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On the linkages between stock prices and exchange rates: Evidence from the banking crisis of 2007–2010

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Abstract

This study examines the nature of the linkages between stock market prices and exchange rates in six advanced economies, namely the US, the UK, Canada, Japan, the euro area, and Switzerland, using data on the banking crisis between 2007 and 2010. Bivariate GARCH-BEKK models are estimated producing evidence of unidirectional spillovers from stock returns to exchange rate changes in the US and the UK, in the opposite direction in Canada, and

1. Introduction

The collapse on September 15th 2008 of Lehman Brothers (LB, until that point the fourth largest investment bank in the US) sent a wave of global panic across financial markets. Following global bank failures and the resulting collapse in liquidity and inter-bank lending, stock market indices in most developed economies experienced significant declines.[1] Higher uncertainty also generated turbulence in the foreign exchange markets, with the major currencies being hit by a reduction in international transactions and a flight to value.[2] An interesting issue is whether financial markets have become more dependent as a result of the uncertainty created by the crisis. Aloui et al. (2011), Kenourgios et al. (2011), Samarakoon (2011), and Dufrénot et al. (2011) among others find indeed an increase in dependence between international stock markets, and similar findings are reported by Coudert et al. (2011) and Bubak et al. (2011) for foreign exchange markets.

Surprisingly, very few studies have investigated the linkages between stock market prices and exchange rates during the recent crisis. At times of financial turmoil, the high volatility of stock markets generates speculative actions by investors and capital flight to value and this may lead to considerable instability in other markets such as foreign exchange markets. This has been shown in the case of the Asian financial crisis when stock markets led the foreign exchange markets (see Granger et al., 2000; Caporale et al., 2002). However, in turbulent times, decoupling may also occur: when stock markets experience severe downturns, investors may only focus on markets where their assets can be seen as

[1] From early October 2007 until the second week of March 2009, the S&P 500 (US), FTSE 350 (UK), and Stoxx 50 Euro (euro area) indices declined by approximately 56%, 48%, and 59%, respectively. Similar stock market falls occurred in Switzerland and Japan, where the lowest points were reached in the second week of March 2009 following peaks on June 1st

conditional mean in case both variables are cointegrated; the Gregory and Hansen (1996) cointegration test is employed. Therefore, a thorough econometric analysis is conducted of the dependence between stock prices and exchange rates during the period under examination.

The paper is organised as follows. Section 2 provides a brief review of the theoretical and empirical literature on the relationship between stock prices and exchange rates. Section 3 describes the data. Section 4 outlines the econometric methodology. Section 5 discusses the empirical results and Section 6 concludes.

2. A review of the literature

There are two main types of theoretical models analysing the linkages between exchange rates and stock prices. 'Flow-oriented' models (Dornbusch and Fischer, 1980) posit that causality runs from the former to the latter, whereas portfolio-based approaches (Branson, 1983; Frankel, 1983) suggest the opposite. In the first case a more competitive exchange rate, assuming that the Marshall-Lerner conditions hold, will improve the trade position of an economy and stimulate the real economy through firm profitability and stock market prices. This approach has been given some empirical support in the literature on asset pricing models based on consumption- and income- (Gregoriou et al., 2009) as well as output (Sousa, 2010). In the second case, the exchange rate is thought to respond to increases in the demand for financial assets such as bonds and stocks. Hence, a bullish domestic stock market will signal favourable domestic economic prospects, thereby inducing capital inflows and an appreciation of the exchange rate (Kollias et al., 2012). Another channel for this type of causality stems from the demand for money (Gavin, 1989).

The empirical literature also provides mixed results. For example, Aggarwal (1981) found a significant positive correlation between US stock prices and the strength of the US dollar using monthly data between 1974 and 1978, although Soenen and Hennigar (1988) reported that the sign depends on the sample used. Subsequent studies used the two-step cointegration procedure of Engle and Granger

(1987) and the maximum likelihood technique of Johansen (1995) to examine the time series properties of both stock prices and exchange rates in the long run. Using monthly data on the US economy for the period 1973-1988, Bahmani-Oskooee and Sohrabian (1992) found that these two variables are not cointegrated, yet there is bidirectional feedback in the short run. Similar findings were reported by Nieh and Lee (2001), who investigated stock prices and exchange rates for the G7 countries and found one-day significant linkages in some countries.

