Hachmi BEN AMEUR · Zied FTITI
Wael LOUHICHI · Jean-Luc PRIGENT
Editors

Crises and Uncertainty in the Economy

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Preface

Since the period 2007–2008, various crises have occurred worldwide. Economic and financial systems have experienced different types of shocks, global financial crises (as in 2007–2008), sovereign debt (as in Europe 2010–2012 and the USA in 2011), geopolitical tensions, Brexit, and recently the health crisis. These different episodes of turmoil have different origins: demand-side, supply-side, or both sides. Therefore, these crises raised uncertainty and complexity in the financial and economic systems. More specifically, we have observed several transformations in policy makers' actions, investors' behaviors, and economic agents. Interestingly, learning from crises might elevate our resilience and might drive policy makers and investors to make appropriate decisions. This handbook aims to discuss these issues. Interestingly, we try in this handbook to propose some thoughts regarding economic dynamics and reactions in times of crisis (first part) as well as financial markets behavior (second part).

The first part, titled The Economic Dynamics in Time of Crisis, covers issues related to policy responses during COVID-19, economic integration, labor mobility in the case of monetary union, macroeconomic policy and climate change, bank lending procyclicality, and cybercrime threats. In the first chapter, **Elias BENGTSSON** (Copenhagen Business School, Norway) aims to investigate the responses of European policy makers to the COVID-19 pandemic's first and second waves. More specifically, Elias Bengtsson proposes an empirical investigation where patterns are sought between contextual factors and policy responses. His analysis highlights three main findings. First, he shows that macroeconomic conditions and policy interactions appear to matter more than countries' number of COVID-19 cases. Second, the level of government indebtedness came out as a significant positive determinant of fiscal stimulus, which is supported by unconventional policy measures. The European institutional context of coordination and joint decision making in fiscal, monetary, and prudential policy likely influence these results and raise important policy questions. The second chapter, developed by **Xiaofei MA** (ESSCA School of Management, France), aims to assess the potential interactions between economic integration and labor mobility based on a two-country model in the context of monetary union. She shows that while labor mobility reduces unemployment rates, capital mobility in contrast increases unemployment rates in both economies. Moreover, she highlights that factor mobility might not stimulate production due to the fall in employment. Xiaofei MA investigates this issue under the period of post-crisis and shows that the divergence across member countries might not simply be due to asymmetric total factor productivity (TFP) shocks, but rather their association with the increase of labor mobility costs.

The third chapter, written by **Muhammad AZAM** (University of Lahore, Pakistan), **Ahmed Imran HUNJRA** (Ghazi University, Pakistan), and **Dilvin TASKIN** (Faculty of Business, Yaşar University, Izmir, Turkey), aims to investigate the role of macroeconomic and financial policies in climate change mitigation in developing economies. The analysis shows that monetary policy stabilization and fiscal policy stabilization can be leveraged to cover green financing gaps and can also be used to overcome climate change issues. More interestingly, the authors highlight that the financial structure in several developing countries is rather an obstacle to climate change mitigation and particular attention should be addressed. In the fourth chapter, **Hassen RAÏS** (ESSCA School of Management, France) investigates the passthrough of exchange rate dynamics to the financial sphere. Based on a smooth transition regression model, he shows that the exchange rate volatility rises more than proportionally with the global financial stress for emerging countries than developing ones. Interestingly, he puts out regional contagion effects spreading from one currency to other currencies in the neighboring area. In the fifth chapter, **Małgorzata PAWŁOWSKA** (Warsaw School of Economics, Poland) aims to assess whether the market structure has an impact on procyclicality in the European Union bank loan markets for three types of loans (residential mortgage, consumer, and corporate loans). She shows that the procyclical responses regarding residential mortgage loans and corporate loans are significantly stronger and prolonged when the banking sector is more concentrated. In addition, the authors highlight nonlinear relations between the market structure and credit procyclicality and find some heterogeneities between advanced and transitioning European Union banking sectors.

In the sixth chapter, Vasileios Vlachos (International Hellenic University, Greece) investigates the role of macroeconomic factors on living standards in times of macroeconomic uncertainty. More specifically, the author assesses the macro-level determinants of material deprivation for four countries, Greece, Italy, Portugal, and Spain, over the period 2005–2019. Author highlights the role of government expenditure in terms of social protection benefits and unemployment benefits, is critical to the size of severe material deprivation. Through disaggregating countries into subsamples among more industrial economies and lesser ones, the results highlight that economic growth for industrial economies (lesser industrial economies) will (will not) contribute to the reduction of severe material deprivation through labor and wages channels. Interestingly, our results show that the decrease of severe material deprivation rates will be less time consuming in economies with smaller income gaps.

The second part of this handbook is composed of six chapters about the functioning of financial markets, especially during the recent health crisis. Chapter 7 by **Emanuele CITERA** (The New School for Social Research, New York) proposes a theoretical model to recover the distribution of daily returns for all the stocks included in the S&P 500 index over the period January 1, 1988–December 31, 2019. The author shows that stock returns distributions result from endogenous fluctuations of investors' behavior which generates stable frequency distributions. Chapter 8 is co-authored by **Marcos GONZÁLEZ-FERNÁNDEZ** and **Carmen GONZÁLEZ-VELASCO** (University of León, Spain). The authors examine the effect of COVID-19 fear on four European stock indices: CAC40, DAX30, FTSE-MIB, and IBEX35. They use Google Search Volume Index to proxy coronavirus investors fear. The results show an increase in pandemic fear leads are followed by strong negative stock returns.

Hasna CHAIBI, and Fatma HENTATI (FCF Lab-University of Tunis El Manar) and **Ines GHAZOUANI** (ISG Tunis, GEF2A Lab) are co-authors of Chap. 9 entitled "COVID-19 Crisis and Financial Performance: Evidence from Tunisian Firms." The authors propose to investigate the impact of the COVID-19 outbreak on the Tunisian Stock market. They broke down their sample of listed companies into two sub-samples: high-affected industries and low-affected industries. The authors found a strong negative reaction of the Tunisian market during the pandemic period, especially for companies included in the high-affected industry sectors. Chapter 10 is co-authored by **Mohamed YOUSFI** (IHEC Sousse, University of Sousse, Sousse, Tunisia), **Younes BEN ZAIED** (EDC Paris Business School, OCRE Research Lab, Paris), and **Youssef TLICHE** (EM Normandie Business School, Le Havre, France). The goal of this chapter is to assess the correlation between the US market and a sample of cryptocurrencies during the recent COVID-19 crisis. The results are supportive of the contagion hypothesis. Interestingly, the authors show that ETH and bitcoin have the highest hedging effectiveness.

Dimitris ANASTASIOU (Athens University of Economics and Business), in Chap. 11, proposes a literature review for the resolution methods of non-performing. This chapter discusses the main management methods for NPLs through distinction between the ex-post and ex-ante management of NPLs. More specifically, the author targets the main resolution of NPLs across various banking systems. Chapter 12 is co-authored by **Foued HAMOUDA, Rabeb RIAHI, and Jamel. E. HENCHIRI** (URRED, Higher Institute of Management, University of Gabès Tunisia). This chapter aims to assess the accuracy of risk models used during the recent health crisis. The authors test their hypothesis using several risk models. They show that the conditional extreme value theory (EVT) outperforms the other benchmark models. The last chapter of this handbook is co-authored by **Abderrazek BEN MAATOUG** (ISG Tunis, GEF2A Lab), **Mohamed Bilel TRIKI** (The Applied College, University of Bisha & ISG Tunis, GEF2A Lab), and **Donia ALOUI** (Carthage Business School, University of Tunis Carthage). It investigates the relationship between the incomes of Tunisian farmers and climate change. The authors recommend that farmers use crop insurance as a means of hedging against income fluctuations caused by climate change characterized by an increase in temperature and a reduction in rainfall.

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Part I
Economic Dynamics in Time of Crisis

Chapter 1
Covid-19: What Determines Policy Responses Across Europe?

Elias BENGTSSON

1.1 Introduction: Policy Determinants and Interactions in Pandeconomies

A decade after the great recession, we are facing something not experienced for the better part of a century. Just as the drama following the global financial crisis acted out with frightening resemblance to the great depression, the Covid-19 pandemic mirrors the Spanish flue with mass causalities and widespread fear. Both events serve as clear reminders of our societies' vulnerabilities. Both also represent major disruptions for the economy – globally and domestically.

The outbreak of Covid-19 is however an unprecedented economic shock in terms of its nature and magnitude. The economic outlook has suffered an unmatched blow on the backdrop of substantial reductions in demand. Job losses have spiked, income prospects have fallen for those employed and distancing measures have contributed to less spending. Many industries have experienced dwindling cash flows and crumbling production. This is also interrelated to sudden and substantial increase in risk and disruptions in key financial markets. Jumps in volatilities have characterised all asset classes. Fixed income has been particularly affected through rising credit spreads, and even the safest segments have experienced spikes in long-term yields (Schrimpf et al. 2020).

Financial policy makers are seeking to mitigate the impact on the real economy through extraordinary fiscal, monetary and prudential policies. Fiscal measures – such as guarantee schemes for households and firms, tax deferrals, subsidised loans

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and moratoria on debt payments – are widespread.[1] Monetary authorities have cut interest rates to support aggregate demand. Central banks have also used a variety of tools – including last resort lending operations and asset purchases – to ensure proper functioning of the financial system and an effective transmission of monetary policy. Prudential authorities have lowered capital requirements, as well as altered credit model requirements and dividend practices.

This chapter analyses policy measures in response to the Covid-19 pandemic's first and second waves in Europe. It is based on an empirical analysis where patterns are sought between contextual factors and policy responses. More specifically, it conducts regression analyses to understand the conditions that influence policy choices (in the shape of macroeconomic and social variables) and how different social and financial policies – and policy actors – interact.

Whereas most research on C19 policy has focused on the effects of policy measures in terms of their economic implications (Eppinger et al. 2020; Carlsson-Szlezak et al. 2020; Baldwin 2020; Guerrieri et al. 2020; Eichenbaum et al. 2020; Mulligan 2020; McKibbin and Fernando 2020 etc.), this chapter contributes to the small but growing literature that seeks to understand how policy choices interact and vary across countries.[2] Although the bulk of this literature is conceptual and/or theoretical (cf. Reis 2021), exceptions include Sarker (2020), who explores variations in financial policy responses in a cross-country context. Gourinchas (2020) discusses policy interactions between social and fiscal policy over the short and long run. Elgin et al. (2020) incorporates both dimensions and consider how economic stimulus relate to the stringency of social regulation. They show that variables such as median age, public health measures and GDP per capita predict governmental responses in terms of economic stimulus. However, they show that stringency of social regulation does not explain the magnitude of economic stimulus.

Closest to this chapter is Benmelech and Tzur-Han (2020) who study determinants of fiscal and monetary policy responses from the outbreak of Covid-19 until May 2020 across a sample of emerging markets and advanced economics. This chapter extends the scope of that study to also include the second wave of the pandemic, and by considering additional policy interactions in the shape of prudential and social policy, as well as the role of private policy initiatives. In addition, the European context of this chapter implies a more homogeneous sample of countries that also are coordinated and governed by a set of common rules, regulation and practices relating to financial policy. The empirical context is also unique as it represents the first case where loosened macroprudential policy has to interact with other policies in the European post-crisis regulatory architecture. In addition, the findings also add knowledge on financial policy opportunities and

[1] For a description of measures taken in US, CA, UK, JP and the Eurozone, see Cavallino and De Fiore (2020).

[2] Including impacts on labour supply, consumption spending, financial markets, government expenditure and trade.

limitations in low interest rate environments (Bernanke et al. 2019; Borio and Gambacorta 2017) and how recent extension of financial policy mandates to cover more complex risks (Giuzio et al. 2019) may manifest in practice.

The results presented in this chapter show that that macroeconomic conditions and policy interactions appear to matter more than countries' number of Covid-19 cases. The level of government indebtedness came out as a significantly positive determinant of fiscal stimulus. Policy interaction also matters, but merely between financial policies – social restrictions do not influence fiscal or prudential policy. In addition, unconventional policy measures support expansionary fiscal policy measures and loosening of prudential policy measures. The European institutional context of coordination and joint decision making in fiscal, monetary and prudential policy likely influence these results. Finally, it seems private initiatives such as moratoria or eased lending standards potentially substituted fiscal stimulus as the pandemic entered its second wave in Europe.

The remainder of this chapter is outlined as follows: Sect. 1.2 provides an overview of the Covid-19 context and related policies, and presents the data and methodology that underlie the analysis; Sect. 1.3 analyses conditions that influence policy and how different policies interact; Sect. 1.4 concludes.

