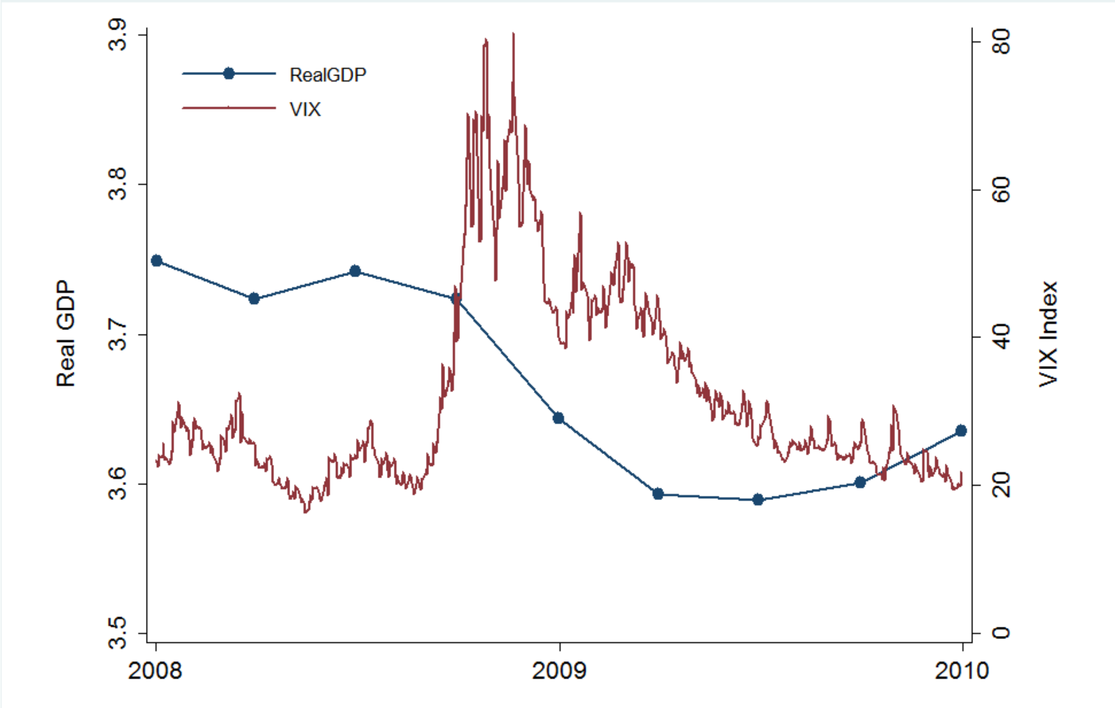
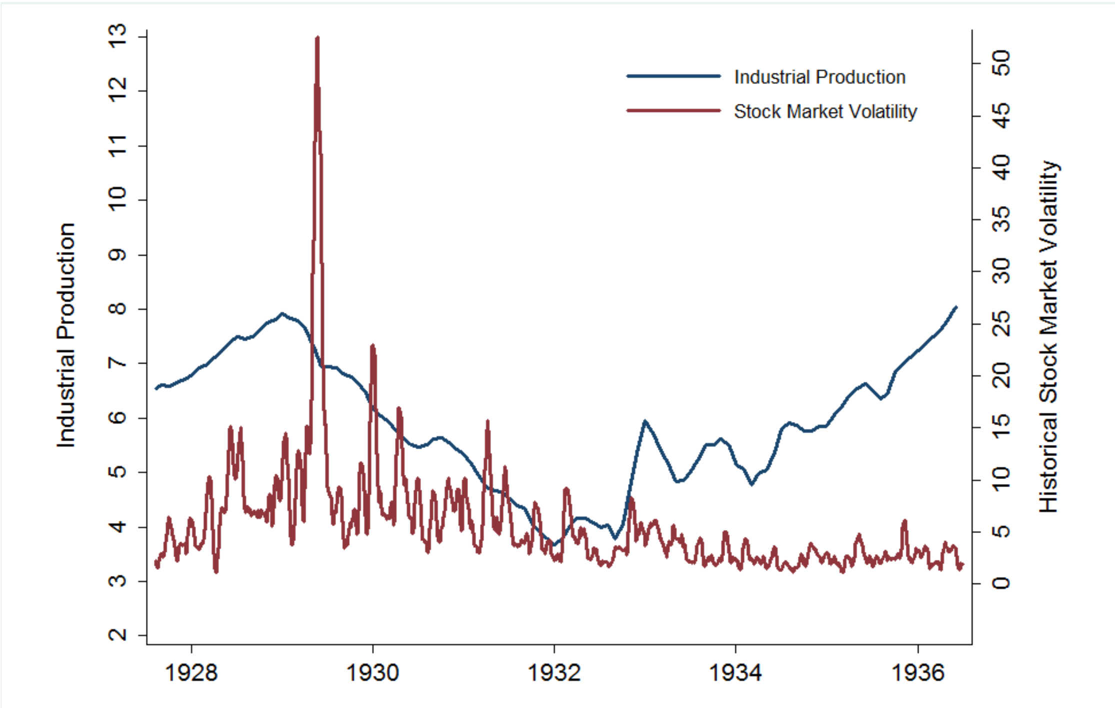


Figure 2.2: Industrial Production and Stock Market Volatility during the Great Depression



spike in volatility should have causal effects of its own.

The rest of the essay proceeds as follows. Section 1 presents the model and section 2 describes the calibration procedure. Section 3 discusses the model assumptions and results, evaluates them and compares them with the empirical evidence. The last section concludes.

2.1 The Model

2.1.1 Agents

Agents in the economy are modeled as an infinite sequence of overlapping generations (OLG). For simplicity, each generation has the same size and is assumed to live two periods. There are two types of young agents, sophisticated and nonsophisticated, which are assumed to be risk averse. The share of nonsophisticated and sophisticated agents are fixed and respectively denoted by n and $1-n$ where $0<n<1$. They work, consume and save in the first period and retire in the second period. Their income in the second period is equal to the return on savings they made in the first preiod.

In the first period, the agents decide how much to work, how much to consume in the current period and save for the second period, and how to allocate savings between safe and risky assets to maximize their lifetime utility. The safe and risky assets are interpreted respectively as bonds and stocks. The price of the safe asset is always 1 in terms of the numeraire consumption good. Its one period return is known with certainty. The risky asset, stock, is supplied at a fixed amount and both the level and the volatility of its price are time varying and determined as discussed below.

Equilibrium asset pricing structure follows De Long et al. (1990) and stock price is determined by consolidating the portfolio choice decisions of both types of agents. The critical assumption in agents' problem is that the two types of agents price the risky asset, stock, differently. The sophisticated agents correctly discount future dividends. The nonsophisticated agents, on the other hand, may be subject to "mood" shocks regarding the future performance of the stock, which in turn causes their valuation to deviate from sophisticated agents' valuation. In other words, nonsophisticated agents misperceive the expected stock price based on their irrational beliefs. These shocks to "mood" of nonsophisticated agents are modeled as a stochastic process and both their level and variance are assumed to follow AR(1) processes. In the following subsections both types of agents' problems are specified in more detail.

Using OLG framework for the agents is an appropriate way of modeling the question of the paper for two reasons. First, OLG includes at least two types of agents living in the same period and belonging to different generations, young and old. This structure allows financial assets to be traded between two different agents at each point in time. In this set up young agents' demand for stocks is based on their expectations about the future stock price and can be derived from their optimization problem. Old agents supply the stocks. Equalizing total supply to total demand determine the equilibrium market value of the stock which differs from its fundamental value. Hence, OLG framework, with heterogenous agents in each period, allows the model to generate stock market volatility in the absence of fundamental shocks, and investigate its impact, which is at the core of the paper.

Second, OLG framework allows us to analyze the different periods of the life span explicitly. This is important because agents make their saving and portfolio allocation decisions to maximize their expected future wealth. The model captures how the variations in the stock market affect agents' expectations about their future income which in turn affect their saving and working behaviors when they are young.

Sophisticated agents

There is a continuum of sophisticated agents. They maximize their lifetime utility:

$$\underset{N_t^s, S_t^s, \lambda_t^s}{Max}\, U(C_{y,t}^s, N_t^s) + \beta E_t\left[U(C_{o,t+1}^s)\right] \tag{2.1}$$

subject to:

$$\frac{W_t}{P_t} N_t^s = w_t N_t^s = S_t^s + C_{y,t}^s \tag{2.2}$$

$$S_t^s - B_t^s = \frac{\lambda_t^s P_t^e}{P_t} = \lambda_t^s p_t^e \tag{2.3}$$

$$E_t[C_{o,t+1}^s] = S_t^s r_t^b + \lambda_t^s E_t[(p_{t+1}^e + d_{t+1}) - r_t^b p_t^e] \tag{2.4}$$

where C_y^s and C_o^s respectively represent the consumption of young and old sophisticated agents. P is the price level, W is the nominal wage and w is the real wage level in the economy, S^s is the amount of saving in terms of consumption goods which is allocated to stocks and bonds, B and λ^s are respectively the amount of bonds and stocks purchased by sophisticated agents. Price of one unit of bond is equal to one unit of consumption good. P^e and p^e respectively represent the nominal and real prices of one unit of stock, d is the real dividend payment for one unit of stock, and r^b is the real return on the bond.

Utility function of the agents is defined as:

$$U(C_{y,t}, N_t) = -e^{-2\gamma C_{y,t}} - \nu \frac{N_t^{1+\varphi}}{1+\varphi} \tag{2.5}$$

$$E_t[U(C_{o,t+1})] = E_t[-e^{-2\gamma C_{o,t+1}}] \tag{2.6}$$

where γ is the coefficient of absolute risk aversion and $1/\varphi$ is the Frisch elasticity of labor supply.

Under the assumption of normally distributed returns, maximizing (2.6) is equivalent to maximizing:

$$E_t[C_{o,t+1}] - \gamma \sigma^2_{c_{o,t+1}} \tag{2.7}$$

Since the variance of consumption of old agents is a function of the variance of stock price, $\sigma^2_{c_{o,t+1}} = (\lambda^s_t)^2 \sigma^2_{p^e_{t+1}}$, the expression (2.7) can be rewritten as:

$$E_t[C_{o,t+1}] - \gamma (\lambda^s_t)^2 \sigma^2_{p^e_{t+1}} \tag{2.8}$$

Sophisticated agents choose how much to work, how much to save and how to allocate their savings between risky and riskless assets. First order conditions for the utility maximization problem of sophisticated agents are:

$$U'(C^s_{y,t}) = E_t\left[\beta r^b_t U'(C^s_{o,t+1})\right] \tag{2.9}$$

$$\lambda^s_t = E_t\left[\frac{(p^e_{t+1} + d_{t+1}) - r^b_t p^e_t}{2\gamma\sigma^2_{p^e_{t+1}}}\right] \tag{2.10}$$

$$U'(C^s_{y,t})w_t = -U'(N^s_t) \tag{2.11}$$

where (2.9) is the Euler equation, (2.10) is the demand function of the sophisticated agents for the risky asset and (2.11) is the labor supply function.

Nonsophisticated agents

There is a continuum of nonsophisticated agents. Their optimization problem in period t is:

$$\underset{N^n_t, S^n_t, \lambda^n_t}{Max}\, U(C^n_{y,t}, N^n_t) + \beta E_t\left[U(C^n_{o,t+1})\right] \tag{2.12}$$

subject to:

$$\frac{W_t}{P_t}N^n_t = w_t N^n_t = S^n_t + C^n_{y,t} \tag{2.13}$$

$$S^n_t - B^n_t = \frac{\lambda^n_t P^e_t}{P_t} = \lambda^n_t p^e_t \tag{2.14}$$

$$E_t[C^n_{o,t+1}] = S^n_t r^b_t + \lambda^n_t E_t[p^e_{t+1} + d_{t+1} - a_t - r^b_t p^e_t] \tag{2.15}$$

Note that the only difference between the nonsophisticated and sophisticated agents problem is that the former has an extra term, a, in the budget constraint (2.15). a captures the nonsophisticated agents mood, and more specifically, their degree of pessimism about the future performance of the stock. If the level of a increases, nonsophisticated agents become more pessimistic about the expected value of their savings. If the volatility of a increases, volatility of the expected future value of their savings increases. a is assumed to be stochastic and both its level and volatility are assumed to follow AR(1) processes:

$$a_t = \rho_a a_{t-1} + \sigma^a_t \varepsilon^a_t \tag{2.16}$$

$$\sigma^a_t = (1 - \rho_{\sigma^a})\sigma^a + \rho_{\sigma^a}\sigma^a_{t-1} + \sigma^{\sigma^a}\varepsilon^{\sigma^a}_t \tag{2.17}$$

where $\rho_a < 1$, $\rho_{\sigma^a} < 1$.

In the model, level shocks to mood of nonsophisticated agents are given by increasing parameter ε^a in equation (2.16). Such a shock increases a, makes nonsophisticated agents more pessimistic and in turn depresses stock price. Volatility shocks to the mood of nonsophisticated agents are given by increasing parameter ε^{σ^a} in equation (2.17). These volatility shocks in turn increase the volatility of stock prices. Hence, level and volatility shocks to nonsophisticated agents mood translate into level and volatility shocks to financial markets and the model investigates how these shocks in turn affect real variables.

The first order conditions that follow are:

$$U'(C^n_{y,t}) = E_t\left[\beta r^b_t U'(C^n_{o,t+1})\right] \tag{2.18}$$

$$\lambda^n_t = E_t\left[\frac{(p^e_{t+1} + d_{t+1} - a_t) - r^b_t p^e_t}{2\gamma\sigma^2_{p^e_{t+1}}}\right] \tag{2.19}$$

$$U'(C^n_{y,t})w_t = -U'(N^n_t) \tag{2.20}$$

where (2.18) is the Euler equation, (2.19) is the demand function of the nonsophisticated agents for the risky asset and (2.20) is the labor supply function.

When we consolidate (2.9) and (2.18) with the weights of sophisticated and nonsophisticated agents we obtain the consolidated Euler equation given below:

$$e^{-2\gamma C_{y,t}} = E_t\left[\beta r^b_t e^{-2\gamma C_{o,t+1}}\right] \tag{2.21}$$

where $C_{y,t}$ is the total consumption of young in period t.

$$C_{y,t} = (1-n)C^s_{y,t} + nC^n_{y,t} \tag{2.22}$$

$C_{o,t}$ is the total consumption of old in period t.

$$C_{o,t} = (1-n)C^s_{o,t} + nC^n_{o,t} \tag{2.23}$$

Similarly, we combine (2.11) and (2.20) to obtain the consolidated labor supply function given below:

$$\nu N_t^{\varphi} = 2\gamma w_t e^{-2\gamma C_{y,t}} \tag{2.24}$$

Equilibrium asset pricing

The equilibrium price of the risky asset is determined by setting demand for stocks equal to the supply. The supply of stocks is fixed at S^e which is normalized to 1. It follows that the stock price is determined by setting the total demand of both types of agents equal to one:

$$(1-n)\lambda_t^s + n\lambda_t^n = S^e = 1 \tag{2.25}$$

Equations (2.10), (2.19) and (2.25) determine the evolution of the stock price:

$$p_t^e = 1/r_t^b E_t[(p_{t+1}^e + d_{t+1}) - 2\gamma\sigma_{p_{t+1}^e}^2 - na_t] \tag{2.26}$$

Through forward iteration of equation (2.26), we can define the variance of the stock price as a function of the variance of the nonsophisticated agents' mood. Discounting the expected future variances with the steady state discount factor, it follows:

$$\sigma_{p_t^e}^2 \simeq Var(a_t)\frac{n^2}{(r_{ss}^b - \rho_a)^2} \tag{2.27}$$

$$E_t\left[\sigma^2_{p^e_{t+1}}\right] \simeq E_t\left[Var(a_{t+1})\frac{n^2}{(r^b_{ss}-\rho_a)^2}\right] \tag{2.28}$$

$$E_t\left[Var(a_{t+1})\right] = E_t\left[Var(\rho_a a_t + \sigma^a_{t+1}\varepsilon^a_{t+1})\right] \tag{2.29}$$

$$E_t\left[Var(a_{t+1})\right] = \rho_a^2 Var(a_t) + E_t\left[(\sigma^a_{t+1})^2\right] \tag{2.30}$$

Expected variance of next period stock price is defined as:

$$E_t\left[\sigma^2_{p^e_{t+1}}\right] \simeq \left(\rho_a^2 Var(a_t) + E_t\left[(\sigma^a_{t+1})^2\right]\right)\frac{n^2}{(r^b_{ss}-\rho_a)^2} \tag{2.31}$$

Then, equation (2.26) can be written as:

$$p^e_t = 1/r^b_t E_t\left[(p^e_{t+1}+d_{t+1}) - 2\gamma\left[\left(\rho_a^2 Var(a_t) + E_t\left[(\sigma^a_{t+1})^2\right]\right)\frac{n^2}{(r^b_{ss}-\rho_a)^2}\right] - na_t\right] \tag{2.32}$$

From equation (2.32), we can make two immediate observations. First, stock prices persistently deviate from their fundamental values. The intuition is that because the agents are risk averse the additional risk generated by the unpredictable mood of the nonsophisticated agents can not be eliminated completely. Hence, arbitrage trading stays limited. Second, an increase in both the volatility and the level of the pessimistic beliefs of nonsophisticated agents have a negative impact on stock prices. An increase in the level of pessimistic beliefs decreases only the demand of nonsophisticated agents. However, an increase in the volatility of misperception decreases the demand of both types of agents.