Cointegration may not be detected as a result of model misspecification, and in particular the omission of variables. Phylaktis and Ravazzolo (2005) found that US stock prices were a key channel linking the exchange rates of five Pacific basin countries to their stock indices. On the other hand, Ülkü and Demirci (2012) showed that global developed and emerging stock market returns explain a large

3. Data description

We employ weekly data (Wednesday to Wednesday) to analyse the linkages between stock market prices and exchange rates, because daily or intra-daily data are affected by noise and anomalies such as day-of-the-week effects, while monthly data may be inadequate to trace the short-run evolution of capital across international financial markets. We consider six advanced economies: Canada, the euro area, Japan, Switzerland, the UK, and the US from August 6, 2003 to December 28, 2011, a sample of 441 observations. The exchange rates used are trade-weighted (as calculated by the Bank of England), thus providing a better measure of the competitiveness of these economies (Kanas, 2000), while the stock prices are the main local stock exchange indices. The currencies of these economies are the most actively traded in the foreign exchange markets, while their stock markets are the largest among the developed economies in terms of market capitalisation. The data have been obtained from Thomson DataStream.

We consider two sub-periods: a tranquil or pre-crisis period from August 6, 2003 to August 8, 2007, and a crisis period from August 15, 2007 to December 28, 2011. It is well known that the former corresponds to the so-called "Great Moderation" (see Stock and Watson, 2002), which was characterised by stable and low inflation and a decline in the volatility of other macroeconomic fundamentals. The subsequent global financial crisis (and the associated "Great Recession") clearly represents a new regime.

The start date of the pre-crisis sample is chosen to avoid the impact of major global events such as the 9/11 terrorist attacks and their anniversary in 2002 (see Gregoriou et al., 2009), and the ensuing conflicts in Afghanistan and Iraq as well as the dotcom bubble that burst in late 2002. On the other hand, the crisis period is defined as starting with the first signs of the subprime mortgage crisis in the US in the summer of 2007, ahead of the failure of Fannie Mae and Freddie Mac and the collapse of LB and

AIG. This is also consistent with the study of Melvin and Taylor (2009), who consider August 16th 2007 as the beginning of the crisis in the foreign exchange markets.

The variables in levels are denoted by ίض and Ώض, respectively the log stock prices and log exchange rates, while their first differences (Ύح,ض and Ύت,ض are continuously compounded returns; the data are in percentages and are multiplied by 100. A wide range of descriptive statistics are displayed in Table A1 (see Appendix A). Fig.1a and Fig. 1b show the weekly evolution of the trade-weighted exchange rates and stock prices with their corresponding changes for the period under investigation. Stock returns and exchange rate changes exhibit volatility clustering, especially in the crisis period, which indicates an ARCH model might be appropriate. The Figures also suggest that the log of exchange rates and stock prices might be non-stationary and follow a stochastic trend, while their first difference is co-variance stationary or has a finite variance.[3]

[Insert Fig. 1a-Fig. 1b about here]

4. The VAR-GARCH model

We employ the BEKK representation of Engle and Kroner (1995) for our bivariate VAR-GARCH (1, 1) model to examine the joint processes governing weekly changes in stock market prices and exchange rates for the two sub-periods. This enables us to examine the dependence between both the first and the second moments of stock prices and exchange rates in a dynamic framework. In particular, the conditional mean equation is specified as follows:

[3] This is confirmed by a battery of unit root tests, including the augmented Dickey–Fuller (1981) test, the Phillips and Perron (1988) test and the minimum LM test of Lee and Strazicich (2004) with one structural break in the intercept and a trend.

$$R_t \mid \sigma 2 \sum_{i \mid 1}^{p} \dots_i R_{t4i} \; 2 \; \varsigma R_{wt} \; 2 \; \nu R_{rft} \; 2 \; \iota \div p_{oilt} \; 2 \; \kappa_t$$

$$\sigma \mid \begin{pmatrix} \sigma_S \\ \sigma_E \end{pmatrix}, \quad \dots_i \mid \begin{pmatrix} \dots^{i}_{SS} & \dots^{i}_{SE} \\ \dots^{i}_{ES} & \dots^{i}_{EE} \end{pmatrix}, \quad \kappa_t \mid \begin{pmatrix} \kappa_{St} \\ \kappa_{Et} \end{pmatrix} \qquad (1)$$

where 'Y = ['Y, 'Y , the innovation vector $\kappa \mid T$ 0,'O is normally distributed with |'O| [illegible]eing [illegible]

error process is non-normal.[6] We also employ the multivariate *Q*-statistics (Hosking, 1981) for the squared standardised residuals to determine the adequacy of the estimated model of the conditional variance-covariance matrix to capture the multivariate ARCH and GARCH dynamics.