1.2 The Covid-19 Policy Context, Data and Methodology

1.2.1 The Covid-19 Policy Context

When observing policies relating to Covid-19 across countries, one is struck by the large variety in the number and types of measures across countries. There are also large differences in the measures' magnitudes. The US Fed has lowered its reference rate by 1.5 percentage and many other central banks have made similar cuts. Conversely, the ECB and Bank of Japan maintained their rates. The balance sheets of the latter are expected to increase to approx. 55% and 120% of GDP before the end of 2020, whereas the corresponding figures for the UK and Canadian central banks are around 35% and 20% respectively (Cavallino and De Fiore 2020). Macroprudential measures across the Eurozone will free up more than €20 billion of bank capital to absorb losses and support lending, but the distribution of this amount across countries vary (even after considering GDP). Similarly, in advanced economies, budgetary measures, funding facilities and credit guarantees together amount to a staggering average of 18.7% of GDP (Alberola et al. 2020). Chart 1.1 shows countries' Covid-19 cases. Chart 1.2 demonstrates how Covid-19 fiscal policy responses vary across Europe. Together, these charts illustrate the weak relationship between the magnitude of infected citizens and fiscal amounts spent.

This variety in policy responses raises questions on the determinants of policy makers' actions. Arguably, policy makers across the globe have faced relatively similar conditions for making policy decisions – A comparable and unparalleled

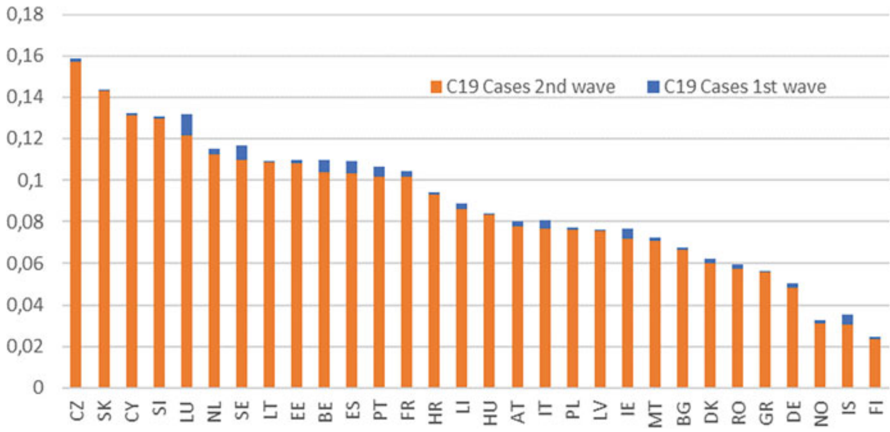

Chart 1.1 Covid-19 cases (% population). (Source: ECDC 2021)

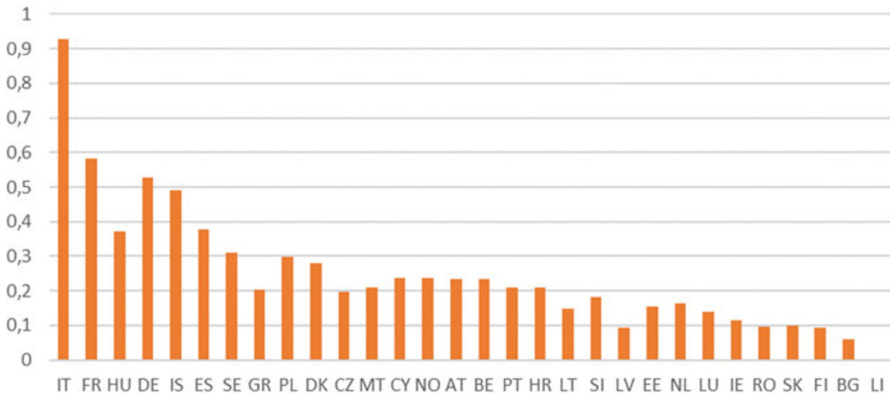

Chart 1.2 Covid-19 fiscal policy responses (% GDP). (Source: ESRB 2021)

exogenous shock characterized by radical uncertainty on its transmission channels and magnitude of impact. Can empirical pandeconomics explain the large variety?

1.2.2 Data

To answer this question, cross-country policies and contextual factors were analysed in search of empirical patterns and relationship. These findings were subsequently interpreted using insights from theory, logic and prior research. Data was collected for 30 European countries (EU27, Iceland (IS), Lichtenstein (LI) and Norway (NO)), covering both policy stances and a range of variables suggested by prior research to matter for policy makers' responses.

The *policy variables* include both the financial space and the stringency of countries social regulations relating to the pandemic. Financial policy measures were constructed based on the ESRB's data on *Policy measures in response to the COVID-19 pandemic*.[3] Due to the little variation in conventional monetary policy across Europe, the data focuses on unconventional monetary policy measures. Thus, financial policies include all fiscal policies, unconventionary monetary policy tools and prudential measures reported. Social regulation is proxied by the composite COVID-19: Stringency Index (Hale et al. 2021). A variable that seeks to capture the role of private policy initiatives was also included. This includes example such as when credit institutions in Estonia agreed to harmonise terms and conditions for deferral period for households and non-financial enterprise in April 2020. *Macro variables* include government indebtedness, sovereign credit ratings, GDP-per-capita (GDP/capita) and domestic Covid-19 cases. Table 1.1 presents all variables used in the study and their sources.

1.2.3 Model Specifications and Summary Statistics

The empirical investigation used a standard econometric approach that is common to the research field of explaining financial policy responses. Patterns of interaction between the above policy and contextual variables were analysed using regression analysis. Such regression analysis reveals any relationships by distinguishing reliable ("statistically significant") patterns from insignificant ones. Moreover, the statistically significant coefficients provide important cues on the relationships between variables; both by displaying the direction of the relationship (i.e. whether it is positive or negative) and the strength of the relationship (i.e. how variation in the independent variables influence the dependent variable).

In more technical terms, the determinants of policy responses and interactions were estimated using the following specification:

(a) $Fiscal_i = \alpha_0 + \alpha_{i1} \times Policy_{i1} + \ldots\ldots + \alpha_{in} \times Policy_{in} + X_i\,\beta + \mathrm{e}_i$
(b) $Prudential\,_i = \alpha_0 + \alpha_{i1} \times Policy_{i1} + \alpha_{in} \times Policy_{in} + X_i\,\beta + \mathrm{e}_i$

The dependent variable in specification is a) aggregate fiscal spending to GDP; and b) # of domestic prudential measures. Country-level macro variables – debt-to-GDP, credit rating, GDP-per-capita and Covid-19 cases – are included in vector *X*i. Tables 1.3, 1.4, 1.5, and 1.6 in the next section present results from estimating different variants of the models, where the combinations of policies and country level variables are included (standard errors in parenthesis). Robust standard errors were applied in all variants to counter heteroskedasticity.

[3] The policy data is available on: https://www.esrb.europa.eu/home/coronavirus/html/index.en.html. Policy measures by European Authorities (EBA, ESMA, EIOPA, ESRB, ECB, FATF) were omitted.

Table 1.1 Variables definitions and sources

Name	Description	Source
Policy variables		
Fiscal policy (*Fiscal*)	Combined volume in relation to end 2019 GDP of direct and off-budget post (direct grants, moratoria, tax deferrals and reliefs classified as fiscal policy by authorities).	ESRB (2021) Policy measures in response to the COVID-19 pandemic: https://www.esrb.europa.eu/home/search/coronavirus/html/index.en.html
Prudential pol. (*Prudent*)	# measures classified as microprudential or macroprudential policy such by authorities.	
Unconv. mon. pol. (*Unconv mon.*)	# measures classified as asset purchase programs, credit or liquidity facilities by central banks.	
Social policy (*Social*)	Covid-19: Stringency Index – a composite measure between 0 and 100 (100 = strictest) based on 9 indicators incl. school/workplace closures and travel bans.	Global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). https://doi.org/10.1038/s41562-021-01079-8
Private policy (*Private*)	# measures of prudential or fiscal nature (i.e. moratoria) by industry associations and initiatives by other private actors.	ESRB Policy measures in response to the COVID-19 pandemic
Macro variables		
Debt-to-GDP (*Gov debt*)	Gross debt of the general government as a percentage of GDP.	OECD General government debt: https://data.oecd.org/gga/general-government-debt.htm
Credit rating (*CreditR.*)	Credit rating reflecting the credit worthiness of a country between 100 (riskless) and 0 (likely to default).	Trading economics: https://tradingeconomics.com/country-list/rating?continent=europe
GDP-per-capita (*GDP/capita*)	GDP per capita in PPS	Eurostat: https://ec.europa.eu/eurostat/databrowser/view/tec00114/default/table?lang=en
Covid-19 Cases (*C19 Cases*)	Cumulative confirmed Covid-19 cases in relation to population.	European Centre for Disease Prevention and Control (ECDC) (2021) Epidemic intelligence: https://www.ecdc.europa.eu/en/cases-2019-ncov-eueea

Note: CY and NO fiscal spending based on IMF (2021) due to inconsistencies in the reporting vis-à-vis other countries

Regressions are run on two different points in time – the first captures the situation at end July 2020 and the second until end August 2021. This seeks to capture the different conditions and interactions of the so-called first and second waves of the pandemic in Europe (Fokas and Kastis 2021; Bontempi 2021).

Table 1.2 provides summary statistics for conditions at the end of the first and second waves. The mean fiscal spending amounts to 11% of GDP by end of

Table 1.2 Descriptive statistics

Wave 1 variable	Mean	Median	S.D.	Min	Max
Fiscal	0.11	0.09	0.09	0.00	0.46
Unconvmon	5.77	6.00	3.18	0.00	16.00
Prudent	1.97	1.00	1.96	0.00	8.00
Private	1.10	0.50	1.35	0.00	4.00
CreditR	76.00	76.00	22.70	0.00	100.00
C19 Cases	0.00	0.00	0.00	0.00	0.01
Social	77.50	80.60	11.00	53.70	96.30
Wave 2 variable	**Mean**	**Median**	**S.D.**	**Min**	**Max**
Fiscal	0.14	0.12	0.10	0.00	0.47
Unconvmon	6.13	6.00	3.61	0.00	16.00
Prudent	4.53	4.50	2.90	0.00	11.00
Private	1.33	1.00	1.58	0.00	5.00
CreditR	76.00	76.00	22.70	0.00	100.00
C19 Cases	0.09	0.08	0.03	0.02	0.16
Social	44.70	42.10	9.79	28.70	64.30
Govdebt	72.40	65.50	43.60	0.01	201.00
GDP capita	108.00	94.00	45.90	55.00	266.00

the first wave, which increases to 14% at the end of the second. Unconventional monetary policies remain relatively constant over the two periods, whereas the use of prudential policy tools increase substantially in the second wave. In terms of macro variables, Covid-19 cases rose sharply in the second wave to amount to 9% the population on average, while – or perhaps as – the stringency of social restrictions decreased in overall the sample.

1.3 Results

1.3.1 Base Model

Table 1.3 shows how the different macro variables relate to Covid-19 fiscal spending measured in relation to GDP for both the first and the second wave. Columns A–D display univariate regressions for debt-to-GDP, credit rating, GDP-per-capita and Covid-19 cases respectively. Multivariate regressions covering all macro variables are reported in column E.

Government indebtedness is the only variable that displays any significant impact on spending; in the univariate regression for the second wave and in the multivariate regressions for both waves. The coefficients are relatively similar in all three cases, where one percentage point higher government debt-to-GDP is associated with around 1% higher fiscal spending. One standard deviation (43.2) increase in government debt from the average (108.1) is thus associated with

Table 1.3 Macro variables and Covid-19 fiscal spending

Dependent variable: Fiscal					
Wave 1	**A**	**B**	**C**	**D**	**E**
Const	0.037	0.128**	0.121***	0.083***	−0.031
	0.037	0.055	0.036	0.019	0.059
Govdebt	0.001*				0.001*
	0.001				0.001
CreditR		0.000			0.001
		0.001			0.001
GDPcapita			0.000		16.092
			0.000		9.818
C19Cases				11.052	−0.001
				7.332	0.000
N	30.000	30.000	30.000	30.000	30.000
Adjusted R2	0.206	−0.033	−0.034	0.041	0.238
Wave 2	**A**	**B**	**C**	**D**	**E**
Const	0.048	0.194***	0.173***	0.176***	0.059
	0.031	0.051	0.037	0.048	0.072
Govdebt	0.001**				0.001
	0.001				0.001**
CreditR		−0.001			0.000
		0.001			0.001
GDPcapita			0.000		0.000
			0.000		0.000
C19Cases				−0.458	−0.360
				0.424	0.444
N	30	30	30	30	30
Adjusted R2	0.277	−0.003	−0.009	−0.010	0.216

Note: */**/*** denote significance at 10%/5%/1% levels

around 50% higher Covid-19 fiscal expenses. This finding corresponds to those of Benmelech and Tzur-Han (2020) both in terms of direction and magnitude. It counters conventional wisdom that suggests that it is easier for counties with lower levels to provide fiscal stimulus to compensate for reductions in private spending (Davig and Leeper 2011; Romer and Romer 2017). Other results are somewhat mixed in relation to other prior studies (Romer and Romer 2021). The insignificance of Covid-19 cases is similar, but the absence of significant effects for credit ratings differs (Romer and Romer 2021; Benmelech and Tzur-Han 2020). This suggests that notions that market access is more important than debt-levels do not apply in the European context.