2.1.2 Firms

There are two types of firms in the model, intermediate and final goods producers.

Intermediate goods producers

Intermediate goods producers are monopolistically competitive and face a quadratic cost of changing their price $P_t(i)$ each period. Each firm i produces $Y_t(i)$ using capital $K_t(i)$ and labor $N_t(i)$. They use debt and equity to finance their investment and face a quadratic cost for adjusting the investment rate. Each firm i chooses its price level, investment and labor demand to maximize the discounted sum of the equity value. All intermediate goods firms have Cobb-Douglas production function with constant returns to scale and a fixed cost fc. Hence, firms maximize:

$$\underset{K_{t+1},I_t,P_t,N_t}{Max}\left[\sum_{s=0}^{\infty} M_{t+s}[\frac{D_{t+s}(i)}{P_{t+s}(i)}]\right] \tag{2.33}$$

subject to:

$$Y_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{-\theta} Y_t = zK_t^{\alpha}(i)N_t^{1-\alpha}(i) - fc \tag{2.34}$$

$$I_t(i) = K_{t+1}(i) - \left(1 - \delta - \frac{\psi_k}{2}\left(\frac{I_t(i)}{K_t(i)} - \delta\right)^2\right) K_t(i) \tag{2.35}$$

$$\frac{D_t(i)}{P_t(i)} = d_t(i) = \left[\frac{P_t(i)}{P_t}\right]^{1-\theta} Y_t - I_t(i) - w_t N_t(i) - r^b_{t-1} B_{t-1} \\ + B_t - \frac{\psi_p}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t \qquad (2.36)$$

where constraint (2.34) states that total production of intermediate good i must be equal to the total demand of final goods producers for intermediate good i. Since intermediate goods producers have monopoly power, they take the demand function as given when they solve their optimization problem. Constraint (2.35) represents the capital accumulation process and constraint (2.36) captures that the profit of the firm i is distributed to the equity holders as dividend payments.

First order condition with respect to N_t gives the labor demand function:

$$w_t = (1-\alpha) z \mu_t K_t^{\alpha}(i) N_t^{-\alpha}(i) \qquad (2.37)$$

where μ_t is the Lagrange multiplier for constraint (2.34) and can be interpreted as marginal cost of producing the intermediate good and $1/\mu_t$ is the mark-up at time t.

First order condition with respect to K_{t+1} gives investment demand equation:

$$q_t = E_t\left[M_{t+1}\left[\alpha z \mu_{t+1} K_{t+1}^{\alpha-1}(i) N_{t+1}^{1-\alpha}(i) + q_{t+1}\begin{pmatrix} 1-\delta-\frac{\psi_k}{2}\left(\frac{I_{t+1}(i)}{K_{t+1}(i)}-\delta\right)^2 \\ +\psi_k\left(\frac{I_{t+1}(i)}{K_{t+1}(i)}-\delta\right)\left(\frac{I_{t+1}(i)}{K_{t+1}(i)}\right)\end{pmatrix}\right]\right] \qquad (2.38)$$

where q_t is the Lagrange multiplier for constraint (2.35) and can be interpreted as the price of a marginal unit of capital.

First order condition with respect to I_t is:

$$1 - \psi_k \left(\frac{I_t(i)}{K_t(i)} - \delta \right) = \frac{1}{q_t} \tag{2.39}$$

First order condition with respect to $P_t(i)$ is:

$$\psi_p \left(\frac{P_t(i)}{P_{t-1}(i)} - 1 \right) \left(\frac{P_t}{P_{t-1}(i)} \right) = \left(\begin{array}{c} (1-\theta) \left[\frac{P_t(i)}{P_t} \right]^{-\theta} + \theta \mu_t \left[\frac{P_t(i)}{P_t} \right]^{-\theta-1} \\ + \psi_p E_t \left[M_{t+1} \frac{Y_{t+1}}{Y_t} \left(\frac{P_{t+1}(i)}{P_t(i)} - 1 \right) \left(\frac{P_{t+1}(i)}{P_t(i)} \frac{P_t}{P_t(i)} \right) \right] \end{array} \right) \tag{2.40}$$

First order condition with respect to $B_t(i)$ is:

$$1/r_t^b = M_{t+1} \tag{2.41}$$

Since Modigliani and Miller Theorem (Terra (2008)) holds in this set up, debt financing and equity financing are equivalent for the firm. Without loss of generality, it is assumed that intermediate goods producers' borrowing is equal to a fixed share of the value of capital:

$$B_t = \tau q_t K_t \tag{2.42}$$

2.1.3 Final goods producers

Final goods producers use the intermediate goods as input, have a constant returns to scale technology and operate in a perfectly competitive market. The representative final goods producer maximizes its profits:

$$P_t Y_t - \int_0^1 P_t(i) Y_t(i) di \tag{2.43}$$

subject to:

$$Y_t = \left[\int_0^1 Y_t(i)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta-1}{\theta}} \tag{2.44}$$

where θ is the elasticity of substitution between intermediate goods.

First order condition gives the demand function for each intermediate good i :

$$Y_t(i) = Y_t \left[\frac{P_t(i)}{P_t} \right]^{-\theta} \tag{2.45}$$

2.1.4 Monetary Policy

It is assumed that monetary authority controls the nominal interest rates to stabilize the economy. Following Basu and Bundick (2012) the monetary authority adjusts the nominal interest rates using the following rule:

$$\ln r_t = \rho_r \ln r_{t-1} + (1 - \rho_r)(\ln r + \rho_\pi \ln \pi_t + \rho_y \ln \frac{Y_t}{Y_{t-1}}) \tag{2.46}$$

Fisher equation gives the relationship between the real interest rate, expected inflation and the nominal interest rate.

$$\frac{r_t}{r_t^b} = E_t \left[\pi_{t+1} \right] \tag{2.47}$$

So, the Euler equation becomes:

$$e^{-2\gamma C_{y,t}} = E_t\left[\beta\frac{r_t}{\pi_{t+1}}e^{-2\gamma C_{o,t+1}}\right] \tag{2.48}$$

2.1.5 Equilibrium Conditions

Total consumption in period t is equal to the summation of the consumptions of young and old agents in period t :

$$C_t = C_{y,t} + C_{o,t} \tag{2.49}$$

Goods market equilibrium implies that total output (net of inflation cost) has to be either consumed or invested:

$$Y_t - \frac{\psi_p}{2}\left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right)^2 Y_t = C_t + I_t \tag{2.50}$$

Labor supply equation (2.24) and labor demand equation (2.37) together give the labor market equilibrium:

$$N_t = \left(\frac{(1-\alpha)z\mu_t\lambda_t K_t^{\alpha}}{\nu}\right)^{1/(\varphi+\alpha)} \tag{2.51}$$

All firms choose the same price $P_t(i) = P_t$, capital $K_t(i) = K_t$ and labor $N_t(i) = N_t$. Inflation is defined as $\pi_t = \frac{P_t}{P_{t-1}}$.

2.1.6 Solution Method

Perturbation AIM algorithm developed by Swanson et al. (2006) is used to solve the model. This algorithm uses *nth* order Taylor approximation around the steady state to find the rational expectations solution of the model.

In order to investigate the independent effects of the second moment shocks, third order approximation is made around the nonstochastic steady state of the model along the lines of Basu and Bundick (2012) and Fernández-Villaverde et al. (2009). Consequently, impulse responses of variables to one standard deviation increase in the financial volatility are estimated in terms of log deviations from their ergodic means.

2.2 Calibration

To analyze the quantitative impact of financial volatility shocks, I calibrate the model at quarterly frequency. Some of the parameters are backed out from the data by matching model generated moments with those in the actual data. Others are based on standard values used in the literature. The resulting parameter set is summarized in Table 2.1.

In the first step of the calibration of the uncertainty shock process, I characterize the financial volatility in the actual data. The proxy for financial volatility I use is Chicago Board Options Exchange Volatility Index (VIX). The VIX is a measure of the expected volatility of the Standard and Poor's 500 stock index, and is the standard proxy of forward-looking financial volatility used in the literature. The VIX is available daily, so I first take the quarterly averages of the index between 1990 and 2014 to match the frequency of the model. The resulting quarterly VIX series has a sample average of 21.01%. I then estimate the following reduced-form autoregressive time series model:

$$VIX_t = (1 - \rho_{vix})VIX_{ss} + \rho_{vix}VIX_{t-1} + \sigma^{vix}\varepsilon_t \tag{2.52}$$

The estimated persistence parameter ρ_{vix} and the standard deviation of the disturbance σ_t^{vix} are respectively 0.73 and 5.01. Hence, one standard deviation shock to VIX increases the level of VIX from its sample average of 21.01% to 26.02%, or by about a quarter.

The second step is to derive a model generated counterpart to VIX and match its moments with the moments of actual VIX index to back out the parameters of the model. The model-implied VIX index I use is the expected conditional volatility of the expected return on the equity of the representative intermediate-goods producing firm. Following Basu and Bundick (2012), the model implied VIX is:

$$VIX_t^{imp} = 100\sqrt{4Var_t[E_t(R_{t+1}^{eq})]} \tag{2.53}$$

where $Var_t[E_t(R_{t+1}^{eq})]$ is the quarterly conditional variance of the expected equity return. Setting the steady state value of model implied VIX equal to its sample mean of 21.01%, the share of nonsophisticated agents (n) is backed out as 14.67%. Similarly, I set the uncertainty shock parameter σ^{σ^a} as 0.0074 so that one standard deviation shock to the volatility of degree of misperception increases the model implied VIX by a quarter as in actual data. Finally, I calibrate the persistence parameter for the uncertainty shock process, ρ_{σ^a}, as 0.73 which is the estimated value of the persistence parameter in the autoregressive process (2.52).

Persistence parameter for the level shock is calibrated using S&P 500 series. Since the series is non-stationary, first it is decomposed into trend and cycle components using Hodrick-Prescott filter, and then persistence parameter of AR(1) process for the cyclical component is estimated. The persistence parameter is found to be 0.88 and is significant at 1%.

Other parameters are determined as follows. Calibration of adjustment cost for investment, ψ_k, is based on Kimball (1995). In particular, adjustment cost parameter is calibrated so that the elasticity of investment to capital ratio with respect to marginal cost of capital is 5. Frisch elasticity of labor supply is equal to $1/\varphi$ and assumed to be 1.25. υ, labor supply constant, is calibrated so that the steady state fraction of time spent in employment is 33% of the one unit of time endowment.

Table 2.1: Calibrated Parameters

Parameter	Value	Definition
α	0.33	Share of capital in the production
β	0.99	Subjective discount rate
δ	0.025	Depreciation rate
z	0.95	Solow residual
θ	6	Elasticity of substitution between intermediate goods
ψ_p	600	Adjustment cost to change price level
ψ_k	8	Adjustment cost to change investment
ρ_a	$0,88$	Persistence of first moment financial shock
σ^a	$0,01$	Volatility of first moment financial shock
ρ_{σ^a}	$0,73$	Persistence of second moment financial shock
σ^{σ^a}	0.0074	Volatility of second moment financial shock
γ	2	Degree of risk aversion
φ	0.8	Inverse of elasticity of labor supply
υ	5.22	Labor supply constant
n	0.1467	Share of nonsophisticated agents
ρ_π	1.5	Sensitivity of nominal interest rate to changes in inflation

2.3 Results and Interpretation

This section reviews and interprets the findings of the model. The first subsection discusses the mechanisms through which financial uncertainty affects real variables and puts them in the context of existing literature. The second subsection presents the impulse response functions to financial volatility shocks and investigates the quantitative impact of the shocks based on evidence from the Great Recession. The third subsection discusses the responses of the real variables to a first moment financial shock. The fourth subsection interprets the model's treatment of financial markets. The last subsection evaluates the performance of the model by comparing its predictions regarding comovements and magnitudes of variables with the actual data.

2.3.1 Modelling the Impact of Financial Market Volatility on Real Variables

In the model, an increase in the volatility of stock prices alters the agents' incentives in two ways. First, when stock price volatility increases, stock price falls, and consequently there is an immediate negative wealth shock to the agents. Second, higher stock price volatility increases the volatility of agents' future income, and because agents are risk averse, creates incentives for precautionary measures. Both of these channels induce the agents to cut back on consumption and increase their savings and labor supply. On the firm side, with monopolistic competition and sticky prices, falling wages increase markup, which in turn depresses labor demand. Under plausible parameter values, the decline in firms' labor demand exceeds the increase in workers' labor supply, and equilibrium wage and employment fall. Finally, higher markup and lower employment reduce the return on capital and decrease investment demand. Hence, in equilibrium, consumption, employment, investment and output all decrease.

From a theoretical perspective, the main finding of the model, that uncertainty depresses output, is not a straightforward result. In particular, in contrast to the current New Keynesian setup, in general-equilibrium neoclassical models with a representative firm and consumer, uncertainty increases output. The different predictions of the two setups can be traced back to differences in the impact of uncertainty on labor demand. In the current setup, uncertainty increases labor supply, but with sticky wages and higher markup, contracts labor demand, leading to a fall in equilibrium employment and output. Assuming labor supply is elastic, it increases in the neoclassical setup too, but in the absence of a change in capital stock and technology, labor demand stays the same, and so equilibrium employment and output increase. As will be discussed below, the evidence on the comovement of variables during recessions lends support to the predictions of the New Keynesian setup over the neoclassical setup.

The paper that the current model relates most closely to is Basu and Bundick (2012), which also investigates the impact of uncertainty on real variables in a New Keynesian setup. There is, however, an important difference. In the current study, the source of uncertainty is financial markets, whereas in Basu and Bundick (2012), household discount rates and total factor productivity. Consequently, while in both models uncertainty shocks depress output through precautionary increases in labor supply and saving, in the current model, there is a second channel which is absent from Basu and Bundick (2012). In particular, in the current model, an increase in the volatility of future stock prices induce an immediate fall in the current stock prices, which acts as a negative wealth shock and exacerbates the negative impact on output.

By modeling uncertainty shocks that originate in the financial markets, the study also offers a contrast to the financial accelerator models where the negative impact of the increase in the cross sectional uncertainty is exacerbated by financial market frictions.[6] In this literature, uncertainty shocks to the variance of idiosyncratic productivity distribution of the firms increases the default risk of the firms and cost of debt financing which in turn causes a decline in investment and output. The current study makes the stronger claim that financial market risk can drive business cycles even in the absence of a fundamental shock elsewhere.

2.3.2 Quantitative Impact of Volatility Shocks and the Great Recession

In this section I use the simulation results to graphically demonstrate the mechanisms through which the impact of financial uncertainty works and provide estimates of the magnitude of the impact.

First consider Figure 2.3, the impact of one standard deviation increase in the financial volatility on the labor market for the parameter set in Table 2.1.