5. Empirical results

5.1. Cointegration test results

The first step is to examine the time series properties of the stock price and exchange rate series. Then, cointegration is tested using the Gregory and Hansen (1996) procedure which allows for a single unknown structural break. This test is likely to be more informative, especially in the crisis period, than time-invariant cointegration tests such as the Johansen (1995) trace test and the pairwise Engle and Granger (1987) test (see Campos et al.,1996; Gregory and Hansen, 1996). The test results are displayed in Table 1.

[Insert Table 1 about here]

The null hypothesis of no cointegration between stock prices and exchange rates is rejected in three cases, in particular, for the euro area and Japan in the pre-crisis period, and for the UK in the crisis period. This suggests that the comovement between stock prices and exchange rates in the euro area and Japan had broken down by the onset of the financial crisis. A possible explanation in the case of Japan is the overvaluation of the yen since 2008. Specifically, the yen hit a record high against the US dollar in late 2011 with the crisis leading to a decoupling of the Japanese stock and foreign exchange markets in the long run. In the euro area, the depreciation of the euro and the uncertainty surrounding the single currency ever since the onset of the crisis might be the reason for the breakdown of the long-run. By

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[6] The procedure was implemented with a convergence criterion of 0.00001, using the quasi-Newton meth43 Tw[(239 Twbrea8ith a coo0030

contrast, it seems that the long-run relation between financial markets in the UK was strengthened by the financial crisis, which led to both series being influenced by similar underlying factors and as a result sharing a single common stochastic trend.

Note that the lack of cointegrating relations may also be the result of misspecification as other fundamental economic variables may work as channels through which the two types of financial markets (stock and foreign exchange markets) are linked in the long run. However, our findings of limited cointegration between stock prices and exchange rates are in line with much of the existing empirical literature (Bahmani-Oskooee and Sohrabian, 1992; Granger et al., 2000; Nieh and Lee, 2001; Alagidede et al., 2011).

tilMindings of .1(y also bM(i)i8.2(at)VAR-G)(ARCHa)-1gere) return spillovers from stock returns to exchange rate changes in the case of Japan, while there are spillovers in the opposite direction in the UK. However, since lagged error correction terms are included in the cases of cointegration, there will be a further channel for causality between the two variables through the error correction term if this is negative and significant as, for example, in Japan in the equations for both stock returns and exchange rates changes. This implies that both variables adjust to the steady-state equilibrium in Japan, and there is bidirectional feedback. By contrast, the lagged error correction term in the euro area is negative and significant only in the equation for exchange rate changes, suggesting that the adjustment towards equilibrium takes place through this variable.

In the crisis period, instead, the results indicate the existence of spillovers from stock returns to exchange rates changes in the US and the UK, in the opposite direction in Canada, and bidirectional spillovers in the euro area and Switzerland. With regard to the UK, the lagged error correction term in the equation for exchange rate changes is found to be negative and significant, implying an adjustment mechanism through the exchange rate and reinforcing the evidence of causality from stock returns to exchange rate changes.

Granger et al. (2000) concluded that capital flows played a major role in the interactions between stock prices and exchange rates during the Asian flu period. Fig. 2 shows the evolution of portfolio investment liabilities and current accounts as a percentage of GDP for all countries over the sample period considered here. The causality from stock returns to exchange rate changes in the US and UK is seemingly consistent with the portfolio approach. Given that the US was the centre of the crisis, the decline in the stock market at the onset of the crisis in late 2007, along with the collapse of LB and the downgrade of its debt status, induced capital outflows (see Fig. 2) and a depreciation of its currency. This also applies to the UK as the collapse of LB in the US and the shutdown of their offices in London sent a wave of panic right through the UK stock market followed by severe downturns and a sharp depreciation of the British pound.