1.3.2 Public Policy Interactions

Table 1.4 examines interactions between Covid-19 related policies, again covering both the first and the second wave. The only significant macro variable (Government indebtedness) from Table 1.3 is maintained for control purposes. The dependent variable is still fiscal spending to GPD, and columns A-C examines the interactive effect from social, unconventional monetary and prudential policy. Column D provides the results from regressing the combined effect of the latter two. Government debt remains significantly correlated with fiscal spending, but this also applies to unconventional monetary policy. The effect remains in both the first and second waves with a magnitude of around 0.005. This implies that each additional unconventional monetary policy tool applied by central bank increases fiscal spending with half a percentage point. One standard deviation in the number of unconventional monetary policy tools (3.15) is thereby associated with 1.5%

Table 1.4 Public policy impact on Covid-19 fiscal spending

Dependent variable: Fiscal				
Wave 1	**A**	**B**	**C**	**D**
Const	0.089	0.012	0.042	0.018
	0.115	0.036	0.040	0.039
Govdebt	0.001***	0.001	0.001	0.001*
	0.000	0.001	0.001	0.001
Social	−0.001			
	0.002			
Unconvmon		0.005**		0.005*
		0.002		0.002
Prudent			−0.007	−0.007
			0.006	0.006
N	30	30	30	30
Adjusted R2	0.184	0.204	0.195	0.191
Wave 2	**A**	**B**	**C**	**D**
Const	−0.037	0.021	0.023	0.010
	0.056	0.030	0.036	0.034
Govdebt	0.001	0.001**	0.001**	0.001**
	0.001	0.001	0.000	0.001
Social	0.002			
	0.002			
Unconvmon		0.005*		0.004
		0.003		0.003
Prudent			0.006	0.004
			0.005	0.006
N	30	30	30	30
Adjusted R2	0.293	0.288	0.286	0.277

Note: */**/*** denote significance at 10%/5%/1% levels

higher fiscal spending. This effect may suggest that while the unconventional policy measures are expansionary policy measures, they also reduce debt servicing and facilitate taking on additional debt. Monetary and fiscal policy appears to complement rather than substitute each other in this respect.

Column B, which regresses the combined effect of government debt and unconventional policy measures also has the highest predictive ability of the variation in fiscal spending (adjusted R2 amounts to 0.2). The correlation between social and prudential policy, on the other hand, are not significant – neither in the first nor second waves. Although insignificant, it is however notable that in the first wave, both social and prudential policy are negatively correlated with fiscal spending. That does not corroborate arguments that strict social regulation is necessary in pandemics to prevent surges in cases associated with fiscal stimulus (Romer and Romer 2021). Further, the negative correlation between easing of prudential requirements and fiscal spending could suggest that prudential policymakers maintain tougher policy stances in more expansive fiscal environments, as risk taking may increase in the financial system as a side effect.

Table 1.5 reports the results from regressing government indebtedness and other policy stances on prudential policy. The only significant effect is for the second Covid-19 wave, where unconventional policy initiatives are positively related to prudential policy measures. The coefficient is around 0.3 which implies that one standard deviation of unconventional policy implies a reduction of active prudential policy tools by one. This suggests that expansionary monetary policy is not perceived to lead to excess risk taking in the financial sector that warrants any prudential policy tightening. There are no effects when adding social policy (unreported in Table 1.5).

Table 1.5 Interaction of unconventional monetary and prudential policy

Dependent variable: Prudent				
	Wave 1		Wave 2	
	A	B	C	D
Const	0.733	0.821	4.073 ***	2.474 *
	0.728	1.028	1.158	1.392
Govdebt	0.017 **	0.017 **	0.006	0.004
	0.008	0.008	0.014	0.012
Unconvmon		−0.017		0.294 *
		0.102		0.161
N	30	30.000	30	30
Adjusted R2	0.114	0.082	−0.026	0.078

Note: */**/*** denote significance at 10%/5%/1% levels

1.3.3 *Public-Private Policy Interactions*

Prior research indicates that private actors play important roles in financial policy. Private policy actors and networks often engage in voluntary self-regulation to pre-empt formal regulation (Mattli and Woods 2009; Milner and Moravcsik 2009; Bengtsson 2013, 2020). The analysis of how private policy initiatives influence formal Covid-19 policies is based on a hypothesis that policy initiatives in the private and public spheres influence one another. Table 1.6 shows that this indeed is the case. The top rows show regressions results where Prudential policy is the dependent variable, and the lower rows three Fiscal policy. For both dependent variables, the number of private policy initiatives is used as independent variables (column A), as well as in combination with unconventional monetary (columns B and E) and social policy (columns C and F). Again, regressions are run on the conditions at the end of both the first and second waves.

Table 1.6 Interactions between private and public policy

Dependent variable: Prudent	Wave 1			Wave 2		
	A	B	C	D	E	F
Const	0.816	0.800	−0.454	4.097 ***	2.508 *	2.774
	0.721	1.052	1.910	1.175	1.466	2.349
Govdebt	0.009	0.009	0.007	0.009	0.005	0.004
	0.007	0.007	0.009	0.015	0.015	0.018
Private	0.436 *	0.438 *	0.431 *	−0.176	−0.085	−0.119
	0.221	0.234	0.224	0.405	0.447	0.409
Unconvmon		0.003			0.290 *	
		0.104			0.169	
Social			0.018			0.037
			0.032			0.063
N	30	30	30	30	30	30
Adjusted R2	0.146	0.113	0.123	−0.056	0.044	−0.086
Dependent variable: Fiscal	**Wave 1**					
	A	B	C	D	E	F
const	0.036	0.012	0.088	0.049	0.022 **	−0.035
	0.036	0.037	0.096	0.032	0.032	0.065
Govdebt	0.001 **	0.001 *	0.001 **	0.001	0.001	0.001
	0.001	0.001	0.001	0.000	0.000	0.001
Private	−0.004	−0.002	−0.004	−0.004 **	−0.003 *	−0.001
	0.015	0.015	0.015	0.010	0.010	0.010
Unconvmon		0.005 **	−0.001		0.005	0.002
		0.002	0.001		0.003	0.002
N	30	30	30	30	30	30
Adjusted R2	0.179	0.174	0.154	0.254	0.262	0.266

Note: */**/*** denote significance at 10%/5%/1% levels

The patterns for how private policy initiatives correlate with prudential and fiscal policies are diametrically opposed. For prudential policy, private policy initiatives are positively related in the first wave. In the second wave, the effect disappears. This could suggest that in countries where the gravity and uncertainty in the initial wave induced policy responses from both private and public actors. Alternatively, private initiatives could be pre-emptive measures by private actors in expectations of policy responses from the prudential regulator.

For fiscal policy, there is no significant correlation in the first wave, but a significant – albeit small – negative one in the second wave. Here, each private policy initiative is associated with around half a percentage point less fiscal spending. This could potentially result from policy substitution between private and public policy, where private initiatives such as moratoria or eased lending standards substitute expansionary fiscal policy.

1.4 Discussion

This chapter represents a rare empirical contribution to research on how policies interact in response to exogeneous shocks; a field hitherto dominated by conceptual and theoretical discussion.[4] The analysis of European policy responses to the Covid-19 pandemic displays the complexity faced by policymakers – visible in this chapter's sometimes surprising results that differ from those of prior research.

One key finding is that macroeconomic conditions and policy interactions appear to matter more than the severity of crisis. The empirical analysis shows that there is no relation between countries' fiscal responses to the number of Covid-19 cases. In contrast, what matters more is the level of government indebtedness, which came out as a significantly positive determinant of fiscal responses for both the first and second wave. The effect higher debt levels have on fiscal spending is positive, which contrasts conventional wisdom, but corresponds to other recent *pandeconomics* research. However, this prior research has showed that the most important explanatory factor of fiscal spending is countries' credit ratings. This chapter demonstrates no such effect. This suggests that the notions that market access is more important than debt-levels do not apply in the European context. This could be the result of investors' being comforted by regional common macroeconomic rules and procedures, a relaxing of budgetary rules and state aid restrictions, but more importantly the European Council's Next Generation EU – an unprecedented fiscal package adopted by in summer 2020.[5] Credit ratings may

[4] C.f. Reis (2021). An exception is Bengtsson (2021).

[5] The Next Generation EU (NGEU) fund is a European Union economic recovery package to support member states adversely impacted by the COVID-19 pandemic. Agreed to by the European Council on 21 July 2020, the fund is worth €750 billion. The NGEU fund will operate from 2021–2023. It will be tied to the regular 2021–2027 budget of the EU's (MFF). The comprehensive NGEU and MFF packages are projected to reach €1824.3 billion.

matter less when national fiscal policy is accompanied by EU-wide stimulus funded by jointly issued debt. However, this may create expectations that future crises will be solved by mutual borrowing. This in turn may give rise to policy issues from moral hazard by individual Member States.

Another key finding relates to policy interaction. The results in this chapter clearly show that it matters, but it seems to be confined to financial policy interaction; social restrictions do not influence fiscal or prudential policy. This is somewhat surprising since without appropriate public health measures, stimulating aggregate demand would probably increase Covid-19 cases and thereby counteract the policy intentions of the stimulus. This argument that strict social regulation must accompany fiscal stimulus to avoid surges in infections (e.g. Romer and Romer 2021) does not seem to hold in Europe. More expected is perhaps that unconventional policy measures are support expansionary fiscal policy measures, although these policy options conceptually could act as substitutes. Expansionary monetary policy, by pushing down interest rates, also reduces debt servicing, facilitate taking on additional debt and provide conditions for further fiscal stimulus. For Eurozone countries, ECB effectively provided a monetary backstop to government debt in this fashion.[6] Again, moral hazard issues may follow from such backstops which create future policy challenges relating to budgetary discipline.

When the use of prudential tools were added to the policy mix, unconventional policy initiatives became positively related to prudential policy measures in the second Covid-19 wave. Two very different argument could potentially explain this finding. One is that expansionary monetary policy was not perceived by policy makers to cause any excess risk taking in the financial sector, and thereby warrant maintained or toughened prudential stances. The other is that policy confusion, uncertainty about the outlook or political economy constraints prevented authorities to maintain or tighten the prudential policy stance.[7] Even before the pandemic downturn, policy discussions highlighted the need for a clear and common understanding of crisis conditions to find common ground and coordinate between different policy areas.[8] Political economy constraints at the national level may also hinder prudential authorities to impose policies that in part may counteract fiscal policy.[9] Again, the particular European context may also matter- prudential authorities in the EU are required to seek approval from the Council of the EU for using (and potentially relaxing) particular instruments, and where ECB plays a decisive role for number of macroprudential instruments for Eurozone countries.

The third key finding relate to how public and private policy interacted in the pandemic. Private policy initiatives were positively related to prudential policy loosening in the first wave, and negatively to fiscal policy in the second wave. This could suggest that in countries where the gravity and uncertainty in the initial wave

[6] See, for instance, Bartsch et al. (2020).

[7] See for instance Dehmej and Gambacorta (2019); Blanchard et al. (2010); Galati et al. (2011).

[8] See Osinski et al. (2013).

[9] See Bengtsson (2021).

induces policy responses from both private and public actors. As uncertainty fell as the pandemic continued, policy substitution may have occurred between private and public policy, where private initiatives such as moratoria or eased lending standards potentially substituted fiscal stimulus. This is in line with prior research that demonstrates that private policy actors and networks often engage in voluntary self-regulation to pre-empt formal regulation (e.g. Mattli and Woods 2009; Milner and Moravcsik 2009; Bengtsson 2013, 2020).

There are many potential extensions of this research that could shed additional on the policy conundrums highlighted above. One is to apply more fine-grained approaches to quantify differences in prudential and monetary policy stances to the analysis. One could also seek to better understand how other types of regional policies at the EU level influence policy responses in Member States. Another is to include additional factors – such as vaccination rates, unemployment rates and capex spending – and empirically investigate how and why policy stances evolve as the recovery takes hold. Whenever that happens.

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Chapter 2
Financial Integration and Labor Mobility in a Monetary Union

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2.1 Introduction

What are the potential effects of labor mobility and capital mobility within a monetary union? Under the recent COVID situation and lockdowns, the cross-border labor and capital mobility are highly reduced. According to our simulation, this increasing cost of especially labor mobility, may lead to an even more asymmetric economic development across member countries, such as countries in the European Monetary Union.

The debate of asymmetric economic growth across member countries in the EMU can be traced back to the 2008 financial crisis. As shown in Fig. 2.1, the unemployment rates in Spain, Greece and other Peripheral European countries continue to increase while this rate remains moderate in the Central or North European countries such as Germany, France and Austria. In the aftermath of 2008 financial crisis, the divergent performances across EMU member countries become the focus of policy debate. The discuss on Optimum Currency Area comes back to people's sight. The policy makers face to reduce the divergent performances across member countries in the EMU and increase the overall welfare.