[6]See the seminal paper by Bernanke, Bernanke et al. (1999) and among others Gilchrist et al. (2014), Christiano et al. (2013), and Arellano et al. (2010).

As discussed above, labor supply shifts out, but labor demand contracts more, so equilibrium employment and wage fall.

Figure 2.3: Labor Market Equilibrium before and after the Volatility Shock

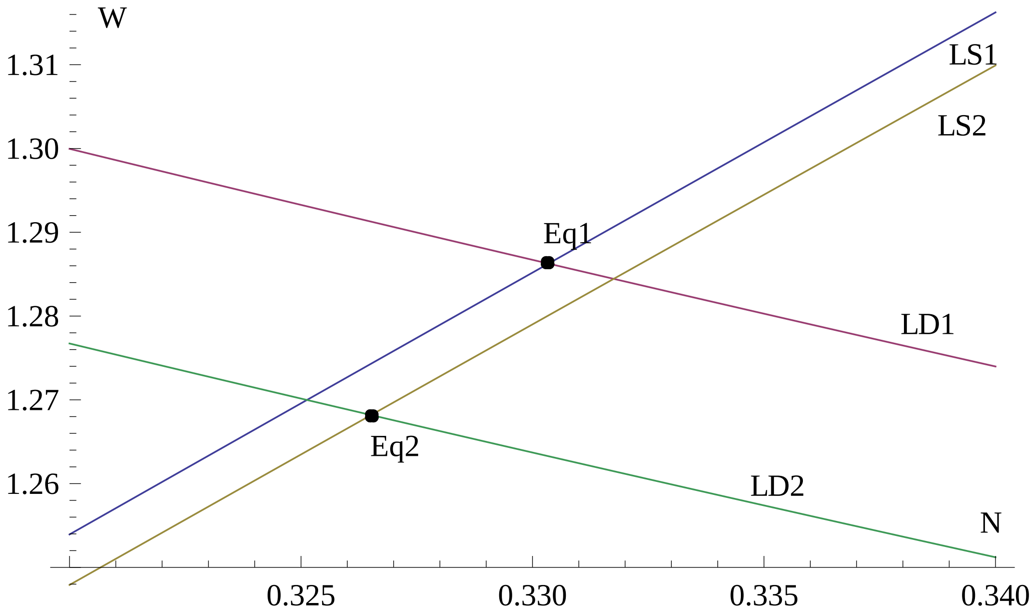
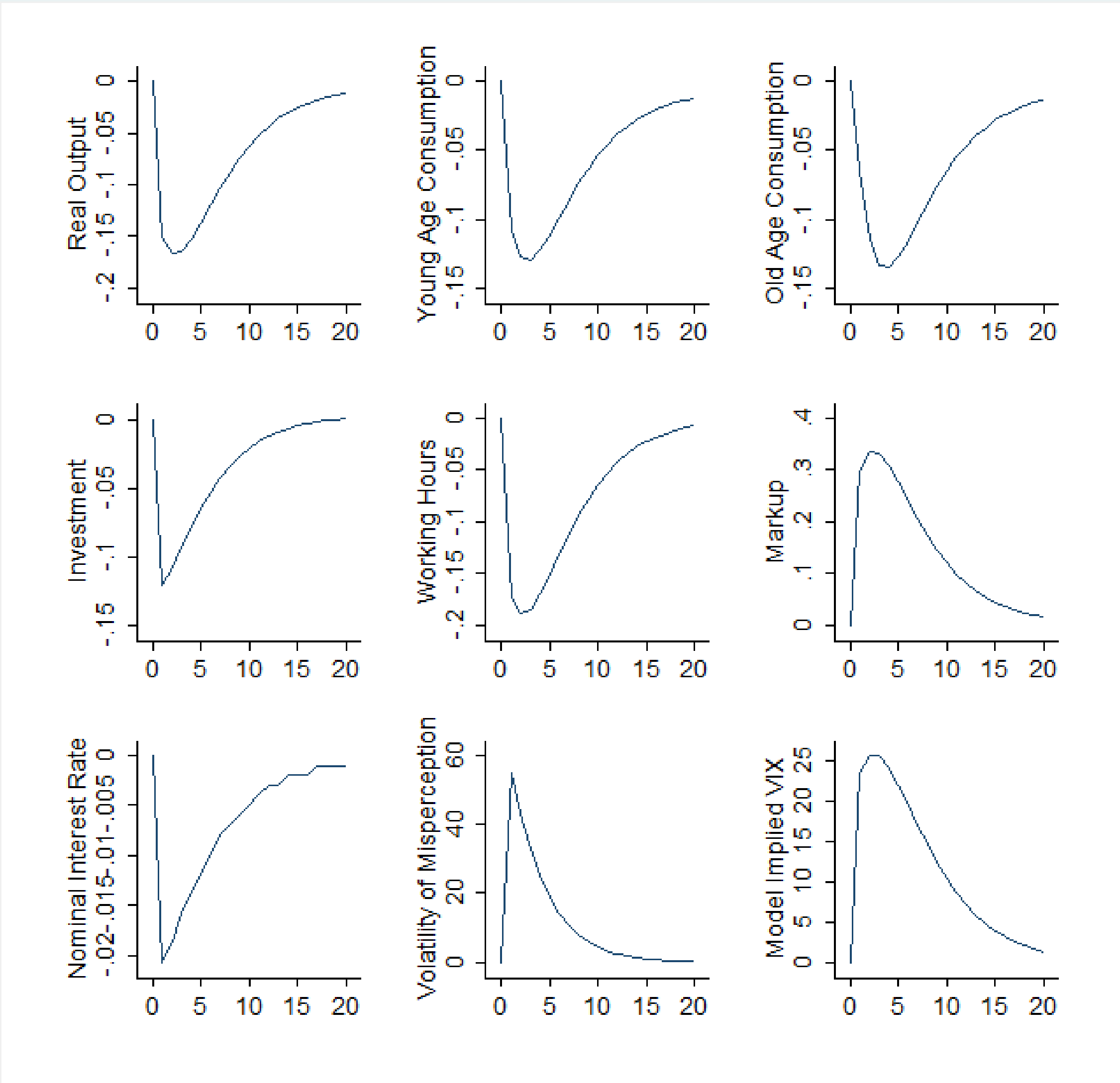


Figure 2.4 traces the impulse response functions of the real variables to the one standard deviation volatility shock to the degree of misperception of the nonsophisticated agents on a quarterly basis. One standard deviation increase in the volatility increases the model implied VIX by 25% compared to its ergodic mean as we observe in data. Consistent with the empirical evidence on recessions, the volatility shock is accompanied by fall in real output and its components. In particular, one standard deviation increase in volatility generates a 0.18% reduction in hours worked, 0.17% reduction in output, 0.12% reduction in investment and 0.13% reduction in consumption.

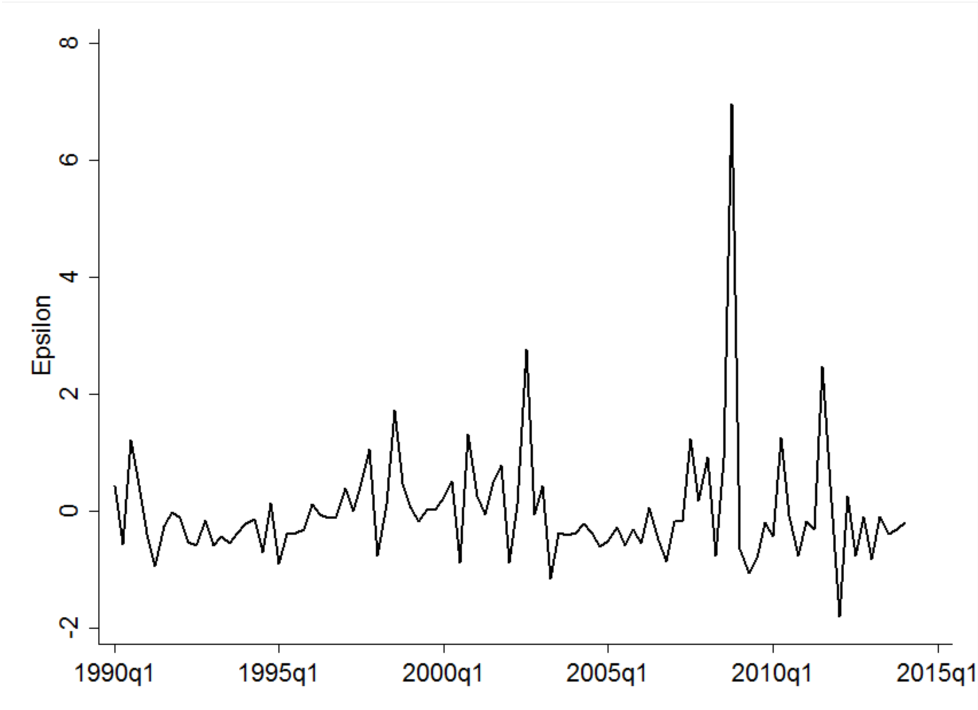
To put these magnitudes in context, I next turn to evidence from the Great Recession. Figure 2.5 shows the VIX-implied volatility shocks, calculated by dividing the residuals of autoregressive process (2.52) by its standard deviation.

Figure 2.4: Impulse Responses to One Standard Deviation Financial Volatility Shock



It shows that the increase in the VIX index during the Great Recession was approximately 6.5 standard deviations. Hence, to estimate the real impact of financial volatility during the Great Recession, the responses of real variables in Figure 2.4 should be multiplied by 6.5. Table 2.2 summarizes the resulting estimates of quarterly changes in real variables. The model estimates a 1.11% peak drop in output, a 1.17% peak drop in working hours, a 0.78% peak drop in investment and a 0.85% peak drop in consumption. To put these estimates in

Figure 2.5: VIX Implied Uncertainty Shocks (residual of equation 2.52 is divided by its standard deviation).



context, in the first quarter of 2009, the output gap was -6.2%.[7] Because the model abstracts away from the fundamental shocks that were at work during the Great Recession, the numbers are not comparable per se, but the findings of the model suggest that roughly 18% of the gap can be attributed to the increase in the financial volatility which is a substantial impact.

Table 2.2: Simulation Results for the Great Recession

	Peak Drops
Output	1.11%
Working hours	1.17%
Investment	0.78%
Consumption	0.85%

[7]Congressional Budget Office estimates.

2.3.3 First Moment Financial Shocks

Note that the discussion up to this point focused on the impact of volatility shocks. A relevant question is the impact of level shocks. In the literature, a number of papers have investigated the impact of first order shocks to financial markets on output through different modeling setups. For example, in Jermann and Quadrini (2009), financial shocks enter to the process through exogenous shocks to borrowing capacity of firms which is determined by the enforcement constraint. A decline in the borrowing capacity of the firms requires an increase in the equity financing and a reduction in the dividend payments. However, equity payout cost prevents firms from reducing dividend payments and force them to cut back employment. Hence, the weakness in their model is that whole impact is based on the assumption that firms can not change dividend payments immediately when business conditions change. In Iacoviello (2014), financial shocks enter through an increase in the number of borrowers who default and cause banks to deleverage. Financial shock in this model is not exogenous because lenders face a destruction of their assets which is a positive wealth shock to the borrowers side. Due to this wealth transfer, borrowers consume more while savers consume less. However, decline in the consumption of savers does not offset the increase in the consumption of borrowers since they also save less in order to smooth their consumption over time. As a result aggregate consumption rises while hours and investment decrease. These papers identify different transmission mecanisms nevertheless both of them show that negative shocks to the financial system have significant negative consequences on real production.

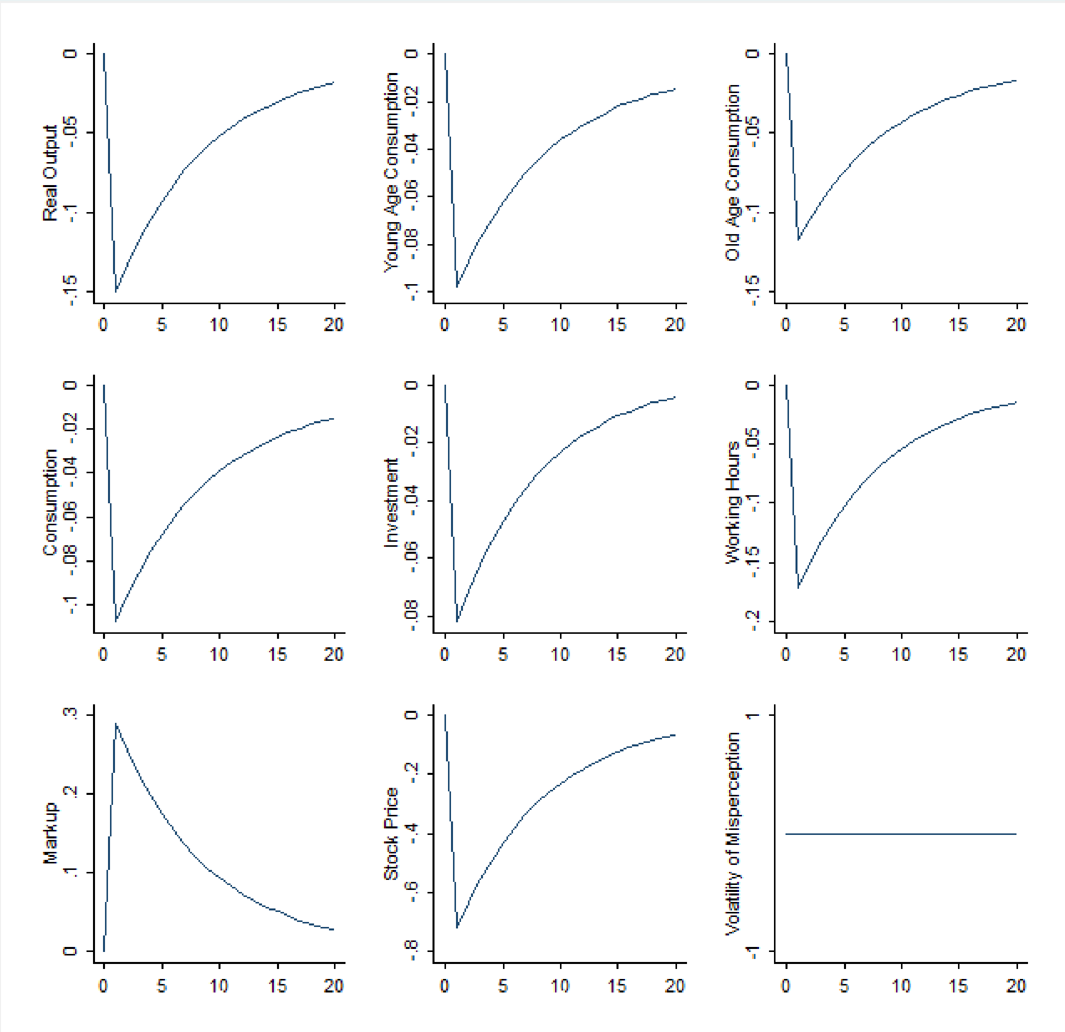
By changing parameter a, the level of misperception of agents, the current model allows investigating the impact of level shocks on real variables. Figure 2.6 summarizes the impact of one standard deviation increase in degree of pessimism. Overall, the responses of the real variables are similar to the responses to volatility shock. To see why, first note that, the impact of a volatility shock to agents' mood worked through two channels: the negative wealth effect and the incentives for precautionary measures against future volatility. Both of these channels had the effect of increasing agents' labor supply and incentive for savings. In the case of a level shock to the pessimism of the agents, the stock price again declines, so the wealth shock is there, but there is no change in future volatility, so the shock does not create a change in precautionary incentives. The overall effect, however, is still an increase in agents' labor supply and higher incentive for savings. This in turn causes a decline in the aggregate demand. Consequently, consumption, investment, employment and output decline.

2.3.4 Modelling Financial Market Volatility

In the model, uncertainty in financial markets is generated by shocks to the "mood" of the nonsophisticated agents. In this respect, the model follows a long line of literature that goes back to Keynes (1936) and argues that markets can fluctuate under the influence of investors' animal spirits. According to this literature, due to behavioral biases, investors may misprice assets and asset prices may diverge from their fundamental values.[8] There is growing

[8]See De Long et al. (1990), Barberis et al. (1998).