[Insert Fig. 2 about here]

The finding of causality from exchange rate changes to stock returns in Canada, on the other hand, is consistent with the monetary approach. The depreciation of the Canadian dollar resulted in a decline of the Canadian stock market, even though Canada did not seem to experience major capital outflows compared to other countries. The lack of any interactions between stock returns and exchange rate changes in Japan, by contrast, can be attributed to country-specific factors. The fact that Japan is a well-regulated economy and owns huge foreign exchange reserves played a significant role in strengthening its currency and making it immune to the crisis (Wong and Li, 2010).

As far as the exogenous variables in the conditional mean equations are concerned, the return on the world stock index exerts strong influence on stock returns and exchange rates changes in most cases, especially in the crisis period, suggesting its dominance in the transmission of shocks and information to other markets around the globe. The impact of the domestic interest rate, by contrast, appears to be limited. This reinforces the notion that the quantitative easing policies adopted by the monetary authorities throughout the crisis period were ineffective. One possible explanation is that the economic cycle did not respond because of the breakdown of both the financial system and the monetary transmission mechanism via the banks.

With regard to the influence of world oil price changes, this increased in the crisis period compared with the pre-crisis one in most countries, except Switzerland. The effects on stock returns in the case of Switzerland, in the pre-crisis period, and Canada and the UK, in the crisis period, are consistent with the findings of Filis et al. (2011), who argued that stock markets react positively to demand-side oil price shocks. The two periods in this study are characterised

The Hosking multivariate *Q*-statistics of order (4) and (8) for the squared standardised residuals suggests at the 5% significance level that the multivariate GARCH (1,1) structure adequately captures volatility, and hence no further variance dynamics are required.

6. Conclusions

In this study, we have analysed the nature of the linkages between stock market returns and exchange rate changes in six advanced economies, namely the US, the UK, Canada, Japan, the euro area, and Switzerland. Specifically, we have examined the extent to which they have been affected by the banking crisis of 2007–2010 employing weekly data from August 2003 to December 2011. The estimation of bivariate GARCH-BEKK models provides evidence of unidirectional spillovers from stock returns to exchange rate changes in the US and the UK, in the opposite direction in Canada, and of bidirectional feedback in the euro area and Switzerland during the recent financial crisis. Our findings are consistent with those of Granger et al. (2000) and Caporale et al. (2002), who examined the 1997 Asian financial crisis.

Furthermore, causality-in-variance tests for the crisis period lend support to the existence of causality-in-variance from stock returns to exchange rate changes in Japan, in the opposite direction in the euro area and Switzerland, and of bidirectional feedback in the US and Canada. These results reflect cross-country differences in terms of policies, cycle phases, expectations, the degree of liberalisation, and capital controls (Nieh and Lee, 2001). Furthermore, given the fact that the currencies under investigation are the most actively traded and the corresponding economies are top trading partners, their heterogeneous strength throughout the financial crisis may have played an important role in generating capital flows into and out of these countries. This might be one of the reasons for the different results when analysing th

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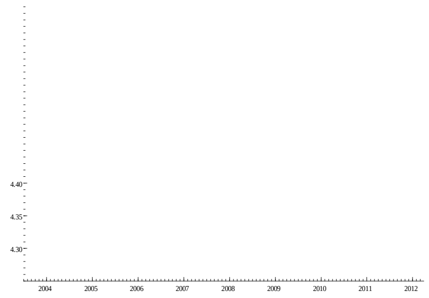
4.40
4.35
4.30
2004
2005
2006
2007
2008
2009
2010
2011
2012

Table 1
Results of Gregory and Hansen (1996)' cointegration tests allowing for a shift at unknown date.