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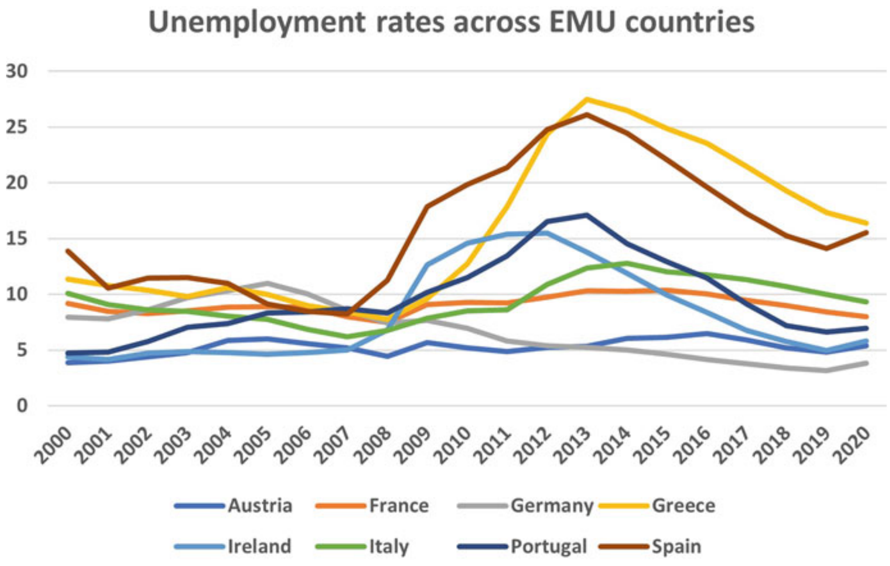

Fig. 2.1 Unemployment rate across EMU member countries, source: IMF

Among the various remedies, factor mobility is considered to be a potential cure. Ideally, if the labor markets across member countries are perfectly flexible and workers or job seekers can move freely among member countries to find the best job for them, then the asymmetric unemployment rates would be largely alleviated. For example, in Spain, due to the burst of real estate bubble after 2008, the unemployment rate reached about 25%. It is true that at that in Spain, unemployed people who lost their jobs during the recession have some difficulties to find a new job in countries such as Germany, mainly due to language barriers. Once the barriers are removed, it is expected that the unemployment rate in Spain will decrease and job seekers can also be better paid once they find a new job in another region.

Similar for capital mobility. Intuitively, the more flexible the capital mobility, i.e. the cross-border lending, the easier for local entrepreneurs to get funding for their projects. Therefore, it is supposed to have more job opportunities in the region thus reduce unemployment caused by insufficient funding networks. On the contrary, if there is few capital mobility across EMU member countries, then there is less opportunity for an entrepreneur to get funding if the domestic economy is in recession. Therefore, the labor and capital mobility are usually considered to be an important cure for the asymmetric economic growth across member countries in a monetary union.

What are the effects of factor mobility for a monetary union? Despite the apparent importance of labor and capital mobility for the optimality of a currency union, there is few widely accepted studies on the interactions between labor and capital mobilities.

By establishing a two-country model, we study the potential interactions between financial integration and labor mobility in the currency union. Our results show that while labor mobility reduces unemployment rates, capital mobility in contrast increases unemployment rates in both economies. Interestingly, factor mobility might not stimulate production due to the fall in employment. We find that shocks on capital mobility cost have secondary effects compared to shocks on labor mobility cost. We also calibrate our model to the EMU and simulate scenario to mimic the recent experiences across EMU member countries. Our results suggests that the divergence of member countries might not be due to asymmetric TFP shocks, but rather its association with the rise/increase of labor mobility costs.

In terms of related literature, in the influential paper of Mundell (1961), Mundell proposed two important channels for an optimum currency area: (1) internal labor mobility; and (2) price and wage flexibility. For the first, asymmetric shocks lead to labor market imbalances across member countries. Labor mobility helps alleviate unemployment pressure in countries hit by negative shocks, since unemployed workers can choose to move to another member countries in which it is easier to find a new job. For the second, with flexible prices and wages, the region hit by negative shocks may automatically adjust/lower its price and wage level, which restores its competitivity and stimulate demand from the goods and labor markets. In EMU, although the financial market seems to be well integrated, labor mobility is still low relative to the United States. In EMU, workers from other member countries represent only 3% of total labor force compare to 30% across the US states.[1]

On the capital side, many research papers show that financial integration or a high capital mobility helps diversify portfolio investment and thus reduce risk from asymmetric shocks. Nevertheless, Krugman (1993) argues that capital mobility tends to amplify regional asymmetric shocks. Krugman (1993)'s arguments are consistent with literatures concerning the financial accelerator. In our experiment, we find that a higher degree of banker's mobility may reduce local credit supply and reduce local job creation. Therefore, there will be more stay unemployed workers and naturally more stay unemployed workers will decide to move. Therefore, similar to Krugman (1993), capital mobility does not necessarily have positive impact in our model.

We establish a theoretical model to study the interaction between factor mobilities. Similar to Pilossoph (2014), our theory is based on three literatures: the country-specific labor market dynamics from the island model in Lucas and Prescott (1974), search and matching in local labor market from Mortensen and Pissarides (1994), and worker's mobility choice from Discrete Choice Theory. The worker's mobility choice is similar to the self-selection model in Roy (1951). Besides the pecuniary moving cost including transport, rent, etc., we also assume that when a worker moves to another country, he/she takes one more period to learn and adapt to the new environment, which we also consider as a form of mobility cost. The financial friction part is also search and matching which is similar to Wasmer and

[1] See, for example, Arpaia et al. (2015) and Curdia and Nechio (2017).

Weil (2004). Bankers have the same mobility choice as workers. We assume that entrepreneurs are local and do not move across countries. We first simulate the model with symmetric calibration, and we find that reducing labor mobility cost helps releasing labor market tightness, thanks to less staying unemployed workers. The effect of capital mobility cost is very small compared to the effects on labor mobility cost. We then calibrate the model with asymmetric choices according to core and periphery EMU member countries. Our results show that asymmetric TFP shocks alone have very limited impact on the labor market, but the association with reductions in labor mobility costs does have significant impact to reduce unemployment rates and improve employment rates.

Related literatures include Mundell (1961) who emphasized the role of factor mobility and price flexibility in the Optimum Currency Union. Recently, Farhi and Werning (2014) study the role of labor mobility within a currency union suffering from nominal rigidities. By combining trade openness and labor mobility, Farhi and Werning (2014) study the impact of labor mobility in the scenarios with external and internal shocks, respectively. Please refer to Dellas and Tavlas (2009) for more detailed literature reviews on the OCA theory.

Recently, Huart and Tchakpalla (2018) measure the mobility in EMU by the stock of foreign population by nationality. Their study shows that the mobility in EMU is relatively low and this responds to the divergent unemployment rate across member countries. Eichengreen et al. (2014) analyze the Eurozone sovereign debt crisis in the aftermath of 2008, and find that in contrast of emphasizing on labor mobility, they suggest putting more efforts on participation rates and bank mergers and acquisitions. Kahanec (2013) and Kahanec and Guzi (2017) find that labor mobility especially the enlarged Euro Area with Central East Europe helps to alleviate asymmetric unemployment rates across member countries, and immigrants play an important role during times of asymmetric economic shocks across member countries. Bertola (2016) finds that the capital outflows across member countries should be associated with labor market deregulation.

Compared to the literatures, our work, on one hand, with a different approach, confirms the analysis as in Kahanec (2013) and Kahanec and Guzi (2017) that labor mobility reduces unemployment rate across member countries in a monetary union. In contrast to Eichengreen et al. (2014) who mention that mergers and acquisitions should be beneficial to the convergence of EMU, our results show that reduced capital mobility might increase unemployment rates across member countries. A good remedy is to improve efficiency and time cost that make inflowed capital as soon as possible to local entrepreneurs. Consistent with Huart and Tchakpalla (2018), our finding finds that the current divergent economic performances acromm EMU member countries might be caused by local labor market barriers. On the other hand, our contribution relative to the literatures, is that we simulate the effects of labor and capital mobility costs explicitly in a general equilibrium model calibrated to the Euro Area, while in the above literatures the framework are either purely empirical or theoretical.

Our paper is organised as following: in Sect. 2.2, we represent the theoretical model; in Sect. ch2:Sec3, we calibrate the two-country model under the symmetric case and simulate the scenario with deterministic and stochastic shocks on productivity and factor mobility costs; in Sect. ch2:Sec4, we do the same experiment in the asymmetric case by calibrating the model to the European Monetary Union, and mimic the scenario after 2008 financial crisis; Sect. ch2:Sec5 concludes our results.

2.2 Model

The model consists of two countries, and in each country there are three types of agents: entrepreneurs, workers and bankers. We assume that entrepreneurs' activities are local. Workers work for entrepreneurs and can choose which country to stay (labor mobility). Bankers have capital and can choose which country to invest in (financial integration).

2.2.1 *Consumption*

Consumers optimize their utility basing on their consumption C_t, which is the composite (CES) of consumption in goods produced in the two countries:

$$C_t = [\omega_s^{\frac{1}{\epsilon}} c_{i,t}^{\frac{\epsilon-1}{\epsilon}} + \omega_m^{\frac{1}{\epsilon}} c_{j,t}^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}}, \tag{2.1}$$

with $c_{i,t}$ and $c_{j,t}$ the consumption of goods produced in country i and country j, and ω_i, ω_j the relative weights of goods produced in the two countries. ϵ is the elasticity of substitution between domestic and foreign goods.

By minimizing the cost, we have:

$$\left(\frac{\omega_i}{\omega_j}\right)^{\frac{1}{\epsilon}} \left(\frac{c_{i,t}}{c_{j,t}}\right)^{-\frac{1}{\epsilon}} = p_{i,t}, \tag{2.2}$$

where $p_{i,t}$ is the relative price of goods produced in country i.

2.2.2 *Workers*

As in Pilossoph (2014), there are three distinct states of the workers: employment, stay unemployment, and move unemployment. Let W_i, S_i, and $S_j - \eta$ represent their respective values, where S_j is the value of stay unemployment in country j and η is the moving cost. If δ_i represents the exogenous separation probability in country i and w_i represents the worker's wage, the value of a job to an employed worker l in country i (net of idiosyncratic taste shocks) is given by:

$$W_{i,t} = w_{i,t} + (1-\delta_i)\beta E_t(W_{i,t+1} + \epsilon_{i,l,t+1}) \\ +\delta_i \beta E_t[\max(S_{i,t+1} + \epsilon_{i,l,t+1}, S_{j,t+1} - \eta + \epsilon_{j,l,t+1})], \quad (2.3)$$

where $\epsilon_{i,l,t+1}$ represents the worker's taste draw for next period in country i. The value of being a stay unemployed worker in country i for worker l (net of idiosyncratic taste shocks) is given by:

$$S_{i,t} = b_i + f_i(\theta_{i,t})\beta E_t(W_{i,t+1} + \epsilon_{i,l,t+1}) \\ +(1 - f_i(\theta_{i,t}))\beta E_t[\max(S_{i,t+1} + \epsilon_{i,l,t+1}, S_{j,t+1} - \eta + \epsilon_{j,l,t+1})], \quad (2.4)$$

where b_i is the value of leisure for the unemployed (or unemployment benefit), and $f_i(\theta_{i,t})$ is the probability for a job seeker in country i to find a job, which will be defined explicitly in the next part.

2.2.3 Labor Market

Each country has their own labor market, therefore country-specific unemployment rates. For country i, the labor force $l_{i,t}$ consists of three groups: the employed $e_{i,t}$, unemployed who stay in the same country $s_{i,t}$, and unemployed who decide to leave to the other country $m_{ij,t}$:

$$l_{i,t} = e_{i,t} + s_{i,t} + m_{ij,t}. \quad (2.5)$$

We define the matching function in country i's labor market as:

$$\Gamma_i(v_{i,t}, s_{i,t}) = \sigma_i v_{i,t}^g s_{i,t}^{1-g}. \quad (2.6)$$

where $v_{i,t}$ is the number of job vacancies, and $s_{i,t}$ is the number of stay unemployed people looking for jobs. We define the country's labor market tightness as $\theta_{i,t} = \frac{v_{i,t}}{s_{i,t}}$. We define $q_i(\theta_{i,t}) = \frac{\Gamma_i(v_{i,t}, s_{i,t})}{v_{i,t}}$ the probability for a job vacancy to be filled by the proper employee, and $f_i(\theta_{i,t}) = \frac{\Gamma_i(v_{i,t}, s_{i,t})}{s_{i,t}}$ the probability for a job seeker to find a job. g is a parameter between 0 and 1.

The stock of employed workers in country i in period $t+1$ is given by:

$$e_{i,t+1} = e_{i,t}(1-\delta_i) + s_{i,t} f_i(\theta_{i,t}), \quad (2.7)$$

where δ_i is the probability that the working contract ends for the worker, if it happens, the worker's situation shifts from employee to unemployment/job seeker.