Figure 2.6: Impulse Responses to One Standard Deviation Level Shocks to Financial Markets



consensus in the literature that the mood shocks play a significant role in financial markets, evidenced by the stock market bubbles and excess volatility in aggregate stock index returns that can not be explained by volatility in fundamentals.[9]

Note, however, that the main question that this essay investigates is how exogenous volatility in financial markets impact real variables. In this respect, in the broader interpretation of the study, the mood shocks can be considered

[9]See Baker and Wurgler (2006).

as an analytical device to generate the exogenous volatility in financial markets in order to trace its impact. Financial markets may become more volatile for reasons other than mood shocks, and the findings of the study regarding the mechanisms through which financial volatility affects output would still be valid.

A critical aspect of the financial markets in the model is that the stock prices deviate from their fundamental values. The rationale behind this deviation might not be immediately transparent, as the efficient market hypothesis argues that even if non-sophisticated traders exist and deviate the prices from their fundamental values, existence of rational arbitrageurs should drive prices towards their fundamental values.[10] However, when the mood of the non-sophisticated traders is unpredictable, arbitrage trading charges additional risk to the arbitrageur. If the arbitrageur is risk averse then arbitrage becomes limited and fails to eliminate the deviations of asset prices from their fundamental values completely. Hence, under limited arbitrage these deviations can be persistent even if there is no fundamental risk.[11]

2.3.5 Validating the Model

The model makes a number of predictions about the impact of financial uncertainty on the agents' incentives and equilibrium outcomes that can be checked against the data. For the agents, it predicts that financial volatility creates incentives for increase savings at the cost of current consumption. This prediction can be traced back to the setup of portfolio selection with one risky

[10]See Fama (1965), Sharpe (1964), Ross (1976).
[11]See De Long et al. (1990) and Barberis et al. (1998).

and one riskless asset and two period lived agents. In this setup, an increase in stock market volatility implies an increase in the volatility of second period income, and, because agents are risk averse, a decrease in the expected second period utility. Moreover, since stocks become riskier, demand for stocks, and consequently, stock price falls. Agents try to accommodate these negative shocks by increasing their incentive to save. On the empirical front, there is a long line of literature supporting this prediction. For example, Carroll and Samwick (1998) provide empirical evidence that income uncertainty induces agents to increase their precautionary savings. Regressing household wealth on their measure of income uncertainty, the paper estimates that between 32% and 50% of wealth in their sample is attributable to the extra income uncertainty.

On the firm side, the model predicts procyclical marginal costs and countercyclical markups through sticky prices. These predictions accord well with the empirical literature. For example, Bils (1987) finds that short run marginal costs change procyclically whereas prices do not respond cyclical fluctuations immediately and hence markup, price to marginal cost ratio, is countercyclical. Likewise, Galeotti and Schiantarelli (1998) provide evidence for a negative relationship between markups and aggregate demand.

Most importantly, the model predicts that financial uncertainty leads to a contraction in investment, consumption and consequently in output. This prediction is consistent with the empirical evidence. On the empirical front, Romer (1988), Choudhry (2003) and Raunig and Scharler (2011) argue that an increase in stock market volatility makes people feel unsafe about their future income and causes a substantial decline in durable consumption and investment demand. The rationale behind this finding is that households perceive stock market volatility as a predictor of future economic conditions even if they do not hold stocks. Hence, higher stock market volatility is a strong signal of higher uncertainty about their future income causing them to postpone investment activities and durable goods consumption which in turn leads to a contraction in output.

Another way to evaluate the performance of the model is to compare the non-targeted moments estimated by the model with the actual figures. Table 2.3 presents the moments generated by the model and compares them with the values observed in data.

Table 2.3: Non-targeted Moments

	Ergodic means	Actual average values
Investment to GDP ratio	24.6%	20.7%
Consumption to GDP ratio	75.4%	67.2%
Mark-up	18.29%	23.5%
Annual interest rate	6.4%	4.5%
Equity risk premium	4.28%	5.38%

In the model, investment is estimated to constitute 24.6% of the output, which is close to the actual average figure of 20.7% for the US between 2000-2014.[12] Since there is only investment and consumption in the model, the remaining 75.4% is estimated as consumption, and the model does not provide estimates for government expenditures and net exports.

As for short term interest rates, the model generates an ergodic mean of $4 \times 1.6\% = 6.4\%$, which bodes well with the actual average figure of 4.5% for

[12]Data is taken from OECD.

the short term interest rates between 1990-2009 for the US.

For the markup ratio, the model generates an estimate of 18.3%. This estimate is also reasonable. For example, Martins et al. (1996) investigate markup ratios for manufacturing industries between 1970 and 1992 and find average ratios of 15.2%, 20.8%, and 15.3% respectively for the US, Japan, and the UK. With more recent data from 1981 to 2004, Christopoulou and Vermeulen (2012) find average markup ratios of 23.5% and 20% for the manufacturing industries in the US and the Euro area.

Implicit in the model is also a particular explanation to the equity premium puzzle. According to the model, the equity risk premium is higher than what is justified by the fundamentals, because the volatility of the mood of the non-sophisticated investors introduces additional stock price volatility. Assuming an absolute risk aversion parameter of 2, the model generates an ergodic mean of $4 \times 1.06\% = 4.28\%$ for the equity risk premium. This estimate is very close to the actual average value of the equity risk premium for the years between 1962 and 2011 which is 5.38%.[13]

2.4 Conclusion

This essay investigates whether an increase in uncertainty in financial markets helps drive business cycles. While the financial consequences of real volatility shocks has been modeled extensively, the real consequences of financial volatility shocks have received less attention. The Great Recession, however, suggests that financial volatility may independently contribute to the severity

[13] See Damodaran (2013).

of economic downturns. This essay investigates this impact by a model at the intersection of the literatures on equilibrium asset pricing under the noise trading risk and DSGE models with monopolistically competitive firms and sticky prices. The results of the model suggest that the negative impact of financial volatility on output works by contracting aggregate demand and the simulation results suggest this impact is substantial.

The finding that financial volatility is an independent cause of real downturns has immediate policy implications. It suggests that policy makers shouldn't be oblivious to an increase in the financial volatility even if they believe it does not reflect a shift in the fundamentals. More generally, the results suggest that the policymakers should treat increased financial volatility as a problem in and of itself, rather than a symptom of underlying fundamental issues.

While the model does not focus on driving the optimal monetary policy rules, its findings have clear policy implications. The model finds that the increase in financial market volatility during recessions has an independent and significant contribution to the contraction in aggregate demand. Hence, the results of the model highlight the importance of policy measures aimed at reducing volatility and increasing the confidence in financial markets. For example, policy makers can turn to forward guidance policies and reduce the volatility of the expectations of the agents about the future path of the interest rate. To go beyond these general recommendations and drive the specifics of such policies, further research is needed.

CHAPTER 3

UNCERTAINTY, FINANCIAL DEVELOPMENT AND REAL ECONOMIC ACTIVITY

This study investigates whether financial development moderates the negative impact of uncertainty shocks on real economic activity. To test this conjecture, I compare the impact of macro level uncertainty as measured by stock market volatility on real GDP growth for countries with different financial development levels. To address potential endogeneity concerns, the estimation is made using Two Stage Least Squares (2SLS) technique where plausibly exogenous natural disaster, political and terrorist attack shocks are used as instruments for stock market volatility. The estimation results are consistent with the conjecture that uncertainty shocks hurt countries with developed financial markets less.

Uncertainty shocks may affect real sector through different channels, and financial development matters for these channels in various ways. For one, uncertainty shocks depress aggregate demand because agents take precautions against higher uncertainty of their future income.[1] Second, higher uncertainty

[1]See Basu and Bundick (2012) and Fernández-Villaverde et al. (2011).

increases default risk of the firms which increases the credit spreads and their cost of borrowing.[2] Third, uncertainty shocks distort resource reallocation among more and less productive firms.[3] In well functioning financial systems credit constraints and transaction costs are lower, the liquidity problems are less severe and obtaining information about the possible investment projects is less costly. Hence, if the financial system works properly, some of the precautionary savings are replaced by credit, firms have less liquidity problems, borrowing is less costly and resources are allocated more efficiently. Consequently, I conjecture that an improved financial system decreases the negative impact of uncertainty shocks on real output.

The contribution of this study is to investigate this conjecture using an extensive data set and a clear identification strategy. In the empirical analysis, the dependent variable is quarterly real GDP growth. The independent variable of interest is uncertainty (as measured by stock market volatility) interacted with financial development. The conjecture that financial development mitigates the negative impact of uncertainty shocks implies that the coefficient of this interaction term should be positive and significant. In the regression analysis, the main concern is potential endogeneity issues. To address this concern, the paper follows the identification strategy employed in Baker and Bloom (2013). In particular, in Two Stage Least Squares estimation, uncertainty is instrumented by natural disasters, terrorist attacks, political coups and revolutions, while also controlling for country and year fixed effects.

In testing this conjecture, I build on two previous empirical studies that

[2]See Gilchrist et al. (2014), Christiano et al. (2013), and Arellano et al. (2010).

[3]See Finally, Bloom et al. (2012)

separately test the impact of uncertainty and financial development on real output. As discussed above, the identification strategy and the data on uncertainty shocks builds on Baker and Bloom (2013). As for financial development, the study relies on indices developed by Čihák et al. (2013), who build separate indices for different aspects of financial development. In different empirical specifications, I test the moderating impact of six different measures of financial development from their data set on the transmission of uncertainty shocks, which include proxies for financial depth, stability and access.

The results of the empirical analysis provides strong support for the conjectured mitigating impact of financial development on the negative impact of uncertainty shocks. Using a quarterly panel data set for the period between 1971 and 2009 for 54 countries, the regression results find significant coefficients for the interaction between uncertainty and various proxies of financial development. More specifically, the regression results show that a greater financial depth, access and stability all decrease the negative impact of uncertainty on economic growth. The finding is robust when various country characteristics, including population, real GDP, per capita real GDP, country and year fixed effects are included in the regressions as control variables.

The findings of this study contributes to the literature on impact of uncertainty shocks on real economic activity. On the emprical front, Alexopoulos and Cohen (2009), Bloom (2009), Baker and Bloom (2013), Baker et al. (2013), Caldara et al. (2014), and others show that uncertainty shocks depress economic activity. Gilchrist et al. (2014) find that credit frictions are crucial in the transmission of uncertainty shocks based on a VAR framework. Similar to the current study Aghion et al. (2005) and Aghion et al. (2009) find that negative impact of uncertainty is lower if financial development is higher when they include the interaction of private credit with the volatility in the regressions. However, when the uncertainty is instrumented by the standard deviation of the commodity price shocks due to the endogeneity concerns the interaction term turns out to be insignificant in Aghion et al. (2005). The main contribution of this study is to provide evidence that this negative impact of the uncertainty shocks is not uniform across countries with different financial development levels and employ an identification strategy first developed by Baker and Bloom (2013) to adress potential endogeneity concerns about the finding.

The rest of this chapter proceeds as follows. Section 1 discusses the literatures on uncertainty, financial development and growth and develops the main conjecture of the study. Section 2 presents the empirical model and describes the data. Section 3 summarizes the findings and the last section concludes.

3.1 Theoretical Review

This study is at the intersection of the literatures on the impacts of financial development and uncertainty shocks on growth. Consequently, I first briefly discuss these two literatures and highlight the theoretical arguments as to why financial development might alter the impact of uncertainty on output.

Both the theoretical and empirical literatures suggest that financial development facilitates economic growth. The theoretical literature identifies the basic functions of financial system as producing information for capital allocation, monitoring investment projects, diversifying risk, pooling savings and easing the exchange of goods and services.[4] Accordingly, a higher financial development level facilitates economic growth by providing liquidity, allocating capital to highest return projects and stimulating specialization and adoption of new technologies.[5] On the emprical front, recent papers such as Levine (2005) and Demirgüç-Kunt and Levine (2008) use financial depth as a measure of financial development and show that financial development has a causal impact on economic growth.

An important observation about financial development is that it has more than one dimension. In this respect, the four subcategories that Čihák et al. (2013) have identified are useful. Accordingly, these four subcategories are depth (size of the services provided by financial system), access (the breadth of use of financial instruments), efficiency (lower cost of financial services) and stability (solvency risk). The authors also treat and measure financial development for financial markets and institutions separately.

There is also a sizable literature on the impact of uncertainty shocks on economic growth. Below, I discuss three of the channels discussed in this literature. The first strand in the literature focuses on the demand side effects of macro level uncertainty shocks. For example, Basu and Bundick (2012), and Fernández-Villaverde et al. (2011) estimate the impact of uncertainty shocks on real variables in a New Keynesian business cycle model. In these models, uncertainty shocks respectively refer to the increase in the volatility of demand and fiscal policy tools. In particular, this literature suggests that an increase

[4] See Levine (2005)

[5] See Grossman and Stiglitz (1980), Boyd and Prescott (1986), Greenwood and Jovanovic (1989), Greenwood and Smith (1997), Acemoglu et al. (2006)

in the volatility induces precautionary motives of the agents because they are risk averse. Precautionary behavior of the agents in turn causes a decline in the consumption and investment demand in the economy. Consequently, real production falls below its potential level because the output is demand determined in the New Keynesian setup.

For this first strand, even though financial sector is excluded from the model for simplicity, it is very relevant. The relevance of the financial sector is due the fact that in both theoretical and empirical literatures countries with higher financial development levels have lower precautionary incentives against uncertainty. For example, Leland (1968), Kimball (1990), Weil (1993), Aiyagari (1994), Jappelli and Pagano (1994) and Fulford (2013) theoretically show that there is a negative and monotonic relationship between saving rate and and financial development. The intuition is that when financial markets are incomplete, agents increase their savings as a self-insurance against idiosyncratic risks. On the empirical front, Liu and Woo (1994), Jappelli and Pagano (1994), and Loayza et al. (2000) show that an increase in the financial development level causes a reduction in the saving rate.

To summarize, the literature suggests that uncertainty shocks creates incentives for precautionary savings and contracts demand and output. However, since financial development curbs precautionary incentives, it follows that the negative impact of uncertainty on output should decrease with financial development.

The second strand of the literature focuses on the effects of micro level uncertainty on firms in an economy with financial frictions. In this vein, building on Bernanke et al. (1999) framework, Gilchrist et al. (2014), Christiano et al. (2013), and Arellano et al. (2010) investigate the impact of uncertainty shocks in an economy with debt contracts between entrepreneurs and lenders. The interest rate for these debt contracts is endogenously determined and includes a premium for the default risk of the entrepreneurs. When the volatility of the cross sectional distribution of the idiosyncratic productivity of the firms increases, entrepreneurs' default risk and cost of borrowing increases. This in turn depresses firms' investment and decreases real production.

This second strand in the literature is also consistent with the conjecture that the negative impact of uncertainty shocks on output will be less in financially developed countries. The intuition is that in these models the negative impact of uncertainty works through firms' default risk and the cost of borrowing, and financial development reduces these financial frictions.

As the third strand in the literature, Bloom et al. (2012) suggests that resource reallocation among heterogenous firms and consumption smoothing play crucial roles in the transmission of uncertainty shocks to the real economic activity. In particular, an increase in the uncertainty increases the return to inaction causing firms to choose to wait instead of investing. This reduces the productivity growth in the economy because productive firms pause expanding and unproductive firms pause contracting. This in turn causes a decline in investment and output. Optimal consumption smoothing of the agents through intertemporal reallocation of resources causes a milder recovery from the depression. Consequently, if financial system is not functioning well, it does not allow for consumption smoothing, the efficiency in the reallocation of resources declines and uncertainty has a more adverse impact. Hence, as in the first two strands, the negative impact of uncertainty worsens with financial frictions.