Regression	Model	US	UK	Euro area	Canada	Japan	Switzerland
Panel A: Pre-crisis Period (6/8/2003 – 8/8/2007)							
s_t on e_t	C	-3.19196(0)	-3.08175(4)	-3.82809(5)	-3.67072(7)	-4.70262(6)[b]	-4.02025(7)
		[2005:10:12]	[2004:03:17]	[2005:07:13]	[2006:09:20]	[2005:10:05]	[2004:04:21]
	C/T	-4.53539(8)	-4.63858(8)	-4.90082(8)	-4.05644(3)	-4.82672(0)	-3.90222(1)
		[2007:01:10]	[2004:05:26]	[2004:05:26]	[2004:06:09]	[2005:10:19]	[2005:10:12]
	C/S	-4.53539(0)	-3.17808(4)	-3.87397(3)	-3.86972(0)	-4.55561(6)	-4.16180(1)
		[-4.53539]	[2005:05:18]	[2005:04:20]	[2006:12:20]	[2005:10:05]	[2005:07:20]
e_t on s_t	C	-3.53476(0)	-3.75928(4)	-3.45693(5)	-3.46975(7)	-4.06898(6)	-4.01916(0)
		[2005:06:08]	[2006:09:13]	[2005:07:13]	[2006:09:20]	[2006:09:06]	[2004:04:21]
	C/T	-3.76708(0)	-3.60004(5)	-5.04845(0)[b]	-3.53679(7)	-4.45423(6)	-4.67705(0)
		[2005:06:08]	[2006:09:06]	[2005:05:25]	[2006:09:20]	[2004:11:10]	[2004:05:26]
	C/S	-4.53794(0)	-3.83692(4)	-3.49849(5)	-3.87491(0)	-4.33849(6)	-4.06924(0)
		[2005:06:08]	[2006:06:14]	[2005:07:13]	[2006:12:20]	[2006:07:12]	[2004:05:26]
Panel B: Crisis Period (15/8/ 2007- 28/12/ 2011)							
s_t on e_t	C	-3.84091 (0)	-4.40818(0)	-2.82358(7)	-3.11350(0)	-3.56361(0)	-2.96637(5)
		[2008:10:01]	[2009:09:02]	[2008:08:06]	[2008:11:26]	[2009:12:16]	[2008:08:27]
	C/T	-4.24787 (0)	-4.43335(0)	-3.10692(8)	-3.13766(8)	-4.04147(0)	-3.13346(0)
		[2008:10:01]	[2009:09:02]	[2008:07:30]	[2008:11:26]	[2008:06:04]	[2008:09:24]
	C/S	-4.28696(0)	-4.84225(0)	-2.65910(7)	-3.09940(8)	-4.33630(0)	-3.74662(5)
		[2008:09:10]	[2009:05:13]	[2008:08:06]	[2008:11:12]	[2009:07:15]	[2009:09:30]
e_t on s_t	C	-3.53036(5)	-4.56105(0)	-3.70638(7)	-3.22176(8)	-3.59815(0)	-2.89831(6)
		[2008:08:27]	[2009:09:02]	[2010:03:17]	[2009:08:05]	[2009:12:16]	[2010:06:30]
	C/T	-4.23494(6)	-4.45426(0)	-3.95378(7)	-3.19527(8)	-4.06951(0)	-3.79277(5)
		[2010:02:03]	[2008:11:19]	[2010:03:17]	[2009:07:29]	[2008:06:04]	[2010:10:20]
	C/S	-3.44785(5)	-5.12481(0)[b]	-3.96372(7)	-3.28833(8)	-3.91908(0)	-3.20739(6)
		[2008:04:23]	[2009:09:02]	[2010:04:14]	[2009:12:16]	[2009:12:16]	[2010:04:14]

The test due to Gregory and Hansen (1996) is conducted by regressing s_t on e_t and the reverse regression. Model C allows for a shift in the intercept, Model C/T allows for a shift in the intercept and trend, and Model C/S allows for a shift in both intercept and slope vector. The corresponding critical values for each model are from Table 1 in Gregory and Hansen (1996). The lag order is chosen on the basis of *t*-tests in parenthesis (.) subject to a maximum of 8 lags. Breakpoints are in square brackets [.].

[a] significant at 1 %.

[b] significant at 5%.

Table 2

The estimated bivariate GARCH-BEKK model for Japan.

Panel A: Pre-crisis Period (6/8/ 2003-8/8/2007)			Panel B: Crisis period (15/8/2007-28/12/2011)		
	Ƴ (*i*=*S*)	Ƴ (*i*=*E*)		Ƴ (*i*=*S*)	Ƴ (*i*=*E*)
Conditional Mean Equation					
σ_i	0.065 (0.134)	−0.097 (0.064)	σ_i	−0.283[b] (0.136)	0.202[a] (0.072)
$\cdots_{Si,t41}$	0.136[b] (0.057)		$\cdots_{Ei,t41}$		−0.151[a] (0.049)
$\cdots_{Ei,t41}$	0.052[b] (0.024)		ς_i	0.966[a] (0.053)	−0.271[a] (0.930)
ξ_i	−3.293O (1.446)	−0.395[a] (0.931)	ι_i		

Table 3

The estimated bivariate GARCH-BEKK model for the US.