2.2.4 Bankers

There are three distinct states of the bankers: maintaining contract with an entrepreneur, contract finished and keep investing in the same country, and contract finished and looking for investment in the other country. Let W_i^b, S_i^b, and $S_j^b - \eta^b$ represent their respective values, where η^b is the capital mobility cost. If δ_i^b represents the exogenous separation probability in country i, for banker l, the value of maintaining contract with an entrepreneur in country i (net of idiosyncratic taste shocks) is given by:

$$\begin{aligned} W_{i,t}^b &= (1-\delta_i)\rho_{i,t} - \delta_i c_{1i}^e + (1-\delta_i^b)\beta E_t(W_{i,t+1}^b + \epsilon_{i,l,t+1}) \\ &\quad + \delta_i^b \beta E_t[\max(S_{i,t+1}^b + \epsilon_{i,l,t+1}, S_{j,t+1}^b - \eta^b + \epsilon_{j,l,t+1})], \end{aligned} \tag{2.8}$$

where $\epsilon_{i,l,t+1}$ represents the banker's taste draw for next period in country i. With probability $1 - \delta_i^b$, the banker enjoys repayment from the entrepreneur; with probability δ_i, the banker finances the entrepreneur to recruit workers with recruitment cost c_{1i}^e, this is in the case in which the work contract between entrepreneur and the previous worker ends. The value of looking for investment in the same country i for banker l (net of idiosyncratic taste shocks) is given by:

$$\begin{aligned} S_{i,t}^b &= -c_i^b + q_i(\phi_{i,t})\beta E_t(W_{i,t+1}^b + \epsilon_{i,l,t+1}) \\ &\quad + (1 - q_i(\phi_{i,t}))\beta E_t[\max(S_{i,t+1}^b + \epsilon_{i,l,t+1}, S_{j,t+1}^b - \eta^b + \epsilon_{j,l,t+1})], \end{aligned} \tag{2.9}$$

where c_i^b is the value of search effort for the banker. $q_i(\phi_{i,t})$ is the probability that the banker find a new investment opportunity, which will be explained in the next part.

2.2.5 Credit Market

The credit markets within each country are subject to standard search frictions. For each country i, let $b_{i,t}$ denote the total size of bankers. The investment will consist of current contracted bankers $w_{i,t}^b$ and stayers/movers. Stayers $s_{i,t}^b$ will be bankers searching for investment in country i. Movers $m_{ij,t}^b$ will be bankers searching for investment in country j. Thus, the total bankers' size in country i will be given by:

$$b_{i,t} = w_{i,t}^b + s_{i,t}^b + m_{ij,t}^b. \tag{2.10}$$

The probability that stayers in country i meet jobs in country i is determined by the country-specific matching function $\Gamma_i^b(v_{i,t}^b, s_{i,t}^b)$, where $v_{i,t}^b$ represents the total number of investment vacancies in country i. $\Gamma_i^b(v_{i,t}^b, s_{i,t}^b)$ is constant returns to scale and has the particular form:

$$\Gamma_i^b(v_{i,t}^b, s_{i,t}^b) = \sigma_i^b(v_{i,t}^b)^g(s_{i,t}^b)^{1-g}. \tag{2.11}$$

where σ_i^b is the country-specific match efficiency and g is the vacancy share of the matching function. Letting $\phi_{i,t} = \frac{v_{i,t}^b}{s_{i,t}^b}$ denote the country's credit market tightness, the probability that bank credit in country i turn into investment is given by $q_i(\phi_{i,t}) = \frac{\Gamma_i^b(v_{i,t}^b, s_{i,t}^b)}{v_{i,t}^b}$. The probability that credit seekers find bank funding in country i is given by $f_i(\phi_{i,t}) = \frac{\Gamma_i^b(v_{i,t}^b, s_{i,t}^b)}{s_{i,t}^b}$. Therefore, the transition probabilities satisfy the standard relationship $f_i(\phi_{i,t}) = q_i(\phi_{i,t})\phi_{i,t}$.

The stock of contracted bankers in country i in period $t+1$ is given by:

$$e_{i,t+1}^b = e_{i,t}^b(1-\delta_i^b) + s_{i,t}^b f_i(\phi_{i,t}), \tag{2.12}$$

with δ_i^b the probability that the contract between banker and entrepreneur ends.

2.2.6 Entrepreneurs

Turning to the entrepreneurs, each entrepreneur has three states: maintaining contract with the banker and the worker, maintaining contract with the banker but breaking up contract with the worker, and terminating the banking contract. Let W_{1i}^e, W_{2i}^e, S_i^e represent their respective values. The value of maintaining contract with a banker and a worker in country i (net of idiosyncratic taste shocks) is given by:

$$W_{1i,t}^e = p_i y_{i,t} - w_{i,t} - \rho_{i,t} + (1-\delta_i^b)\beta E_t[(1-\delta_i)W_{1i,t+1}^e + \delta_i W_{2i,t+1}^e] + \delta_i^b \beta E_t(S_{i,t+1}^e), \tag{2.13}$$

where p_i is the price of final goods, $w_{i,t}$ is the wage for employee, and $\rho_{i,t}$ is the cost of loans borrowed from bankers.

The value of maintaining contract with a banker and breaking up with the worker in country i (net of idiosyncratic taste shocks) is given by:

$$W_{2i,t}^e = (1-\delta_i^b)\beta E_t[q_i(\theta_{i,t+1})W_{1i,t+1}^e + (1-q_i(\theta_{i,t+1}))W_{2i,t+1}^e] + \delta_i^b \beta E_t(S_{i,t+1}^e), \tag{2.14}$$

The value of looking for investment in the same country i for entrepreneur l (net of idiosyncratic taste shocks) is given by:

$$S_{i,t}^e = -c_{2i}^e + f_i(\phi_{i,t})\beta E_t(W_{2i,t+1}^e) + (1-f_i(\phi_{i,t}))\beta E_t(S_{i,t+1}^e), \tag{2.15}$$

where c^e_{2i} represent the searching cost for the entrepreneurs.

Production follows the form:

$$y_{i,t} = a_{i,t}. \tag{2.16}$$

The wage $w_{i,t}$ is determined by the bargaining between the entrepreneur and the worker:

$$bargain(W_{i,t} - S_{i,t}) = (1 - bargain)(W^e_{1i,t} - W^e_{2i,t}), \tag{2.17}$$

where $bargain$ is a parameter between 0 and 1 which represents the bargaining power of entrepreneurs.

The financing cost $\rho_{i,t}$ is similarly determined by the bargaining between the banker and the entrepreneur:

$$(1 - bargain)(W^e_{2i,t} - S^e_{i,t}) = bargain(W^b_{i,t} - S^b_{i,t}). \tag{2.18}$$

2.3 Calibration

In the calibration part, we first consider a symmetric case, in which two countries have identical characters. This calibration is qualitative rather than quantitative. A more detailed calibration to the Euro Area can be found in Sect. 2.5.1, in which we effectuate simulation for the asymmetric case by assuming the two economies have different economic fundamentals. We set quarterly discount rate β to 0.99, corresponding to an annual interest rate around 4%. The breaking up rate δ is set to 0.03, consistent to Abowd and Zellner (1985)'s finding and a broad literature.[2] The unemployment benefit b is about 40% of income as in Shimer (2005). We assume the vacancy filling rate $q(\theta) = 1.2$ corresponding to a monthly vacancy rate at 40%. The credit matching efficiency $f(\phi) = 0.5$, equivalent to a monthly matching efficiency at 1/6. Separation rates $\delta = \delta_b = 0.03$. Unemployment benefit is set to 40% of wage. Consistent to literature Morten and Oliveira (2016), migration cost is about 0.8 to 1.2 times of annual wage, we set $\eta = \eta_b = 4 * w$ in benchmark setting. For the matching function, we choose the value of $g = 0.5$, and $\sigma = 0.5$ for the labor market and $\sigma_b = 0.525$ for the credit market, comparable to Shimer (2005) and Petrosky-Nadeau and Wasmer (2013). For the Discrete Choice function, we set the value of $\rho = 0.3$ as in Pilossoph (2014). The elasticity of substitution ϵ is set to 1.20, implying that goods produced in the two countries are substitutable rather than complementary. The recruitment cost c^e_{1i} is set to 3.6% of annual wage. We assume symmetric searching cost in the credit market, i.e. $c^b_i = c^e_{2i}$ (Table 2.1).

[2] See, for example, Stéphane et al. (2017) and Shimer (2005).

Table 2.1 Parameterization

Parameter	
β	0.99
δ	0.03
σ	0.5
σ_b	0.525
g	0.5
ρ	0.3
ϵ	1.20
η	0.26
η_b	0.26
$bargain$	0.5
b	0.026
c_i^b	1.56
c_{1i}^e	0.009
c_{2i}^e	1.56

2.4 Simulation

In the simulation part, we first simulate the case with transitory shocks on labor or capital mobility costs. This can be interpreted as short term policies that improves labor or capital mobility across member countries in a monetary union. In the second step, we simulate the case with long term permanent shocks on factor mobility costs, which can be interpreted as a long term decision of the government that changes steady state of the economy.

2.4.1 Transitory Shocks on Mobility Costs

We start by the stochastic simulation, with a -30% negative shock on capital mobility cost η_b. Figure 2.2 (as well as Figs. 2.8, 2.9, 2.10, 2.11, 2.12, and 2.13 in appendix) show us the IRFs of key variables to -30% negative shock on capital mobility cost. In this scenario, as it is less costly to move, more bankers move from one country to the other. Number of bankers who stay in a country falls in both economies. As there are less staying bankers looking for investment opportunities, less entrepreneurs find financial support to start the project. As a result, employment in both countries fall, and there are more stay unemployed people (s_i/s_j) in each economy. In general, the unemployment rates rise, implying that the effect on stay unemployment becomes dominant. Wages in both economies fall, due to labor market tightening.

Next, we simulate the scenario in which we give a negative shock on labor mobility cost. Figure 2.3 (as well as Figs. 2.15, 2.16, 2.17, 2.18, 2.19, and 2.20 in appendix) show us the IRFs of key variables to the mobility cost shock. In this scenario, as it is less costly to move, more workers move from one country to the other. Stay unemployment falls in both economies. As there are less staying workers

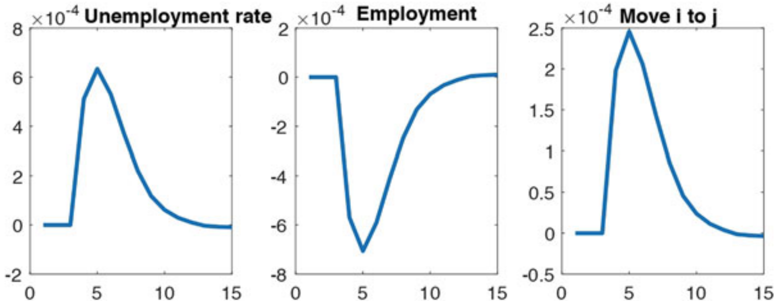

Fig. 2.2 −30% transitory shock on capital mobility cost, symmetric case, unemployment rate = number of unemployed/active population AR(1) process, stochastic simulation

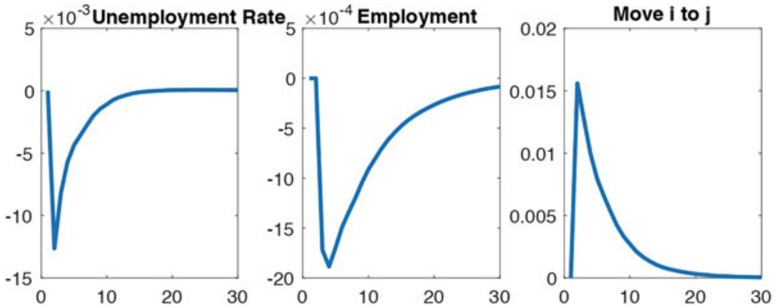

Fig. 2.3 −30% transitory shock on labor mobility cost, symmetric case, unemployment rate = number of unemployed/active population AR(1) process, stochastic simulation

looking for jobs, employment in both countries fall. In general, the unemployment rates fall, implying that the effect on stay unemployment becomes dominant. Wages in both economies increase, thanks to released labor market tightness.

To sum up, reducing labor mobility cost may alleviate unemployment rate, but not necessarily stimulate production due to the decrease in employed workers. Reducing capital mobility cost motivate bankers to move between countries, implying less staying bankers looking for investment, thus reducing funding opportunities for entrepreneurs. This may reduce job opportunities and increase unemployment rate. Labor mobility reduces unemployment rates, and capital mobility in contrast increases unemployment rates in both economies. Interestingly, factor mobility might not stimulate production due to the fall in employment.

2.4.2 Permanent Shocks on Mobility Costs

In this part, we simulate the scenario in which there is a structural reform on capital and labor mobility costs, in other words, we try to make permanent shocks on the factor mobility costs.

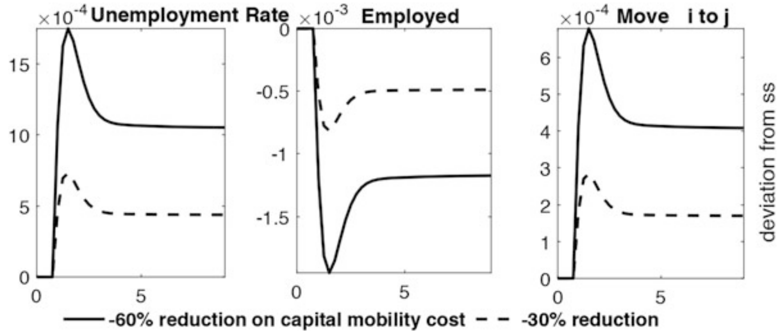

Fig. 2.4 -30% permanent shock on capital mobility cost, symmetric case, unemployment rate = number of unemployed/active population deterministic simulation

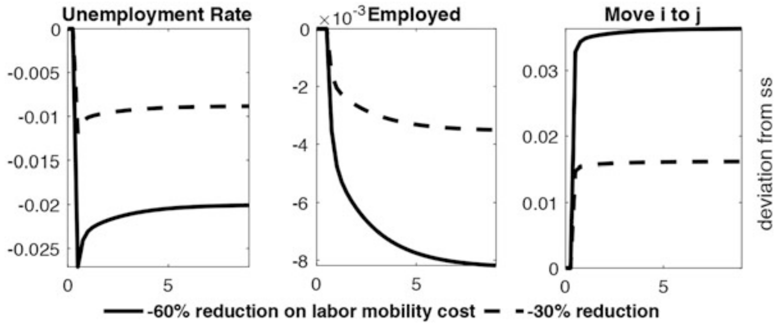

Fig. 2.5 -30% permanent shock on labor mobility cost, symmetric case, unemployment rate = number of unemployed/active population deterministic simulation

We make a -30% permanent shock on capital mobility cost η_b, the probability for bankers to stay π_{ii}^b decreases, which reduces potential funding in the domestic country. For this reason, it is more difficult for entrepreneurs to find financial support, thus create less jobs. As a result, unemployment rate rises (Fig. 2.4).