3.2 Empirical Analysis

3.2.1 Model

The interaction between financial development and uncertainty shocks is investigated using a Two Stage Least Squares model with country and year fixed effects. The estimated equation is:

$$\begin{aligned}\Delta y_{i,t} &= \alpha_1 R_{i,t-1} + \alpha_2 Vol_{i,t-1} + \gamma_j Findev_{i,j,t-1} + \beta_j \left(Vol_{i,t-1} \cdot Findev_{i,j,t-1}\right) \\ &\quad + \delta_m X_{i,m,t-1} + \phi_m \left(Vol_{i,t-1} \cdot X_{i,m,t-1}\right) + \rho_j \left(R_{i,t-1} \cdot Findev_{i,j,t-1}\right) \\ &\quad + \mu_i + \upsilon_t + \epsilon_{it} \qquad (3.1)\end{aligned}$$

$\Delta y_{i,t}$, the dependent variable, is the quarter on quarter growth rate of real GDP.

$R_{i,t-1}$ and $Vol_{i,t-1}$ respectively represent stock market return and stock market volatility for country i lagged one period. These two variables are respectively used as proxies for the first and second moments of business conditions.

$Findev_{i,j,t-1}$ represents the financial development proxy j for country i in period $t-1$. In different specifications, the estimation uses six different measures of financial development including measures of its depth, access, and stability, as will be discussed below.

$Vol_{it-1} \cdot Findev_{i,j,t-1}$, the interaction of the lagged volatility of the stock market and the proxy for financial development, is the main variable of interest. The main conjecture that this study investigates is that this interaction term has a positive and significant coefficient, i.e. financial development curbs the negative impact of uncertainty on real growth rates.

$X_{i,m,t-1}$ and $Vol_{i,t-1} \cdot X_{i,m,t-1}$ are respectively the control variable m for country i lagged one period and its interaction with the lagged stock market volatility. In different specifications, population, total and per capita real GDP and their interactions with volatility are included as controls. These variables are included in the regression to address the concern that they might both be correlated with financial development proxy and be relevant for the impact of the uncertainty shocks and hence their omission from the regression equation might lead to omitted variable bias. For example, if GDP per capita is correlated with financial development and rich countries are better able to accommodate the negative consequences of uncertainty shocks, then omitting GDP per capita and uncertainty interaction from the regression would cause and upwards bias in the estimated coefficient for the financial development-uncertainty interaction.

In some specifications, the interaction between lagged stock market return and lagged financial development, $R_{i,t-1} \cdot Findev_{i,j,t-1}$, is also included as a control variable. The concern is again omitted variable bias. Since stock market return is likely to be correlated with stock market volatility, if its interaction with financial development is omitted, the estimated interaction of financial development and uncertainty would be biased.

All specifications include country and quarter fixed effects, μ_i and υ_t These fixed effects respectively control for the impact of time invariant country specific variables and period specific common shocks to all countries.

The main concern in the estimation is endogeneity. This concern is particularly valid for stock market return and volatility variables, the proxies for the first and second moment of business conditions. In particular, because these variables are forward-looking variables, they might be affected by expected future drops in output.

To address the endogeneity problem for these variables, following Baker and Bloom (2013), the model is estimated using Two Stage Least Squares method, instrumenting stock market return and volatility by exogenous natural disaster, terrorist attack, political coup and revolution shocks. Bloom and Baker's identifying assumption is that some of these exogenous shocks primarily have level and others have primarily volatility effects. For example, a natural disaster is likely to cause material destruction and hence is likely to create a level effect. On the other hand, a terrorist attack has limited material damage but is likely to generate volatility. The details of the way these variables are constructed are discussed below.

By the same reasoning, the interaction of financial development with stock market volatility, the main variable of interest, is instrumented by the interaction of financial development with the same set of natural disaster, terrorist attack and political shocks. Likewise, any other control variable interacted with stock market volatility or return is instrumented by its interaction with these instruments.

3.2.2 Data

The data set includes variables for 54 countries between the years 1970-2009 at quarterly frequency. The years after 2009 are excluded because of inconsistencies in the quality of data

The data for real GDP growth, stock market volatility, stock market return, and the instruments used for stock market volatility and return are based on Baker and Bloom (2013) who in turn rely on Global Financial Database and IMF Statistics Division. Real GDP growth series measures quarter-on-quarter growth. The base years for the real GDP series used in the growth rate calculations are different, but since regressions are based on growth rates, this does not affect the results. Stock market returns and volatility are adjusted for inflation.

The natural disasters in the data set include extreme weather events, earthquakes, epidemics, floods, landslides,, volcanoes, fires, and alike. Terrorist attacks include attacks with greater than 30 deaths before 1993 and greater than 15 deaths after. The higher threshold for the earlier period is due data availability issues. Two types of political events are coded separately. Political coups are defined as forceful seizure of executive authority by an opposition group from within the government. Political revolutions are events featuring violent conflict between a country's government and politically organized opposition groups who seek to change the government.

In constructing the shock variables, Baker and Bloom (2013) also weigh each natural disaster, terrorist and political event by the increase in Google News daily article counts of the affected country in the fifteen days after the event compared to the fifteen days before the event.

Weighing the events by the increase in the news articles helps address two issues. First, only unanticipated events are included because anticipated events like elections do not generate jumps in coverage on the day they occur. Second, it allows distinguishing between large shocks that are likely to have a national economic impact and small shocks that are not.

The financial development variables are based on Čihák et al. (2013). The authors provide proxies for different dimensions of financial development. In this study, following earlier empirical studies in the literature, I focus on the proxies of financial depth, defined as the size of financial institutions and markets.

For the size of financial institutions, I use two proxies: private credit by deposit money banks to GDP (fidp) and deposit money banks' assets to GDP (fida). The first proxy only includes private credit to the real sector by deposit money banks and has been the more commonly used proxy in the literature. The second proxy is more comprehensive in that it also includes credit to government as well as bank assets in addition to private credit. Despite differences in their definition, these two variables are highly correlated.

As for the size of financial markets I use the ratio of sum of stock market capitalization and outstanding domestic private debt securities to GDP (fmdsc). Čihák et al. (2013) proposes this measure as a proxy for the sum of the sizes of stock and bond markets. Because in regression analysis I use stock market measures of returns and volatility, for robustness, I also include outstanding domestic private debt securities to GDP (fmds) by itself.

In addition to proxies of financial depth, I also include a proxy for financial access. Financial access is defined as the degree to which individuals can and do use financial institutions and markets. To the extent entrepreneurs that are not well-connected are discriminated against and barred from access to finance, this creates financial frictions. As a proxy for access, I use the ratio of market capitalization excluding top ten companies to total market capitalization (fmac). The premise underlying this proxy is that a lower market concentration reflects easier access for newer or smaller issuers.

The last financial development variable included in the analysis is the ratio of bank nonperforming loans to gross loans (fisn), a proxy for financial stability. This proxy, and more generally financial stability are relevant for the analysis, because under uncertainty shocks, it determines the firms' bankruptcy risk and degree of access to liquidity. Note that in contrast to the other five proxies, a higher value of fisn indicates lower financial development. Hence, for consistency, we include fisn variable in the regression after taking its negative value.

As for control variables, population and real GDP is taken from Penn World Tables. Real GDP is expenditure based at chained PPPs and in million 2005$. Real GDP per capita is the ratio of real GDP to population.

Table 3.1 presents the summary statistics for the variables employed in our econometric analysis. There are 54 countries in the sample, 40 years between 1970 and 2009, but since in the regression analysis certain variables are lagged,

Table 3.1: Summary Statistics for Variables

Variable	Obs.	Mean	Std Dev.	Min.	Max
Real GDP Growth	5359	0.8768	1.688	-22.279	12.836
Stock Market Return	5359	0.0106	0.1503	-0.7885	0.9235
Stock Market Volatility (in logs)	5359	-4.5307	0.5496	-6.212	-2.0411
Natural Disaster Shocks	5359	0.0299	0.0994	0	1.6203
Political Coup Shocks	5359	0.0021	0.0444	0	1.4486
Revolution Shocks	5359	0.00028	0.0101	0	0.3698
Terroris Attack Shocks	5359	0.00608	0.09011	0	2.5897
Private Credit to GDP (fidp)	4776	63.458	42.393	4.58	237.58
Deposit Money Banks' Assets to GDP (fida)	4776	76.436	46.431	9.05	248.08
Outstanding Domestic Private Debt Securities to GDP (fmds)	2687	28.152	28.023	0.01	184.84
Outstanding Domestic Private Debt Securities Plus Stock Market Capitalization to GDP (fmdsc)	2662	93.157	64.658	5.14	315.16
Market capitalization excluding top 10 companies to total market capitalization (fmac)	1571	46.993	17.374	2.79	85.68
Bank nonperforming loans to gross loans (fisn)	2247	-6.776	7.588	-48.6	-0.1
Population (in millions)	5359	65.317	141.510	0.3671	1156.9
Real GDP (in trillions)	5359	0.8579	1.6699	0.0095	13
Real GDP per Capita (in millions)	5359	0.0234	0.0689	0.00023	0.9644

the data for 1970 effectively drops out. The regressions are done at quarterly frequency, implying an upper limit of 54*39*4=8424 observations. Because quarterly real GDP and stock market data is missing for the earlier years for some of the countries, the maximum number of observations drops to 5359. Among the financial development variables, the most comprehensive data is available for fidp and fida, with data for 4776 out of 5359 country years, with only Taiwan and Chile dropping from the sample and losing observations for the earlier years for other countries. For the other four financial development proxies, the number of observations fall.

3.3 Results

Table 3.2 reports the baseline IV estimation results. In all specifications, stock market volatility and return are included as explanatory variables. All specifications also include country and year fixed effects. In each of the six columns, a different proxy for financial development is used. Each development proxy enters the estimation by itself and as interacted with stock market volatility. The coefficient of interest is the coefficient of the interaction term between financial development proxy and stock market volatility. If financial development mitigates the negative impact of uncertainty shocks as conjectured, the estimated coefficient should be positive and significant.

Table 3.2: Baseline IV Estimation Results

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Stock Market Volatility	-5.366***	-4.968***	-7.176***	-3.626**	-25.293*	0.10
	(-3.21)	(-3.24)	(-2.83)	(-1.98)	(-1.89)	(0.11)
Stock Market Return	16.770****	14.188***	3.36	3.09	-2.84	1.59
	(3.30)	(3.11)	(0.73)	(0.55)	(-0.27)	(0.35)
Volatility*fidp	0.090*					
	(1.91)					
fidp	0.401**					
	(1.97)					
Volatility*fida		0.063**				
		(2.24)				
fida		0.284**				
		(2.31)				
Volatility*fmdsc			0.051***			
			(2.73)			
fmdsc			0.235***			
			(2.82)			
Volatility*fmds				0.109**		
				(2.18)		
fmds				0.475**		
				(2.15)		
Volatility*fmac					0.435*	
					(1.71)	
fmac					1.870*	
					(1.71)	
Volatility*fisn						0.135****
						(4.15)
fisn						0.580****
						(4.49)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4776	4776	2662	2662	1571	2247

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

The financial development proxies employed in the first and second columns measure depth of financial institutions (fidp and fida), third and fourth columns measure the depth of financial markets (fmdsc and fmds), fifth column measures access to financial markets (fmac) and the last column measures the stability of financial institutions (fisn). Note that due to data availability issues for the financial development indicators, the number of observations in each specification is different, with most comprehensive data for the first two specifications.

Across the six specifications, the empirical findings are consistent. In particular, the coefficient for the interaction between financial development and volatility is positive and significant at 10% for specifications 1 and 5, 5% for specifications 2 and 4, 1% for specification 3 and 0.1% for specification 6.

Note also that for the first five specifications the coefficient for the stock market volatility variable is negative and significant. This finding implies that had the financial development proxy been equal to zero, the impact of uncertainty shock on output would have been negative and equal to this estimated coefficient. The positive interaction term between stock market volatility and financial development, on the other hand, implies that as financial development proxy increases, the estimated negative impact of volatility on output declines.

The result for specification six, because of the nature of the proxy, should be interpreted differently, but essentially points to the same underlying finding. Fisn variable is created by multiplying the ratio of bank non-performing loans to gross loans with negative 1. Hence, the estimated coefficient for stock market volatility, which is not significantly different from zero, implies that when banks have no nonperforming loans and financial system is stable, uncertainty shocks do not have a significant impact on output. The positive coefficient of the interaction term between fisn and volatility implies that as the ratio of nonperforming loans increases, and fisn becomes more negative, the impact of uncertainty shocks on output becomes more adverse.

In all six specifications stock market volatility, stock market return and the interaction of volatility and financial development are instrumented by the natural disaster, terrorist and political shock variables and their interactions with financial development. Sargan overidentification test is not rejected in any of the specifications which implies that impact of the disaster shocks are fully captured by the endogenous variables. F-statistic for the joint significance of the instruments is higher than 10 for each instrumented variable except for the interaction of the proxies for depth of financial institutions with volatility in specifications 1 and 2. For these two interactions, however, F statistics are still significant at 0.2% level. Hence, the evidence suggests that all instruments have explanatory power.

3.3.1 Marginal Effects

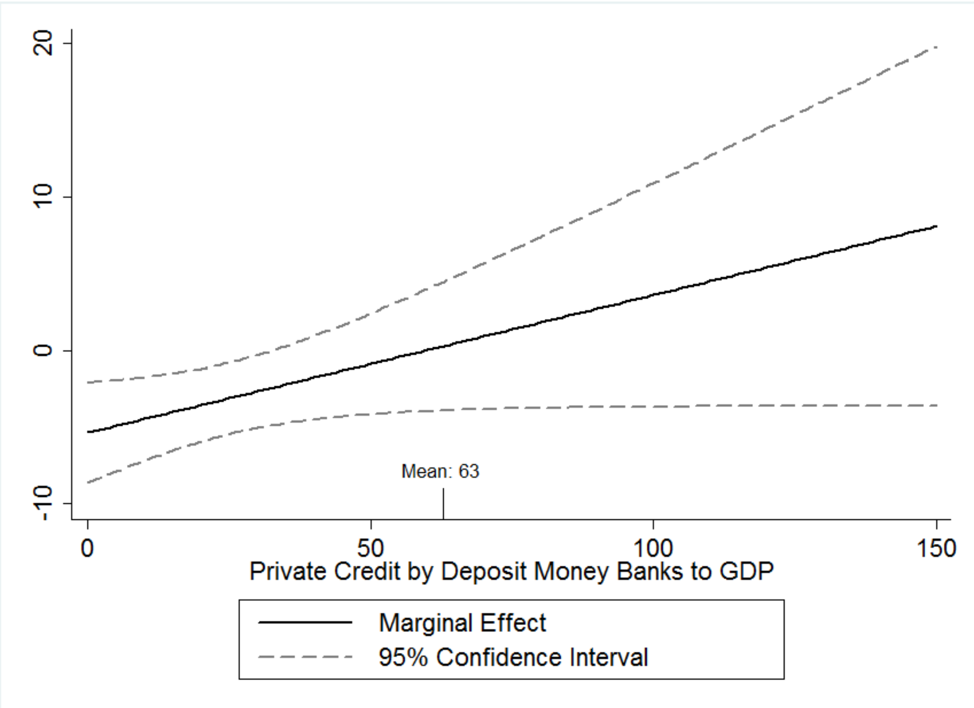
In order to better interpret the empirical findings, I next calculate the marginal effect of volatility shocks on economic growth at each different financial development level. In standard linear models marginal effect of a variable is equal to its coefficient. However, if the model includes a multiplicative interaction, marginal effects are based on the values of the interacted variable. From equation 3.1 marginal effect of volatility on real economic growth (without any control variables) is defined as:

$$\frac{\partial \Delta y_t}{\partial Vol_{t-1}} = \alpha_2 + \beta_j Findev_{j,t-1}. \tag{3.2}$$

Equation 3.2 states that the effect of a marginal change in volatility on real economic growth is conditional on the values of financial development. Note also that with the interaction term the confidence interval for the estimated marginal effect of volatility also varies across financial development levels. In particular, due to the interaction term, the standard error of the marginal effect of volatility is:

$$\sqrt{Var\alpha_2 + Findev_j^2 Var\beta_j + 2Findev_j Cov(\alpha_2, \beta_j)} \tag{3.3}$$

Figure 3.1: Marginal Effect of Volatility for Different Levels of Private Credit by Deposit Money Banks to GDP Ratio



Figures 3.1 to 3.6 plot the marginal effect of volatility on real economic growth for different values of each of the six financial development proxies.