Panel A: Pre-crisis Period (6/8/ 2003-8/8/2007)			Panel B: Crisis Period (15/8/2007-28/12/2011)		
	Υ (*i*=*S*)	Υ (*i*=*E*)		Υ (*i*=*S*)	Υ (*i*=*E*)
Conditional Mean Equation					
σ_i	0.025 (0.053)	0.016 (0.046)	σ_i	0.165^a (0.082)	-0.016 (0.058)
$\cdots_{Si,t41}$	-0.217^a (0.043)		$\cdots_{Si,t41}$	-0.068^b (0.030)	
ς_i					

Table 4

The estimated bivariate GARCH-BEKK model for the euro area.

Panel A: Pre-crisis Period (6/8/ 2003-8/8/2007)			Panel B: Crisis Period (15/8/2007-28/12/2011)		
	ʽΥ⅄ (i=S)	ʽΥ0 (i=E)		ʽΥ⅄ (i=S)	ʽΥ0 (i=E)
Conditional Mean Equation					
σ_i	0.118	–0.235[c]	σ_i	–0.176	–0.201
	(0.084)	(0.142)		(0.166)	(0.076)

Table 5

The estimated bivariate GARCH-BEKK model for Canada.

Panel A: Pre-crisis Period (6/8/ 2003-8/8/2007)			Panel B: Crisis Period (15/8/2007-28/12/2011)		
	Υ (*i*=*S*)	Υ_0 (*i*=*E*)		Υ (*i*=*S*)	Υ_0 (*i*=*E*)
Conditional Mean Equation					
σ_i	0.170^b (0.073)	0.105^c (0.061)	σ_i	-0.109 (0.091)	0.037 (0.071)
ς_i	0.750^a (0.056)	0.152^a 0.052	$\cdots_{Si,t41}$		-0.136^b (0.057)
			$\cdots_{Ei,t41}$		-0.107^b (0.051)
			ς_i	0.641^a (0.037)	0.279^a (0.025)
			ι_i	0.143^a (0.016)	0.061^a (0.014)
Conditional Variance Equation					
c_{Si}	0.371^a (0.133)	0	c_{Si}	0.256^c (0.153)	0
c_{Ei}	-0.210^c (0.126)	-0.000001 (0.075)	c_{Ei}	0.426^a (0.119)	0.000002 (0.091)
ζ_{Si}	0.258^a (0.068)	0.127 (0.083)	ζ_{Si}	-0.247^c (0.142)	0.254^a (0.090)
ζ_{Ei}	0.356^a (0.080)	-0.086 (0.112)	ζ_{Ei}	0.152^a (0.052)	0.454^a (0.118)
b_{Si}	0.846^a (0.042)	-0.097^c (0.052)	b_{Si}	0.915^a (0.069)	-0.128^c (0.077)
b_{Ei}	0.200^a (0.066)	0.952^a (0.024)	b_{Ei}	0.150^c (0.078)	0.784^a (0.106)
Loglik	-604.2614		*Loglik*	-749.813	
$Q(6)$	20.303[0.206]	$Q^2(6)$ 19.401[0.150]	$Q(6)$	20.990[0.178]	$Q^2(6)$ 10.310[0.739]
$Q(12)$	37.567[0.229]	$Q^2(12)$ 31.000[0.415]			

Table 6

The estimated bivariate GARCH-BEKK model for Switzerland.

Panel A: Pre-crisis Period (6/8/ 2003-8/8/2007)			Panel B: Crisis Period (15/8/2007-28/12/2011)		
	ϒ (*i*=*S*)	ϒ$_0$ (*i*=*E*)		ϒ (*i*=*S*)	ϒ$_0$ (*i*=*E*)
Conditional Mean Equation					
σ_i	0.192^b	-0.016	σ_i	-0.136	0.172^a
	(0.092)	(0.031)		(0.117)	(0.048)
$\cdots_{Si,t41}$	-0.095^b		$\cdots_{Si,t41}$		
	(0.047)			(	