When we make a -30% permanent shock on labor mobility cost η, the probability for unemployed to stay π_{ii} declines, which reduces the flow of unemployed people in domestic country. For this reason, unemployment rate falls (Fig. 2.5).

2.5 Case of European Monetary Union

2.5.1 Calibration

We then calibrate our model to the European Monetary Union (EMU). This exercise aims to simulate the explicit effects of labor or capital mobility costs across EMU

Table 2.2 Parameterization for core and periphery countries

	Core	Periphery
β	0.99	0.99
δ	0.03	0.03
b	0.026	0.019
c_b	1.705	1.379
c_{e1}	0.010	0.007
c_{e2}	1.705	1.379
η	0.264	0.194
η_b	0.264	0.194
σ	0.5	0.5
g	0.5	0.5
ρ	0.3	0.3
ϵ	1.20	1.20

member countries, especially in the aftermath of 2008 financial crisis. Based on different economic performances, we divide the EMU member countries into two groups: core and periphery. The core represents the countries of Germany, France, Austria, Belgium, Finland, Luxembourg, Netherlands and Finland. The periphery country represents countries of Spain, Portugal, Ireland, Greece and Italy. The unemployment benefit b is about 40% of income as in Shimer (2005). For the core country, we set the vacancy filling rate $q(\theta) = 1.2$ corresponding to a monthly vacancy rate at 40%, and a monthly job finding rate around 20%.[3] The credit matching efficiency $f(\phi) = 0.5$, equivalent to a monthly matching efficiency at $1/6$ as in Brzustowski et al. (2016). From data of IMF (1990–2007), we set the relative labor force as 1:1.44 for the periphery and the core; and the relative productivity is set at 1:1.08. Relative price in the two countries is 1:1.14. Unemployment benefit is set to 40% of wage. The steady state employment rate is around 60% as in the data. The definition of unemployment in our model is defined as the proportion of stay-unemployed workers, which is about 30%. This number is larger than the data (5–10%), because in the real world, we neglect the deactive population. We compute the vacancy filling rate and credit matching efficiency in periphery country so that the inflow and outflow in the labor and credit markets are fulfilled (Table 2.2).

2.5.2 *Simulation: Scenario After 2008 Financial Crisis*

Although the main cause of 2008 financial crisis is not due to productivity shock, in this section, we try to simulate the GDP growth of EMU in the aftermath of 2008 financial crisis, and to see the associative effects with factor mobility costs. We first give a series of quarterly TFP shocks from 2008Q1 to 2017Q1. We set the shock

[3] Murtin and Robin (2016).

sizes from the OECD dataset. We compare this baseline scenario with scenarios in which we impose reductions on labor mobility cost by 30% and 60%, respectively. Figure 2.6 shows us the simulation results. We have a few remarks: first, without shocks on labor mobility cost, the TFP shocks along have very limited impact on employment (less than ±0.5%); second, when associating with policies that reduce labor mobility cost, the impact of crisis on labor market is significantly mitigated. In our simulation, with 60% reduction on labor mobility cost, the unemployment rate falls by 3pp in the periphery, and 2pp in the core. From another point of view, the divergence across member countries which we see in data (Fig. 2.1) might not be simply due to asymmetric TFP shocks, but suspiciously attributed to the association with rises/increases in labor mobility costs, such as unfavorable migration policies, etc.

We then simulate the case with different capital mobility costs: the capital mobility cost is reduced by 30% and 60%, respectively. Figure 2.7 shows us the results. We remark that employment indicators in our model is much less sensitive to capital mobility cost compared to labor mobility cost. Unemployment fluctuations in the two countries co-move with the number of employed people, meaning that the rise/fall of employed workers affect the number of stay-unemployed people and

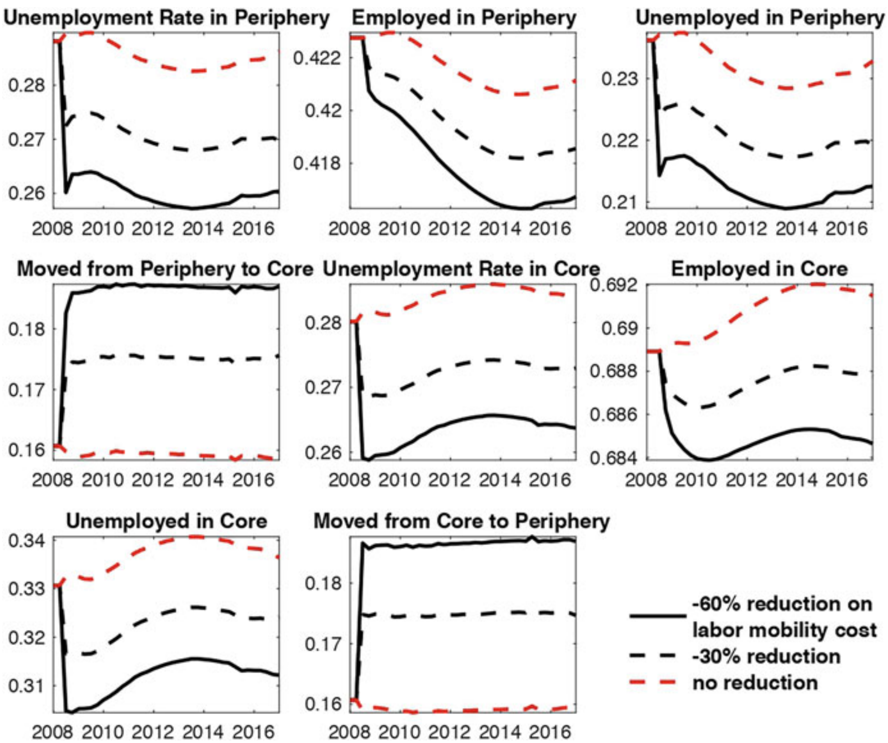

Fig. 2.6 Simulation of the crisis after 2008, with permanent shocks on labor mobility cost

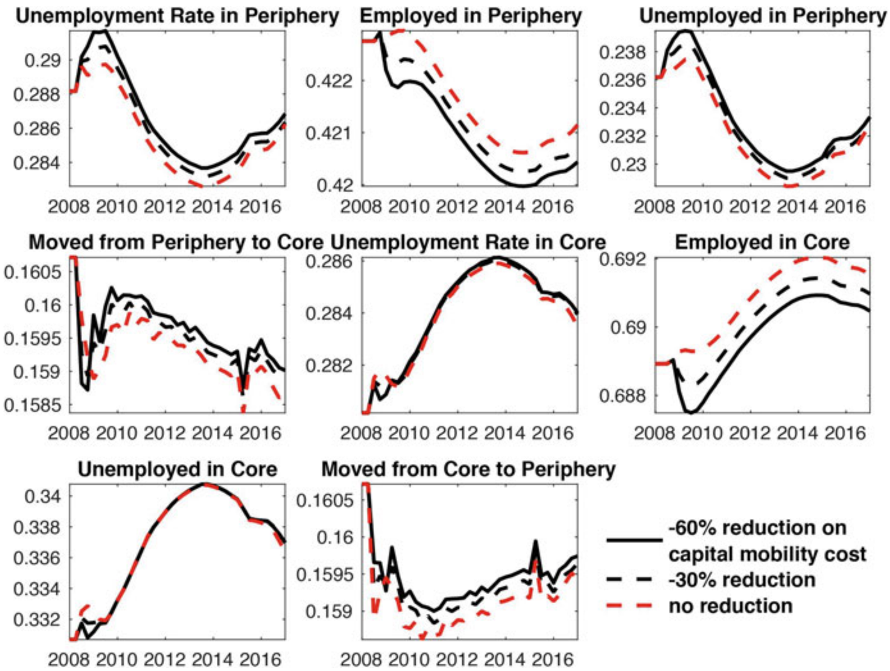

Fig. 2.7 Simulation of the crisis after 2008, with permanent shocks on capital mobility cost

thus influence the overall unemployment rate. In general, this effect is very small as stated in the previous paragraph.

2.6 Conclusion

Since the 2008 financial crisis, the world economy has been facing unceasing challenges. A monetary or trade union in some aspects can help stabilizing unexpected shocks. Of course, an over interacted and unsupervised financial market is dangerous which may amplify the effects from external or internal shocks, such as the 2008 subprime or the sovereign debt crisis. On the other hand, a flexible and mobile labor market helps alleviate asymmetric shocks among member countries, and let countries with more demand absorb labor forces from countries with less demand.

By establishing a two-country model, we study the potential interactions between financial integration and labor mobility. Our results show that while labor mobility reduces unemployment rates, capital mobility in contrast increases unemployment rates in both economies. Compared to labor mobility cost, the effect of capital mobility cost on labor market is secondary. Interestingly, factor mobility might not stimulate production due to the fall in employment. We also calibrate the model to the European Monetary Union and simulate the scenario in the aftermath of 2008 financial crisis. Our counterfactual experiments show that the divergence across member countries might not simply due to asymmetric TFP shocks, but rather their association with the increase of labor mobility costs.

The policy implications are twofold. First, it is important for EMU member countries to encourage labor mobility, because according to our study, it is the main cure to reduce unemployment rates in member countries. The main barrier for labor mobility in EMU today is language. For example, when a Spanish job seeker moves to France or Germany, this person has to learn the local language first and it takes time. Especially during the burst of real estate bubbles around 2008, low skilled workers in the construction sector have some difficulties to move to another place as few of them are polyglot. Therefore, it is crucial that local governments provide active language trainings to immigrants (who actively seek for a job) as well as temporary living subsidies so that the mover face less mobility cost and he or she will be more willing to move to another country and look for new job opportunities.

Second, to make capital mobility beneficial rather than disturbing for the labor market of a monetary union such as EMU, policy makers should make efforts to improve the efficiency that makes the capital inflow available for local entrepreneurs as soon as possible. However, it may also bring risks if the cross-border interbank credit market lacks of regulation and supervision. Therefore, from the capital side, we suggest that each member country develops its own local credit market as much as possible.

Appendix 1: Discrete Choice Theory

Workers and Bankers

The worker's problem in unemployment is to choose whether to remain stay unemployed or to become move unemployed and transition to the other country. The probability that a worker facing the reallocation choice to become move unemployed is given by:

$$\begin{aligned}\pi_{ij,t+1} &= Pr(S_{i,t+1} + \epsilon_{i,l,t+1} < S_{j,t+1} - \eta + \epsilon_{j,l,t+1}) \\ &= \frac{1}{1 + exp(\frac{S_{i,t+1} - S_{j,t+1} + \eta}{\rho})}\end{aligned} \tag{2.19}$$

Furthermore, we can write the value functions in country i as a function of these move probabilities:

$$\begin{aligned}W_{i,t} &= w_{i,t} + (1-\delta_i)\beta E_t(W_{i,t+1}) + \delta_i \beta \pi_{ii,t+1} E_t(S_{i,t+1}) \\ &\quad + \delta_i \beta \pi_{ij,t+1} E_t(S_{j,t+1} - \eta),\end{aligned} \tag{2.20}$$

$$S_{i,t} = b_i + f_i(\theta_{i,t})\beta E_t(W_{i,t+1}) + (1 - f_i(\theta_{i,t}))\beta\pi_{ii,t+1}E_t(S_{i,t+1})$$
$$+(1 - f_i(\theta_{i,t}))\beta\pi_{ij,t+1}E_t(S_{j,t+1} - \eta),$$

Similarly, for bankers, we can rewrite the banker's value functions in country i as:

$$W^b_{i,t} = \rho_{i,t} - \gamma_{i,t} + (1 - \delta^b_i)\beta E_t(W^b_{i,t+1}) + \delta^b_i\beta\pi^b_{ii,t+1}E_t(S^b_{i,t+1}) \tag{2.21}$$
$$+\delta^b_i\beta\pi^b_{ij,t+1}E_t(S^b_{j,t+1} - \eta^b),$$
$$S^b_{i,t} = -c^b_i + q_i(\phi_{i,t})\beta E_t(W^b_{i,t+1} + \epsilon_{i,l,t+1})$$
$$+(1 - q_i(\phi_{i,t}))\beta\pi^b_{ii,t+1}E_t(S^b_{i,t+1})$$
$$+ (1 - f_i(\phi_{i,t}))\beta\pi^b_{ij,t+1}E_t(S^b_{j,t+1} - \eta^b).$$