Figure 3.2: Marginal Effect of Volatility for Different Levels of Deposit Money Banks' Assets to GDP Ratio

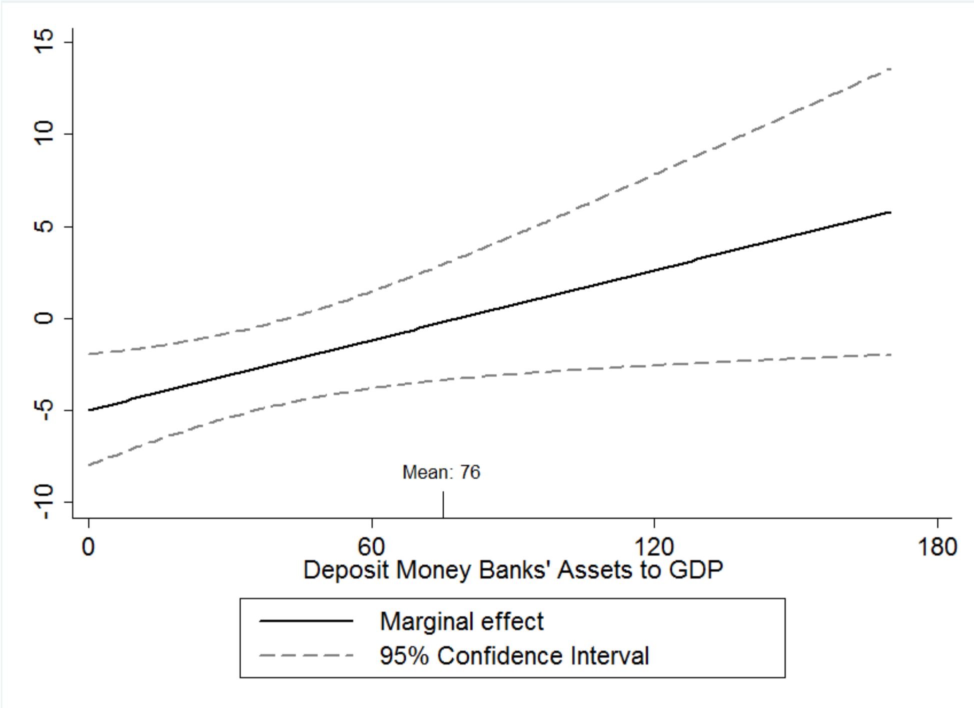
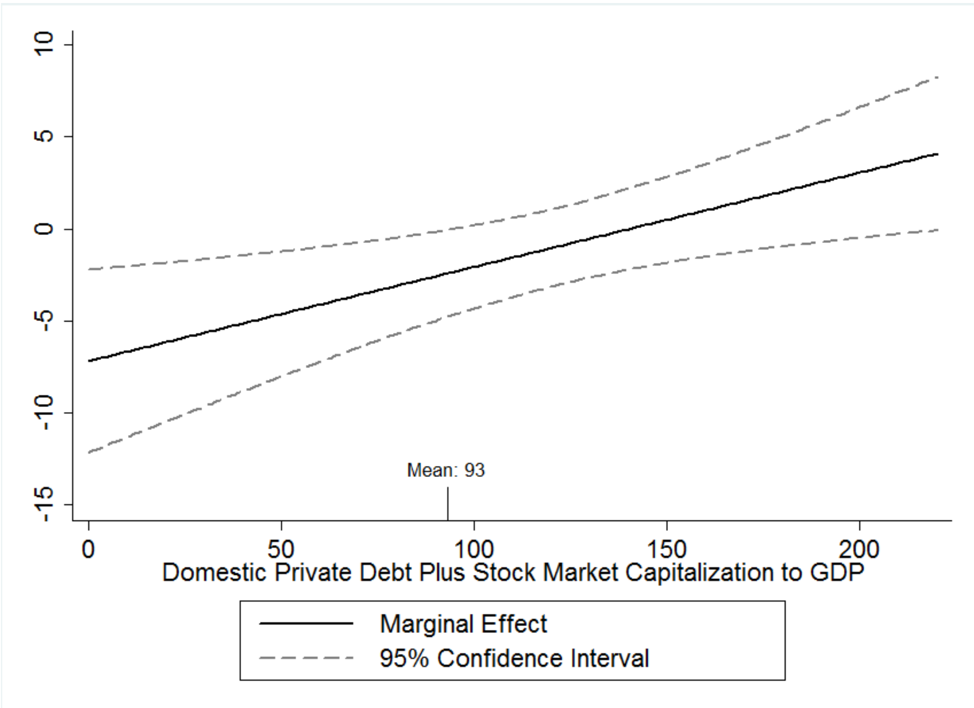


Figure 3.3: Marginal Effect of Volatility for Different Levels of Domestic Private Debt Plus Stock Market Capitalization to GDP Ratio



For all six proxies, the estimated marginal effect line is upward sloping and consistent with our hypothesis that an increase in the financial development

Figure 3.4: Marginal Effect of Volatility for Different Levels of Domestic Private Debt to GDP Ratio

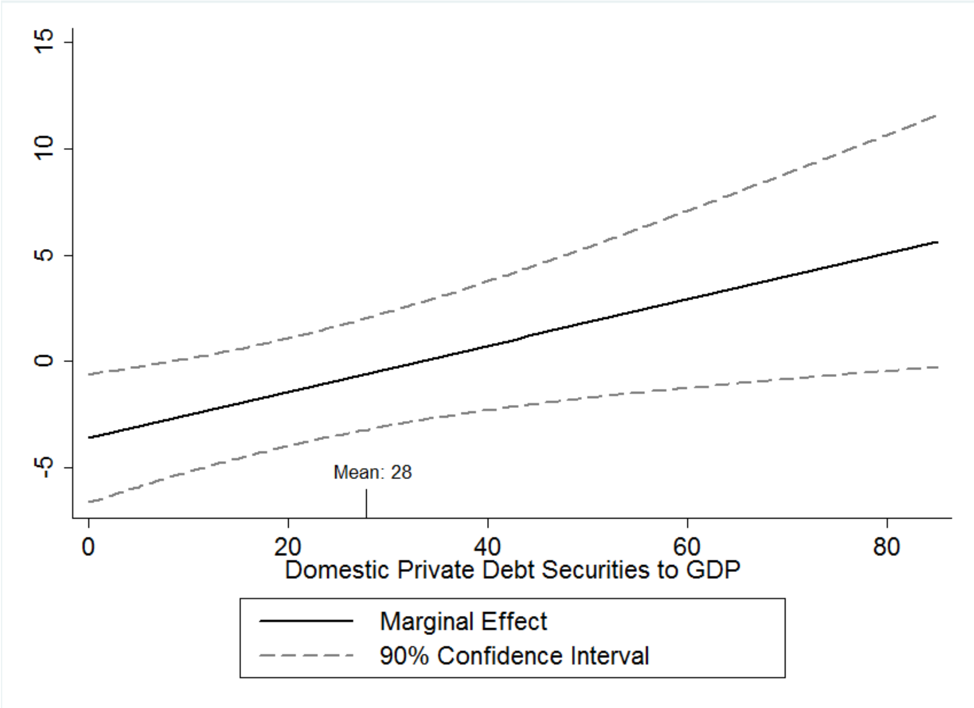
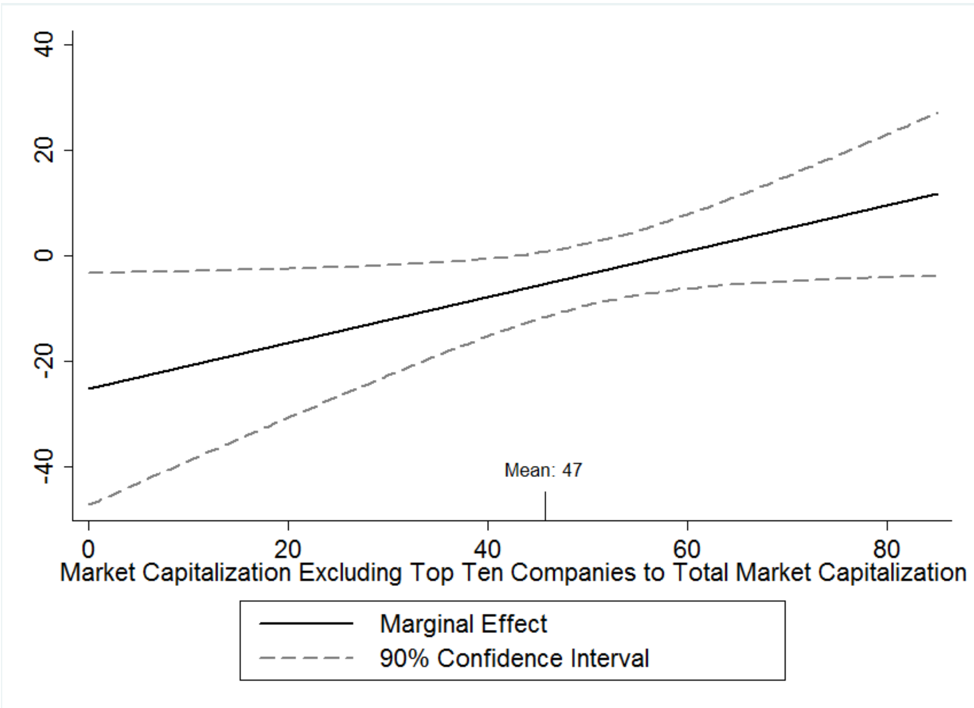
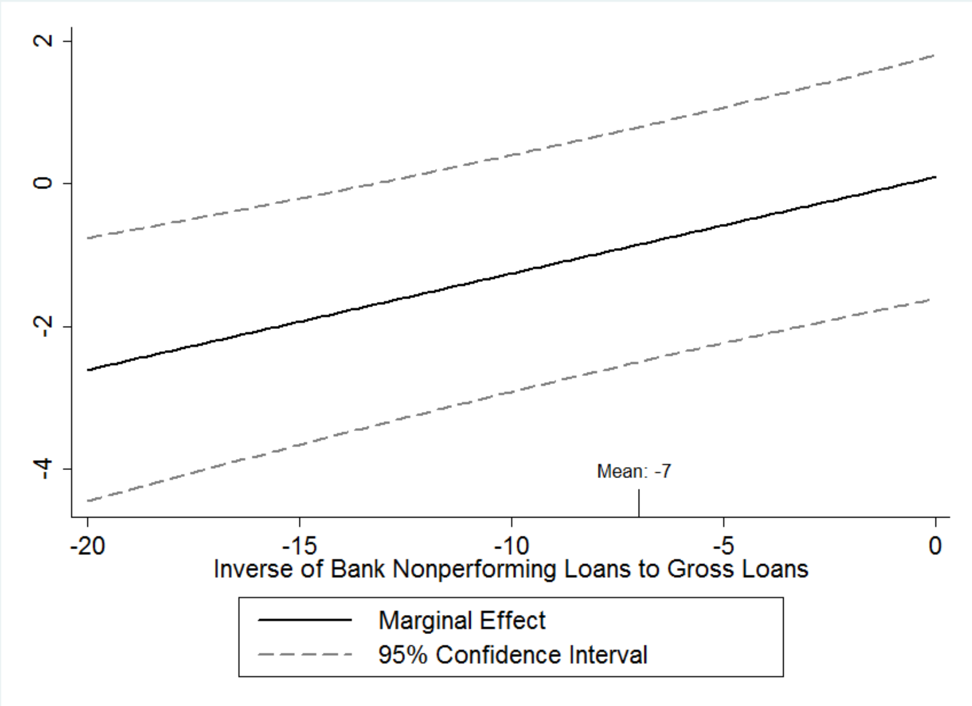


Figure 3.5: Marginal Effect of Volatility for Different Levels of Market Capitalization Excluding Top Ten Companies to Total Market Capitalization



decreases the negative impact of uncertainty shocks. Moreover, marginal effect of volatility on real economic growth is negative and significant at low levels of

Figure 3.6: Marginal Effect of Volatility for Different Levels of the Inverse of Bank Nonperforming Loans to Gross Loans



financial development, and it becomes insignificant at high levels of financial development. This negative impact is significant for fidp, fida, fisn and fmdsc at 95% percent significance level, and for fmds ve fmac at 90% significance level.

3.3.2 Robustness

For robustness check, the six specifications in Table 3.2 are reestimated by including additional control variables and their interactions with stock market volatility. The concern is that these control variables might also be moderating the impact of uncertainty shocks on output and if they are also correlated by financial development their omission might bias the estimation results. To address the endogeneity concern, these control variables enter the regression in lagged form, and their interactions with stock market volatility are instrumented by their interactions with natural disaster, terrorist and political shocks. Because each additional control variable leads to a proliferation of the endogenous variables and instruments, I include them in the regression one by one.

Table 3.3: IV Estimation Results Controlling for Population and the Interaction of Population with Volatility

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Stock Market Volatility	-4.746***	-4.185****	-7.483**	-3.479*	-22.807*	0.21
	(-3.25)	(-3.65)	(-2.23)	(-1.73)	(-1.95)	(0.25)
Stock Market Return	15.582****	12.292****	3.98	3.44	-2.62	1.54
	(3.76)	(3.68)	(0.87)	(0.62)	(-0.29)	(0.34)
Volatility*Population	-0.002	-0.002	0.002	0.001	-0.006	0.000
	(-0.82)	(-0.82)	(0.47)	(0.22)	(-0.85)	(-0.03)
Population	-0.003	-0.003	-0.006	0.001	-0.037	0.004
	(-0.39)	(-0.38)	(-0.45)	(0.06)	(-1.17)	(0.68)
Volatility*fidp	0.084*					
	(1.88)					
fidp	0.376*					
	(1.94)					
Volatility*fida		0.060**				
		(2.25)				
fida		0.266**				
		(2.32)				
Volatility*fmdsc			0.046**			
			(2.30)			
fmdsc			0.213**			
			(2.38)			
Volatility*fmds				0.082*		
				(1.85)		
fmds				0.358*		
				(1.81)		
Volatility*fmac					0.400*	
					(1.89)	
fmac					1.728*	
					(1.89)	
Volatility*fisn						0.133****
						(3.76)
fisn						0.572****
						(4.07)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4776	4776	2662	2662	1571	2247

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

Tables 3.3, 3.4, 3.5 report the estimation results after respectively controlling for population, real GDP, and real GDP per capita and the interaction of each with stock market volatility. The first two controls account for the possibility that the impact of uncertainty shocks might vary with the size of the

Table 3.4: IV Estimation Results Controlling for Real GDP and the Interaction of Real GDP with Volatility

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Stock Market Volatility	-3.086****	-3.349****	-5.293***	-2.002*	-18.753**	0.32
	(-4.43)	(-4.00)	(-3.08)	(-1.70)	(-2.48)	(0.37)
Stock Market Return	8.919****	9.040****	4.05	5.029*	1.97	4.616**
	(4.94)	(5.28)	(1.51)	(1.69)	(0.51)	(2.40)
Volatility*Real GDP	0.098	0.074	-0.560	-0.691	-0.706	0.254
	(0.58)	(0.37)	(-0.88)	(-1.04)	(-1.37)	(1.17)
Real GDP	0.267	0.158	-2.243	-2.547	-3.567	1.061
	(0.33)	(0.16)	(-0.93)	(-1.03)	(-1.57)	(1.22)
Volatility*fidp	0.040*					
	(1.86)					
fidp	0.176*					
	(1.91)					
Volatility*fida		0.035**				
		(2.03)				
fida		0.156**				
		(2.07)				
Volatility*fmdsc			0.057***			
			(2.61)			
fmdsc			0.255***			
			(2.64)			
Volatility*fmds				0.123**		
				(2.10)		
fmds				0.533**		
				(2.08)		
Volatility*fmac					0.373**	
					(2.49)	
fmac					1.610**	
					(2.51)	
Volatility*fisn						0.127****
						(5.67)
fisn						0.545****
						(6.56)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4776	4776	2662	2662	1571	2247

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

country and economy, and the third, with the development level. The baseline findings remain robust with these additional controls. In all specifications, the estimated coefficient for the interaction of volatility and financial development is positive and significant at 10% or higher significance levels.