Inflow and Outflow

For workers, their inflow & outflow dynamics are:

$$e_{i,t+1} = (1 - \delta_i)e_{i,t} + f_i(\theta_{i,t})s_{i,t}, \tag{2.22}$$
$$s_{i,t+1} = \pi_{ii,t}[\delta_i e_{i,t} + (1 - f_i(\theta_{i,t}))s_{i,t} + m_{ji,t}], \tag{2.23}$$
$$m_{ji,t+1} = \pi_{ji,t}[\delta_j e_{j,t} + (1 - f_j(\theta_{j,t}))s_{j,t} + m_{ij,t}]. \tag{2.24}$$

For bankers, their inflow & outflow dynamics are:

$$e^b_{i,t+1} = (1 - \delta^b_i)e^b_{i,t} + q_i(\phi_{i,t})s^b_{i,t}, \tag{2.25}$$
$$s^b_{i,t+1} = \pi^b_{ii,t}[\delta^b_i e^b_{i,t} + (1 - q_i(\phi_{i,t}))s^b_{i,t} + m^b_{ji,t}], \tag{2.26}$$
$$m^b_{ji,t+1} = \pi^b_{ji,t}[\delta^b_j e^b_{j,t} + (1 - q_j(\phi_{j,t}))s^b_{j,t} + m^b_{ij,t}] \tag{2.27}$$

For entrepreneurs, their dynamics are:

$$w^e_{1i,t+1} = (1 - \delta^b_i)[q_i(\theta_{i,t})w^e_{2i,t} + (1 - \delta_i)w^e_{1i,t}], \tag{2.28}$$
$$w^e_{2i,t+1} = (1 - \delta^b_i)[(1 - q_i(\theta_{i,t}))w^e_{2i,t} + \delta^b_i w^e_{1i,t}] + f_i(\phi_{i,t})s^e_{i,t}, \tag{2.29}$$
$$s^e_{i,t+1} = (1 - f_i(\phi_{i,t}))s^e_{i,t} + \delta^b_i(w^e_{1i,t} + w^e_{2i,t}). \tag{2.30}$$

Appendix 2: IRFs

Stochastic Shock on Capital Mobility Cost η_b

See Figs. 2.8, 2.9, 2.10, 2.11, 2.12, 2.13, and 2.14.

Stochastic Shock on Labor Mobility Cost η

See Figs. 2.15, 2.16, 2.17, 2.18, 2.19, and 2.20.