Finally, in Table 3.6, I also control for the interaction between financial development proxies with stock market return to account for the possibility that the impact of level shocks might vary with financial development. In the estimated results, the interaction between financial development and volatility

Table 3.5: IV Estimation Results Controlling for Real GDP per Capita and the Interaction of Real GDP per Capita with Volatility

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Stock Market Volatility	-4.348****	-4.289****	-6.666***	-3.583**	-23.220*	0.42
	(-3.75)	(-3.68)	(-2.81)	(-2.13)	(-1.83)	(0.49)
Stock Market Return	13.234****	11.656****	3.06	2.88	-0.42	1.26
	(3.37)	(3.48)	(0.69)	(0.56)	(-0.05)	(0.27)
Volatility*Real GDP pc	7.677*	6.809*	-3.918	3.967	-4.935	-3.165
	(1.77)	(1.91)	(-1.12)	(1.02)	(-0.34)	(-1.05)
Real GDP pc	8.698	10.281	-5.746	17.064*	-22.537	-4.160
	(1.05)	(1.40)	(-0.77)	(1.92)	(-0.69)	(-0.55)
Volatility*fidp	0.071**					
	(2.01)					
fidp	0.317**					
	(2.06)					
Volatility*fida		0.055**				
		(2.41)				
fida		0.245**				
		(2.47)				
Volatility*fmdsc			0.048***			
			(2.72)			
fmdsc			0.219***			
			(2.82)			
Volatility*fmds				0.103**		
				(2.31)		
fmds				0.450**		
				(2.27)		
Volatility*fmac					0.417*	
					(1.67)	
fmac					1.793*	
					(1.67)	
Volatility*fisn						0.141****
						(3.89)
fisn						0.603****
						(4.17)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4776	4776	2662	2662	1571	2247

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

remains positive and significant, whereas the interaction between return and financial development is insignificant.

3.4 Conclusion

The current study has provided strong evidence that financial development reduces the negative impact of macroeconomic uncertainty on output. While there is a sizable literature on the growth effects of financial development, this result contributes to the literature by identifying an indirect impact through

Table 3.6: IV Estimation Results Including Interaction of Return with Financial Development

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Stock Market Volatility	-5.422***	-4.974*	(7.13)	-3.614*	-32.159**	0.31
	(-2.89)	(-1.81)	(-1.64)	(-1.65)	(-2.33)	(0.19)
Stock Market Return	17.881*	14.24	3.51	3.14	-28.86	2.19
	(1.83)	(0.90)	(0.30)	(0.39)	(-1.00)	(0.24)
Volatility*fidp	0.087**					
	(2.53)					
Return*fidp	-0.03					
	(-0.15)					
fidp	0.386***					
	(2.61)					
Volatility*fida		0.063*				
		(1.76)				
Return*fida		-0.001				
		(-0.00)				
fida		0.284*				
		(1.87)				
Volatility*fmdsc			0.05			
			(1.59)			
Return*fmdsc			-0.001			
			(-0.02)			
fmdsc			0.23			
			(1.62)			
Volatility*fmds				0.108*		
				(1.79)		
Return*fmds				-0.003		
				(-0.01)		
fmds				0.472*		
				(1.77)		
Volatility*fmac					0.614**	
					(2.51)	
Return*fmac					0.61	
					(0.90)	
fmac					2.653**	
					(2.54)	
Volatility*fisn						0.142**
						(2.37)
Return*fisn						0.02
						(0.10)
fisn						0.606**
						(2.49)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4776	4776	2662	2662	1571	2247

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

making the growth performance more robust against exogenous uncertainty shocks. Consequently, it has immediate policy implications and provides further motivation for government policies aimed at encouraging financial development.

There is, however, further work to be done to establish the robustness and relevance of the results. The first concern is that as Bloom and Baker (2013) observe since the results are based on instrumental variables estimation they hold for the countries and years for which there is variation in the instruments. The variation in the instruments in the current analysis, the disaster shocks, is mainly for developing countries. Consequently, a finer reading of the results would be that financial development mitigates negative impact of uncertainty shocks in developing countries. As such, the findings of the study does not contradict the argument that overgrowth of the financial sector has itself been a source of uncertainty and played a major role in instigating the recent Great Recession, because this argument has mainly been made based on the evidence for the developed countries.

A second issue with the analysis is the proxies I use for the macroeconomic conditions. In the regressions, the proxies for the first and second moment changes in macroeconomic conditions are changes in stock market return and volatility. These proxies themselves are affected by financial development. For example, two identical shocks may cause a higher increase in the stock market volatility in a country with lower financial development and this may introduce a bias to the analysis and require further investigation.

A final future direction for research is delineating the mechanisms through which financial development mitigates adverse effects of uncertainty. The theoretical motivation section of the study highlights three different mechanisms to argue for this mitigating impact. In the empirical analysis, I do not distinguish between them and test them together. Yet, each impact works through slightly different channels. Hence, an important extension of the current work would be to identify the aspects of financial development that matter more for the transmission of uncertainty and relate it to the alternative transmission mechanisms identified in the literature.

CHAPTER 4

UNCERTAINTY, CENTRAL BANK CHARACTERISTICS AND REAL ECONOMIC ACTIVITY

This essay investigates the conjecture that a transparent and independent central bank mitigates the adverse impact of uncertainty shocks on real economic activity. To test the conjecture, real GDP growth rates are regressed on the interaction terms between measures of central bank characteristics and the proxy for macroeconomic uncertainty, i.e. stock market volatility. To address potential endogeneity concerns, stock market volatility is instrumented by plausibly exogenous natural disaster, terrorist attack and political coup and revolution shocks in a Two Stage Least Squares model. The estimation results provide strong support for the conjecture that an independent central bank reduces the adverse impact of uncertainty shocks on output. The evidence on the impact of central bank transparency also suggests a moderating impact on the adverse effects of uncertainty shocks, but the data is limited and consequently the result is less conclusive.

The two characteristics of central banks that I focus on are transparency and independence. Central bank transparency refers to the degree to which central bank shares information about the procedures for its decision making, its policy decisions and objectives, the implementation of its policies and the economic variables relevant for the state of the economy. When an uncertainty shock hits the economy, the transparency of the central bank works to reduce the policy uncertainty, undercuts precautionary incentives and mitigates the negative consequences of uncertainty shocks .

Independence, on the other hand, broadly refers to the degree of autonomy a central bank has in choosing and implementing its policies. Under uncertainty shocks, central bank independence matters, because it restricts political interference and the additional ambiguity it introduces to policy making. Consequently, it increases the credibility of the central bank's policies and goals in the eyes of the public and reduces the destabilizing effects of uncertainty shocks on output.

In testing the two conjectures summarized above, we adopt an empirical strategy similar to the one employed in the previous chapter. The dependent variable in the analysis is quarterly real GDP growth. The independent variable of interest is uncertainty (as measured by stock market volatility) interacted with central bank independence in the first set of regressions and central bank transparency in the second set. The conjectures that central bank independence and transparency mitigate the negative impact of uncertainty shocks implies that the coefficient of these interaction terms should be positive and significant.

The main concern with the empirical analysis is endogeneity. In the regression, the level and uncertainty shocks to the economy are proxied by shocks to the stock market return and volatility. The causality between these two variables and real output, however, is arguably two-way. As in the previous chapter, I adopt the identification strategy employed in Baker and Bloom (2013) to address this concern. In particular, in Two Stage Least Squares estimation, stock market return and volatility are instrumented by natural disasters, terrorist attacks, political coups and revolutions, while also controlling for country and year fixed effects and a number of economic, political and financial control variables.

The results of the empirical analysis are consistent with the conjectured impact for central bank independence. Using the index constructed by Bodea and Hicks (2015), the analysis of 43 countries between years 1972-2009 finds strong support for the mitigating impact of central bank independence on the adverse effect of uncertainty. This finding is robust after controlling for country and year fixed effects, the interaction of volatility with population, real GDP, real GDP per capita and political regime. In the previous chapter it was shown that financial development indicators also mitigated negative impact of uncertainty shocks. When these indicators are included in the regression together with central bank independence, the mitigating impact of both remain significant, suggesting both have independent impacts.

The evidence on transparency is mixed. In some specifications, the results suggest transparency reduces the adverse impact of uncertainty and in others its impact is insignificant. This ambiguous result can partly be a consequence of the data limitations, as the data set by Dincer and Eichengreen

(2014) used in the analysis is restricted to the years between 1998 and 2009 and transparency is an attribute that is inherently more difficult to measure compared to other variables included in the analysis. In this respect, reaching a more conclusive result might require revisiting the question of impact of transparency with more comprehensive data or alternative proxies.

The study relates to literature on the impact of central bank transparency and independence on economic outcomes. This literature, however, has mainly focused on the consequences for price stability. Dincer and Eichengreen (2014) argue that higher central bank transparency reduces the surprise component of the monetary policy and fluctuations in the asset prices and improves central bank's commitment capacity. They also find that both the independence and the transparency of the central bank reduce the volatility of the inflation rate. In a similar vein, Van der Cruijsen and Demertzis (2005) and Demertzis and Hallett (2007) show that higher transparency of a central bank decreases the variation in the inflation rate. Alesina and Summers (1993), Crowe and Meade (2008) and Bodea and Hicks (2015) find that independence of central bank reduces the variation in the price level.

This paper contributes to the literature in a number of ways. First, building on the recent literature on the real consequences of uncertainty shocks[1], it does not focus on the impact of central bank characteristics per se, but rather how central bank characteristics alters the impact of uncertainty shocks. Second, in order to establish causality, it adopts a credible instrumentation strategy based on Baker and Bloom (2013) in analyzing this moderating impact . Third, in

[1]Alexopoulos and Cohen (2009), Bloom (2009), Baker and Bloom (2013), Baker et al. (2013), Caldara et al. (2014)

contrast to the focus on price stability in the existing literature, the focus in the current study is the consequences for output.

The rest of this chapter proceeds as follows. Section 1 discusses the existing literature on the consequences of central bank characteristics, with a focus on theoretical studies. Section 2 presents the empirical model and describes the data. Section 3 discusses the results and the last section concludes.

4.1 Theoretical Review

In this section, I review the theoretical models for the economic consequences of the central bank independence and transparency and relate them to the conjectured moderating impact these characteristics may have on the adverse impact of uncertainty shocks on output.

Sargent and Wallace (1981) suggest that central bank independence is necessary for controlling the inflation rate. Their argument is based on the comparison of two different economies which are respectively dominated by fiscal and monetary authorities. If monetary authority dominates fiscal authority, fiscal budget is constrained by the seignorage revenues determined by the monetary authority. Hence, government spending is constrained by the bond demand of agents. In this case monetary authority can keep inflation rate under control. If fiscal authority dominates, monetary authority is forced to finance government deficit which in turn increases inflation. Consequently, they conclude that central bank independence matters for price stability.

Another argument for the importance of central bank independence is based on the dynamic inconsistency problem. Dynamic inconsistency refers to the fact that the optimal decision of a central bank may change from period to period which in turn decreases its credibility.[2] Objectives of central banks may differ from the objectives of governments. Central banks mainly focus on price stability while governments are also concerned with other issues like unemployment and budget deficit. Hence, if a central bank is not independent from the government, the time inconsistency problem gets worse and further erodes its credibility.

As for transparency, Faust and Svensson (2001) model it as better knowledge of the public about the type of the central bank and show that higher transparency stabilizes the price level. More specifically, in their model, agents try to understand central bank's type from the policy process. As the transparency increases agents can follow central bank's objectives better which in turn helps the central bank achieve price stability. Demertzis and Hallett (2007) model both the impacts of lack of transparency about central bank priorities and objective and the state of economic variables. In either case, they find that lack of transparency distorts public's expectation and increases volatility of inflation.

One common insight from the studies on central bank independence discussed above is that the interplay between the objectives of monetary and political authorities complicates monetary policy decision making. It can also be argued that due to greater inherent complexity of political processes, increasing central bank independence reduces policy uncertainty and increases policy credibility in the public eye. Note also that lower policy uncertainty

[2] See Kydland and Prescott (1977) and Calvo (1978).

and greater central bank credibility is likely to matter the most when other exogenous uncertainty shocks hits the economy and central bank needs to respond. In such episodes, I conjecture that central bank independence reduces precautionary incentives of the agents which in turn mitigates the negative impacts of exogenous uncertainty shocks.

The reasoning behind the conjectured mitigating impact of central transparency is more straightforward. A higher transparency implies better public knowledge about central bank's response to exogenous uncertainty shocks and hence reduces policy uncertainty. As discussed for central bank independence, transparency lowers precautionary contraction in demand and output. In the next section, I take these conjectures to test.

4.2 Empirical Analysis

4.2.1 Model

The empirical model closely follows the model used in the Chapter 3. Formally, the interaction between central bank characteristics and uncertainty shocks is investigated using a Two Stage Least Squares model based on the following regression equation:

$$
\begin{aligned}
\Delta y_{i,t} = {} & \alpha_1 R_{i,t-1} + \alpha_2 Vol_{i,t-1} + \gamma_j CB_{i,j,t-1} + \beta_j \left(Vol_{i,t-1} \cdot CB_{i,j,t-1} \right) \\
& + \delta_m X_{i,m,t-1} + \phi_m \left(Vol_{i,t-1} \cdot X_{i,m,t-1} \right) + \rho_j \left(R_{i,t-1} \cdot CB_{i,j,t-1} \right) \\
& + \mu_i + \upsilon_t + \epsilon_{it} \qquad (4.1)
\end{aligned}
$$

In the regression equation $\Delta y_{i,t}$, represents the quarter on quarter growth rate of real GDP and $R_{i,t-1}$ and $Vol_{i,t-1}$ are respectively lagged values of stock market return and stock market volatility which are the proxies for macroeconomic conditions.

$CB_{i,j,t-1}$ represents the proxy for central bank characteristic j for country i in period $t-1$. For the current study, the two characteristics impact of which I investigate are central bank independence and transparency. The details of the proxies employed for these two characteristics are discussed in the data section.

The main variable of interest in the analysis is the interaction term between the lagged values of the volatility of the stock market and the proxy for central bank characteristic, i.e. $Vol_{i,t-1} \cdot CB_{i,j,t-1}$. If independence and transparency indeed mitigates the negative impact of uncertainty on output, the coefficient for this interaction term should be positive and significant.

$X_{i,m,t-1}$ and $Vol_{i,t-1} \cdot X_{i,m,t-1}$ are respectively the control variable m for country i lagged one period and its interaction with the lagged stock market volatility. The control variables are included to account for factors other than central bank characteristics that might alter the impact of uncertainty shocks on output. These control variables include population, polity index, total and per capita real GDP. In other specifications I also include six different proxies for financial development as controls. In chapter 3 it was shown that financial development altered the impact of uncertainty shocks, and by including financial development proxies in the current study, I control for any bias they might introduce to the results and check the robustness of the results of the earlier study on financial development. Since central bank characteristics are correlated with political regime, polity 2 score from Polity IV database and its interaction with volatility is included as a control variable as a proxy for the level of democracy. The interaction between lagged stock market return and central bank characteristics ($R_{i,t-1} \cdot CB_{i,j,t-1}$), is also included because stock market return is likely to be correlated with stock market volatility. Finally, all specifications include country and time fixed effects, μ_i and υ_t.

In addressing the potential endogeneity of the stock market volatility and return, I again rely on the identification strategy proposed by Baker and Bloom (2013). Specifically, in the Two Stage Least Squares estimation, stock market return, volatility, and interaction between these variables with the other explanatory variables are instrumented by exogenous natural disaster, terrorist attack, political coup and revolution shocks and their interactions with the other explanatory variables.

4.2.2 Data

Except for three new variables the data and variables used in the empirical analysis is the same as Chapter 3.

The first new variable is central bank independence index. The data for the index is taken from the database developed by Bodea and Hicks (2015) who update the earlier index constructed by Cukierman et al. (1992). This index is calculated as the weighted average of sixteen indicators in four categories: the chief executive officer, policy formation, objectives and limitations on lending to government. The score is higher when the chief executive officer of the central bank has longer and more secure tenure, his appointment is less political, central bank formulates monetary policy autonomously and without fiscal concerns and the conditions for central bank lending to the government are more restrictive.

The data for the central bank transparency index is based on Dincer and Eichengreen (2014) who in turn follow the methodology of Eijffinger and Geraats (2006). They consider five broad dimensions of transparency which are political transparency (openness about policy objectives), economic transparency (openness about data, models, and forecasts), procedural transparency (openness about the decision process), policy transparency (openness about the policy implications), and operational transparency (openness about the implementation of those decisions). Their database covers more than a hundred central banks and the data is available between 1998 and 2010.

The proxy I use for political regime is the Polity 2 score from the Polity IV database. Polity score is calculated based on the competitiveness and openness of a states election, the extensiveness of political participation, and the degree of checks on executive authority. The final score ranges from -10 (hereditary monarchy) to +10 (consolidated democracy). The data is available between 1800 and 2010 and is used extensively in political science literature.

Table 4.1 presents the summary statistics for these three variables. Central bank independence index is available for the years 1972 and 2009 and 43 countries (China, Taiwan, Ecuador, Egypt, Iran, Luxembourg, Morocco, Nigeria Senegal, Serbia and Tunisia drop from the original sample). Consequently the upper limit for the number of observations is 38*43*4=6536. Real

GDP growth and stock market data is available for 4513 of these observations, so they are included in the analysis. Transparency index is available between 1998 and 2009 and 44 countries (Ecuador, Finland, Iran, Ireland, Luxembourg, Morocco, Senegal, Serbia, Taiwan, Venezuela drop) and 2061 observations for which economic variables are also available enter the sample. Polity 2 score is available for all country and years.

Table 4.1: Summary Statistics for Variables

Variable	Obs.	Mean	Std Dev.	Min.	Max
Central Bank Independence Index	4480	0.5286	0.2408	0.091	0.9595
Central Bank Transparency Index	2061	7.758	3.191	1	14.5
Polity Index	5268	7.157	4.900	-9	10

4.3 Results

Table 4.2 reports the baseline IV estimation results for the moderating impact of central bank independence on uncertainty shocks. In all specifications, in addition to country and period fixed effects, stock market volatility, stock market return, central bank independence, and the variable of interest, the interaction term between stock market volatility and central bank independence are included as explanatory variables. In specification 2, the interaction term between stock market return and central bank independence is also controlled for. In specifications 3 to 6, population, real GDP, real GDP per capita, polity 2 score and the interaction of each with the stock market volatility are respectively added as explanatory variables to specification 1.

In all six specifications, the coefficient of the interaction term between central bank independence and stock market volatility is positive and significant. Moreover, in all six specifications the significance level is higher than 0.1 %. Note also that in all specifications the coefficient of the stock market volatility is negative and significant. This implies that, in countries that have the minimum score on the central bank independence index, uncertainty shocks are estimated to reduce output, and for countries that score higher on the index, this adverse impact diminishes. Among the controls themselves, there is evidence that economic development and democracy helps reduce the adverse impact of uncertainty shocks.

Table 4.2: IV Regression Results for Central Bank Independence

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Stock Market Volatility	-3.975***	-4.317***	-3.324**	-3.818***	-5.111****	-3.818***
	(-2.80)	(-3.15)	(-2.30)	(-2.82)	(-4.58)	(-3.27)
Stock Market Return	4.19	2.17	4.47	4.774**	5.105***	4.442****
	(1.56)	(0.45)	(1.54)	(2.30)	(3.15)	(3.59)
Volatility*CBI	6.634****	7.200****	6.304****	6.469****	5.913****	4.856***
	(4.66)	(4.05)	(4.30)	(3.87)	(3.45)	(3.01)
CBI	30.269****	32.819****	28.866****	29.468****	26.790****	22.176***
	(4.80)	(4.17)	(4.41)	(3.93)	(3.51)	(3.06)
Return*CBI		6.31				
		(0.40)				
Volatility*Population			0.00			
			(0.20)			
Population			0.01			
			(0.54)			
Volatility*Real GDP				0.10		
				(0.56)		
Real GDP				0.38		
				(0.48)		
Volatility*Real GDP pc					127.160**	
					(2.46)	
Real GDP pc					533.429**	
					(2.45)	
Volatility*Polity						0.097*
						(1.67)
Polity Index						0.461*
						(1.80)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4513	4513	4513	4513	4513	4450

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

Table 4.3 repeats the same empirical exercise for the moderating impact of central bank transparency, but the results are not conclusive. In three of the six specifications, the interaction between volatility and central bank transparency is positive and significant at 10% significance level or higher. In two, it carries the right sign, but is insignificant, and in one, it carries the wrong sign.

Table 4.3: IV Regression Results for Central Bank Transparency

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Sock Market Volatility	-10.201**	-8.52	-9.774***	-7.916*	-9.19	-10.17
	(-2.49)	(-1.42)	(-2.75)	(-1.69)	(-1.31)	(-1.31)
Stock Market Return	3.06	17.27	4.889**	5.30	2.97	16.477**
	(0.57)	(0.68)	(2.18)	(1.09)	(0.55)	(1.98)
Volatility*TI	0.810*	0.454	0.790**	0.842*	0.783	-0.659
	(1.69)	(0.66)	(2.43)	(1.92)	(1.32)	(-0.95)
TI	3.251*	1.833	3.183**	3.437**	3.154	-2.530
	(1.71)	(0.69)	(2.50)	(2.09)	(1.42)	(-0.90)
Return*TI		-2.22				
		(-0.56)				
Volatility*Population			0.39			
			(1.28)			
Population			2.09			
			(1.64)			
Volatility*Real GDP				6.526*		
				(1.88)		
Real GDP				27.166**		
				(2.09)		
Volatility*Real GDP pc					0.00	
					(0.76)	
Real GDP pc					0.02	
					(1.22)	
Volatility*Polity						17.450**
						(2.26)
Polity Index						69.947**
						(2.35)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2061	2061	2061	2061	2061	1880

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

There is reason to suspect that the inconclusive finding for the impact of transparency might at least be driven by data quality issues and may require further study. The data for transparency is limited to years after 1998, and the number of observations are less than half the number of observations for central bank independence. Moreover, there is reason to suspect that the proxy employed for transparency may be less accurate than the proxies for other factors controlled for in the regressions. This is both due to the inherent difficulty of measuring transparency compared to, for example, GDP per capita, and the fact that the transparency data set is relatively more recent and less fine tuned compared to, for example, Polity IV dataset.

In the first stage results Sargan overidentification test is not rejected in any of the six specifications which implies that impact of the disaster shocks are fully captured by the endogenous variables. F-statistic for the joint significance of the instruments is higher than 9.5 for each instrumented variable. Hence, all instruments have explanatory power.

4.3.1 Marginal Effects

In this section, I investigate the marginal effect of volatility on real economic growth for different levels of central bank independence and transparency. From equation 4.1 it follows that the marginal effect of volatility shocks on real economic growth (without any control variables) across different levels of the two central bank variables is as follows:

$$\frac{\partial \Delta y_t}{\partial Vol_{t-1}} = \alpha_2 + \beta_j CB_{j,t-1}. \tag{4.2}$$

Equation 4.2 makes clear that that the marginal effect of a marginal change in volatility on real economic growth is conditional on the values of central bank characteristics. Likewise, the standard error for the volatility shock varies with central bank characteristics based on the following equation:

$$\sqrt{Var\alpha_2 + CB_j^2 Var\beta_j + 2CB_j Cov(\alpha_2, \beta_j)} \tag{4.3}$$

Figure 4.1: Marginal Effect of Volatility for Different Levels of Central Bank Independence

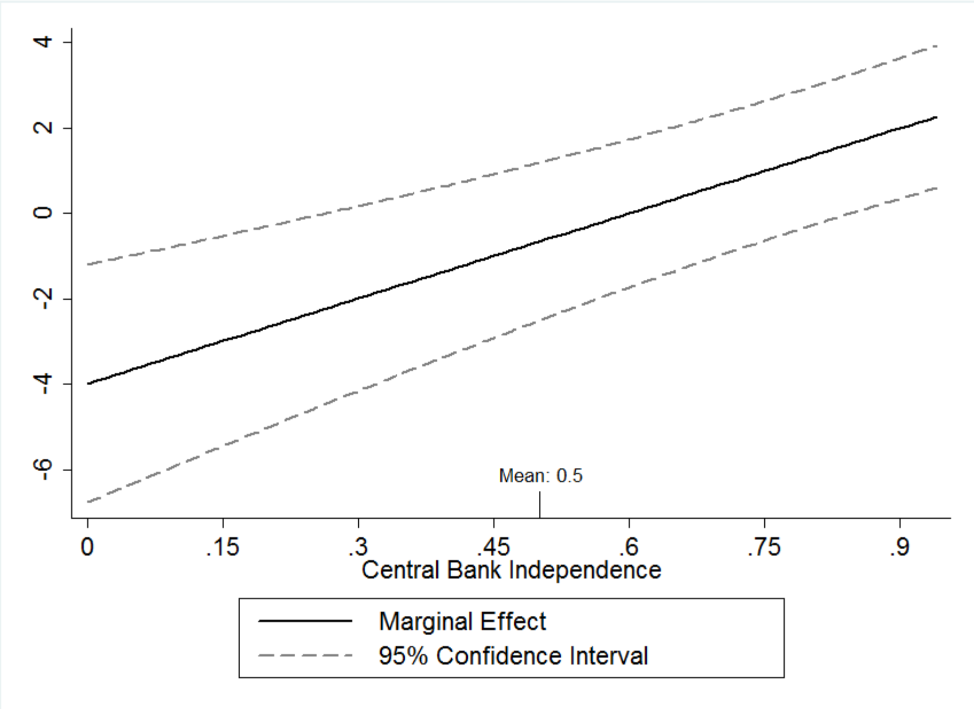
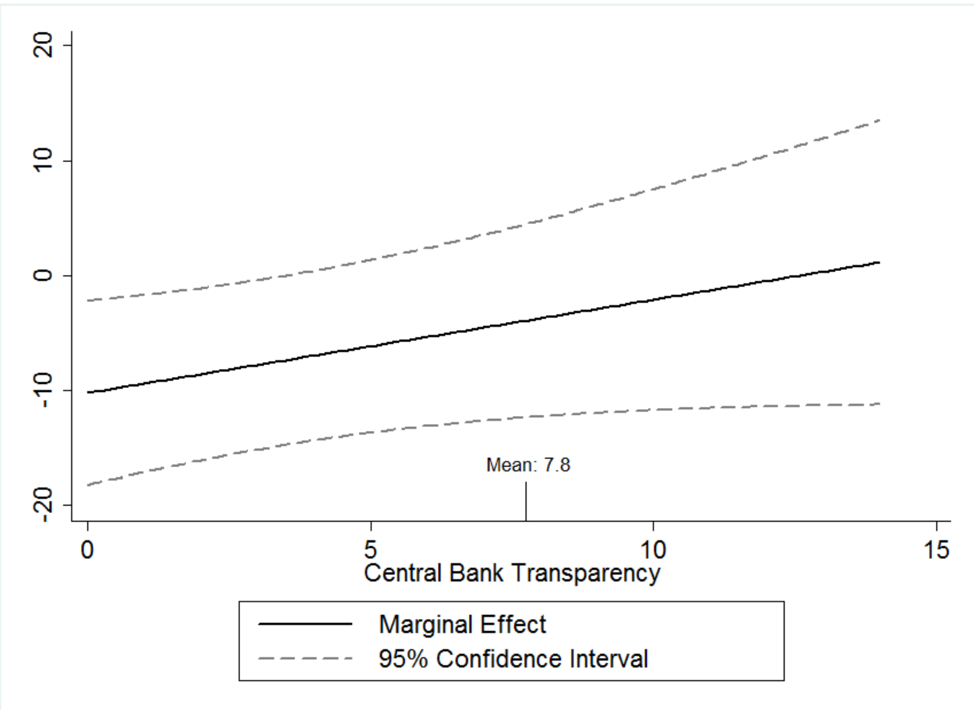


Figure 4.2: Marginal Effect of Volatility for Different Levels of Central Bank Transparency



Figures 4.1 and 4.2 display the marginal effect of volatility on real economic

growth respectively for central bank independence and transparency. Both graphs are upward sloping, consistent with the hypothesis that an increase in the central bank independence and transparency decreases the negative impact of uncertainty shocks. Moreover, for both low levels of independence and transparency, the marginal effect of volatility on real economic growth is negative and significant.

4.3.2 Robustness

Finally, in Table 4.4, I repeat the empirical analysis of the moderating impact of central bank independence this time controlling for six different financial development indicators. The analysis in Chapter 3 had provided support for the claim that these financial development indicators themselves had moderating impact on uncertainty shocks, but that analysis had not controlled for central bank independence. The results show that when both financial development-volatility and central bank-volatility interactions are included in the regression, they both remain positive and significant at 10% and higher significance levels, and hence both factors independently reduce the adverse effects of uncertainty shocks. The only exception is specification five, where the financial development-volatility interaction becomes insignificant. Note, however, this is also the specification with the minimum number of observations and hence should be interpreted with caution.

Table 4.4: IV Regression Results for Central Bank Independence, Controlling for Financial Development and the Interaction of Financial Development with Volatility

	Real GDP Growth					
	(1)	(2)	(3)	(4)	(5)	(6)
Stock Market Volatility	-5.858***	-5.813***	-7.091***	-6.594****	-10.57	-3.02
	(-3.05)	(-3.25)	(-3.16)	(-3.29)	(-1.10)	(-1.08)
Stock Market Return	8.508***	7.792***	1.25	-1.02	7.99	1.35
	(2.76)	(2.97)	(0.37)	(-0.25)	(1.56)	(0.35)
Volatility*CBI	6.857***	6.368***	4.789***	6.443****	10.160**	5.437*
	(2.99)	(2.85)	(3.17)	(4.78)	(2.56)	(1.70)
CBI	31.059***	28.861***	22.335****	29.828****	41.442***	21.720*
	(3.09)	(2.94)	(3.49)	(5.04)	(2.89)	(1.69)
Volatility*fidp	0.036*					
	(1.86)					
fidp	0.165*					
	(1.92)					
Volatility*fidd		0.034**				
		(2.15)				
fidd		0.155**				
		(2.22)				
Volatility*fmdsc			0.024**			
			(2.18)			
fmdsc			0.116**			
			(2.31)			
Volatility*fmds				0.049**		
				(2.03)		
fmds				0.212**		
				(1.97)		
Volatility*fmac					0.08	
					(0.52)	
fmac					0.35	
					(0.53)	
Volatility*fisn						0.135****
						(3.84)
fisn						0.568****
						(4.13)
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4113	4113	2586	2586	1416	1906

t values are displayed in paranthesis. Statistical significance levels:* 0.1 ** 0.05 *** 0.01 **** 0.001

4.4 Conclusion

This study presents evidence that central bank characteristics alter the impact of uncertainty shocks on output. Independent central banks are shown to reduce the negative impact of uncertainty shocks, and there is some evidence that central bank transparency might be having a similar effect. The result about the impact of central bank independence remains robust after controlling for various other factors.

Since this study builds on the data and methodology of the previous study on the interaction between financial development and uncertainty, the same concerns raised for that study also applies to this one. Most importantly, because most disaster shocks that instrument for volatility and return occurred in developing countries, the careful reading of the results would emphasize that they are mainly relevant for developing countries.

From a theoretical perspective, the main issue with the analysis is that it investigates the impact of the structural characteristics of the central banks, but not its objectives. It is clear, however, independent central bank that targets inflation might respond to an uncertainty shock very differently from an independent central bank that does not. Hence, an important extension for the current work would be to work with a finer classification that also takes the objectives of the central bank into account. It might also be interesting to investigate the impact of uncertainty on price stability in addition to the current analysis of output.

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