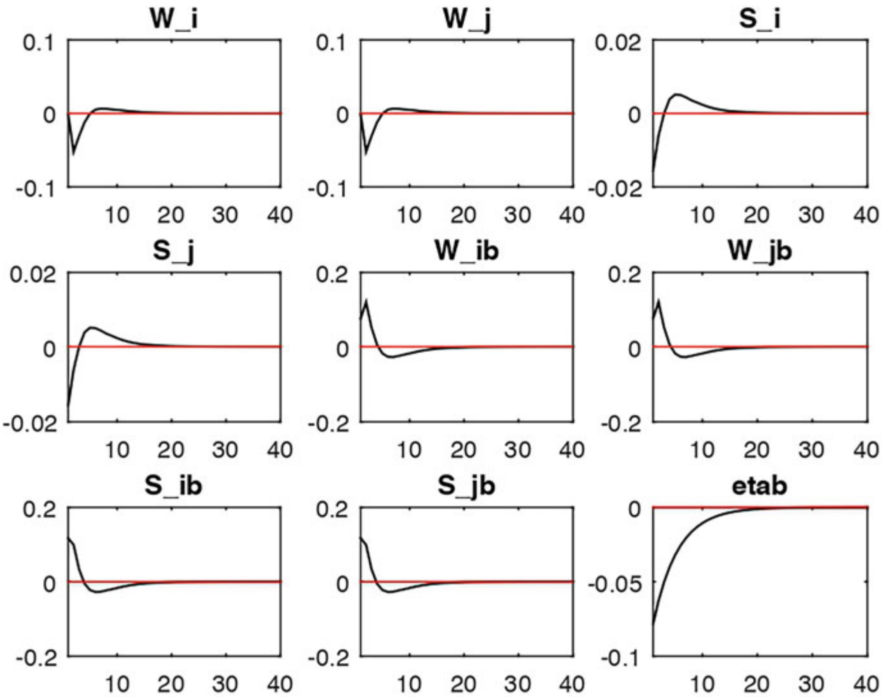

Fig. 2.8 IRFs of −30% shock on η_b, the mobility cost for bankers

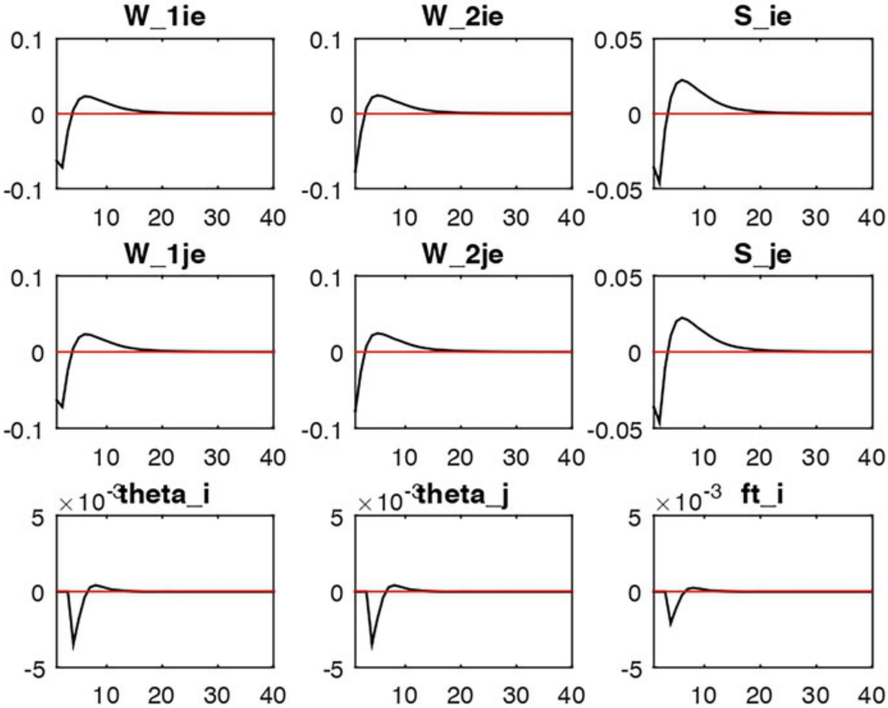

Fig. 2.9 IRFs of −30% shock on η_b, the mobility cost for bankers

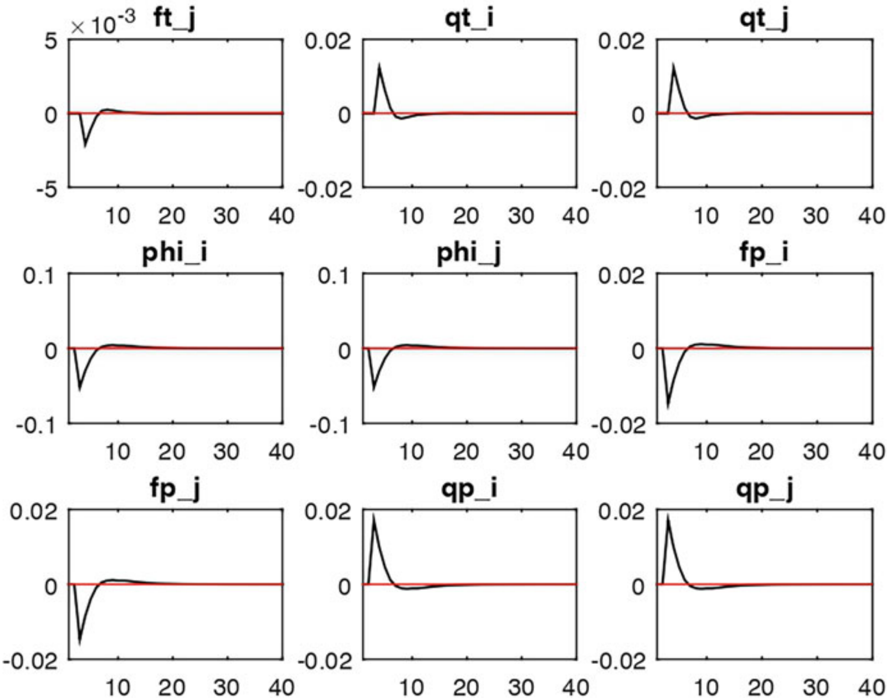

Fig. 2.10 IRFs of -30% shock on η_b, the mobility cost for bankers

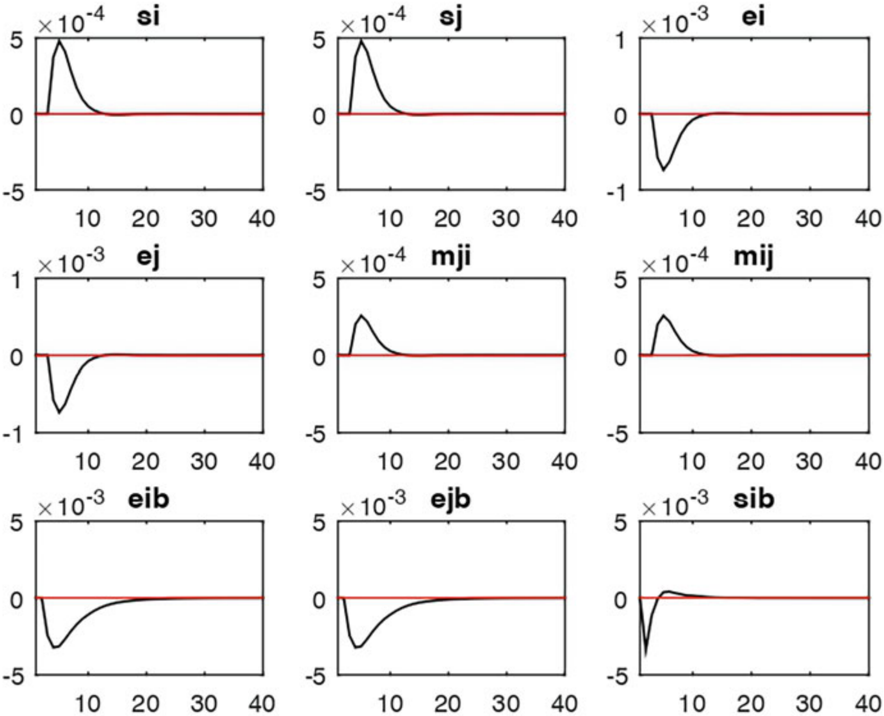

Fig. 2.11 IRFs of -30% shock on η_b, the mobility cost for bankers

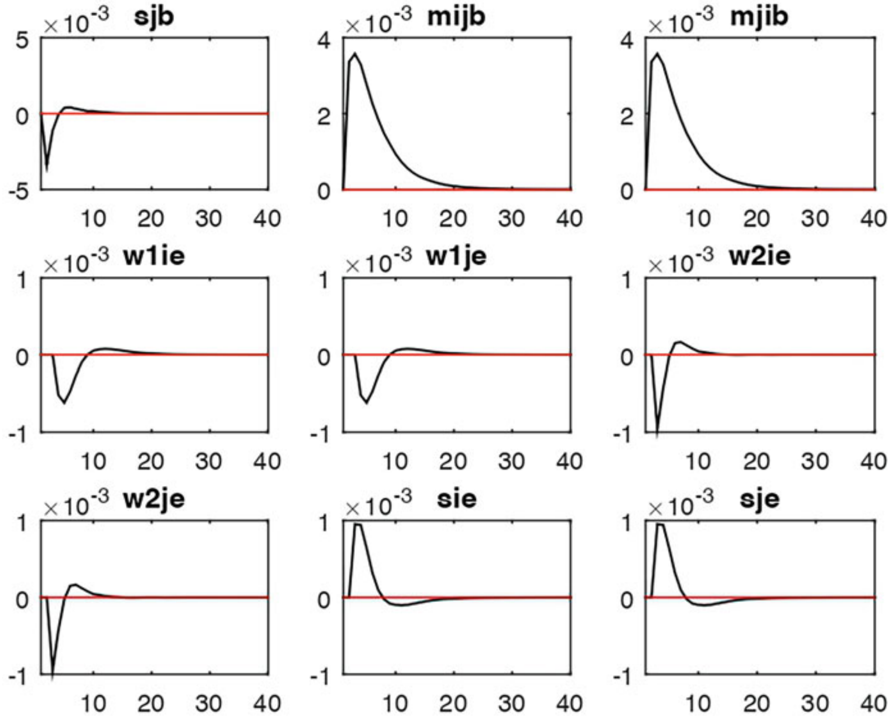

Fig. 2.12 IRFs of -30% shock on η_b, the mobility cost for bankers

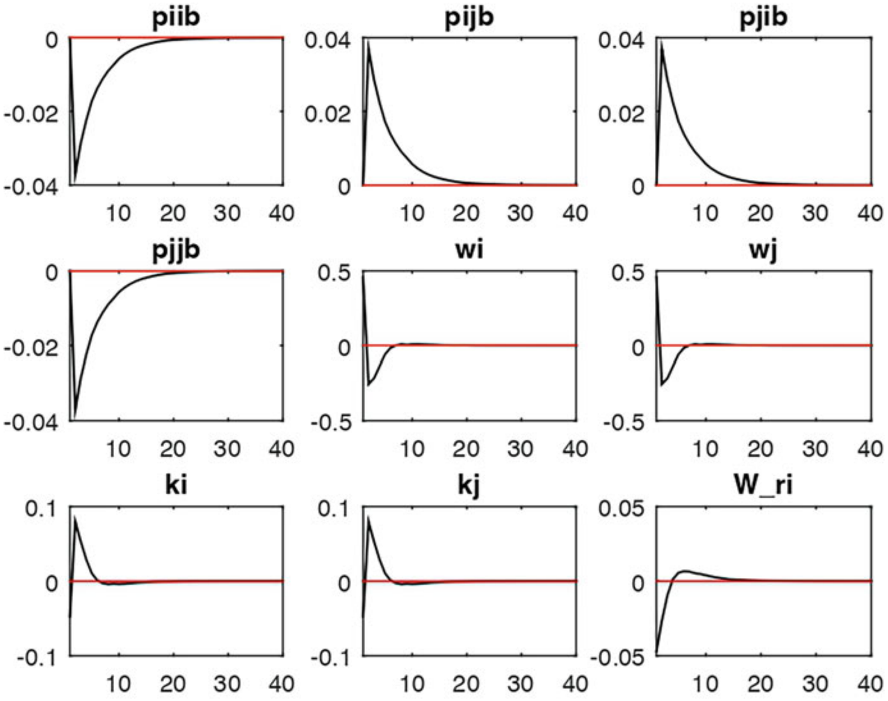

Fig. 2.13 IRFs of -30% shock on η_b, the mobility cost for bankers

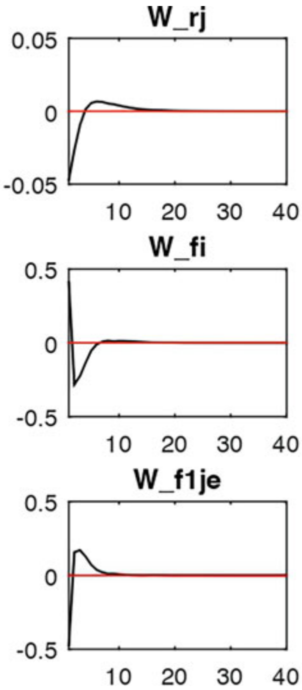

Fig. 2.14 IRFs of -30% shock on η_b, the mobility cost for bankers

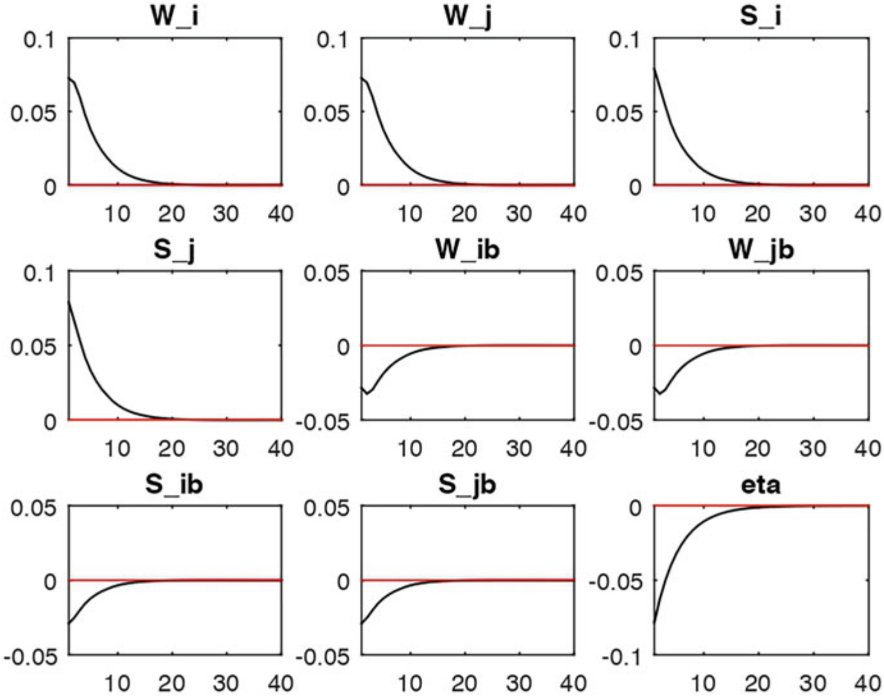

Fig. 2.15 IRFs of -30% shock on η, the labor mobility cost

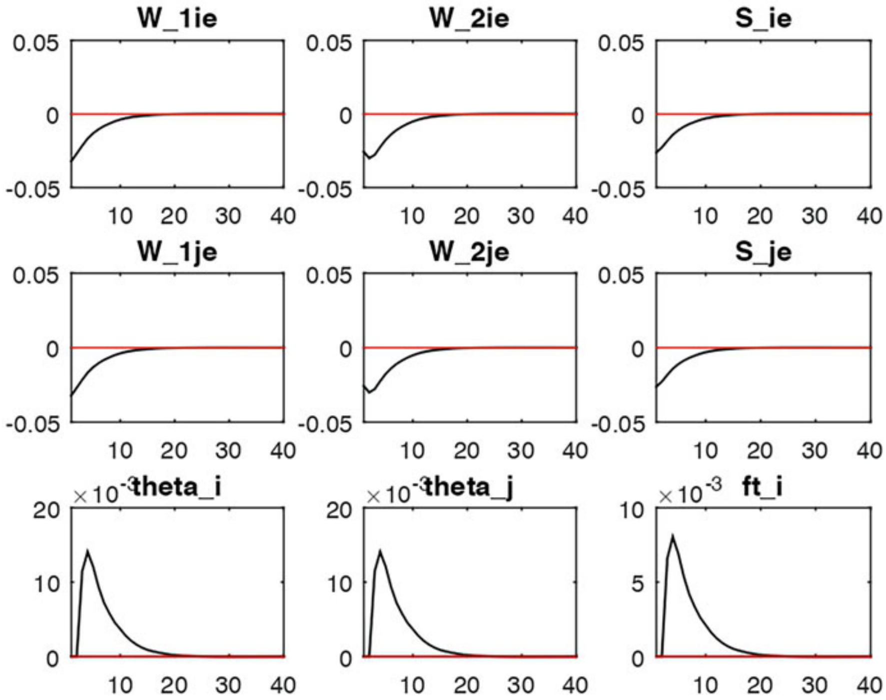

Fig. 2.16 IRFs of −30% shock on η, the labor mobility cost

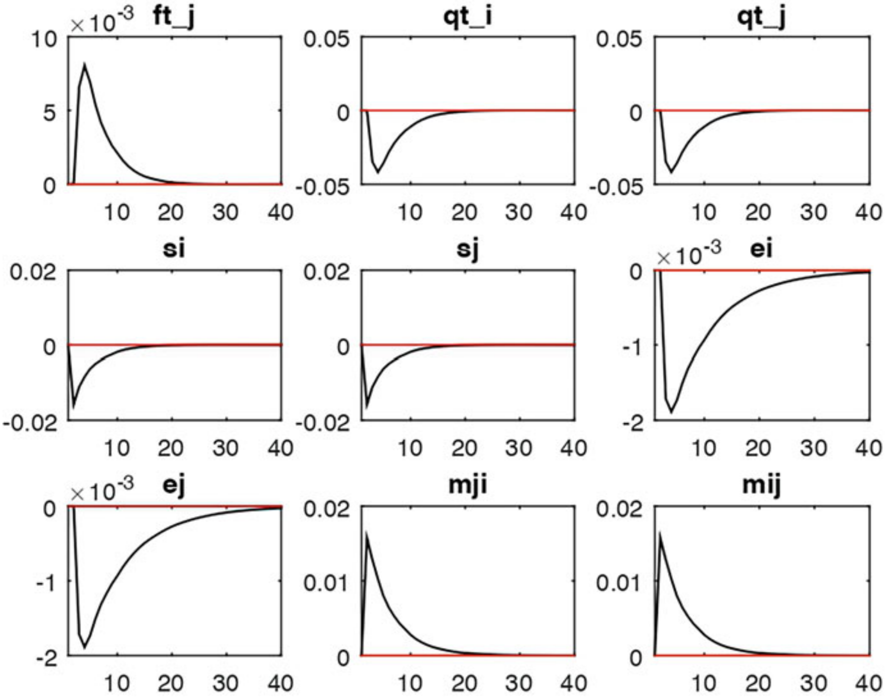

Fig. 2.17 IRFs of -30% shock on η, the labor mobility cost

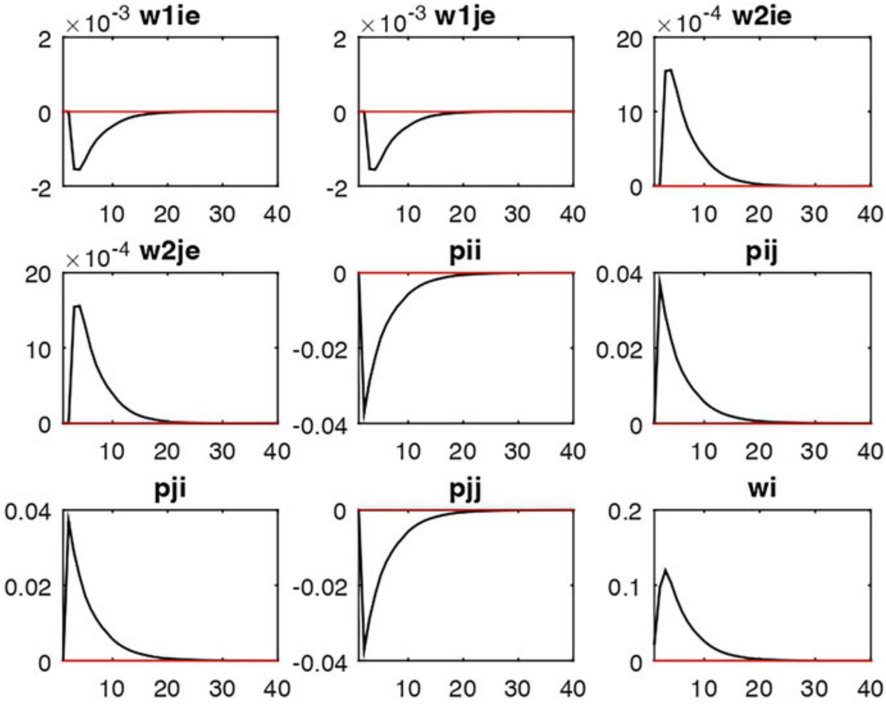

Fig. 2.18 IRFs of -30% shock on η, the labor mobility cost

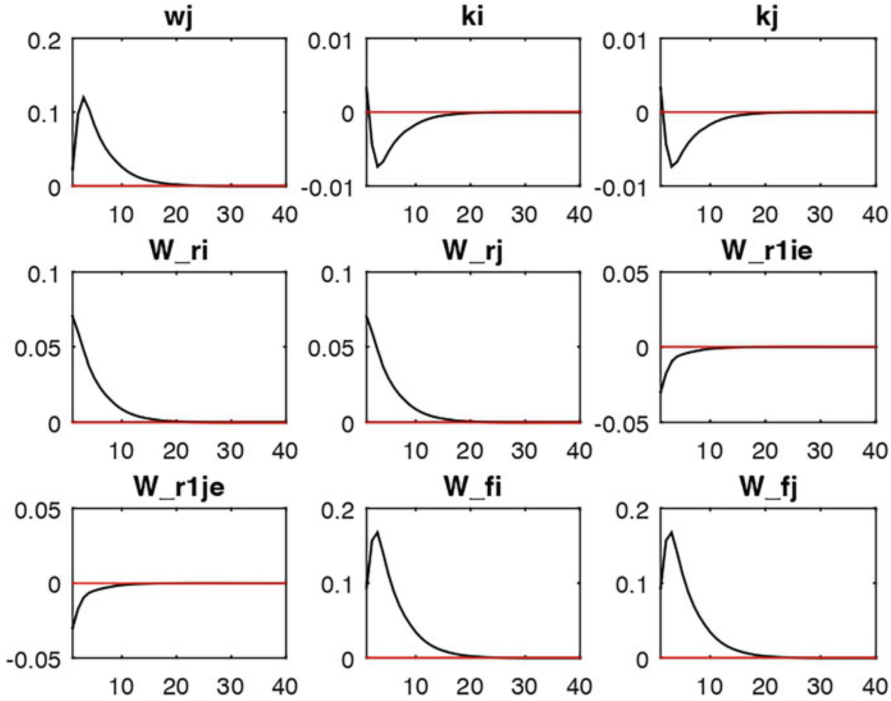

Fig. 2.19 IRFs of -30% shock on η, the labor mobility cost

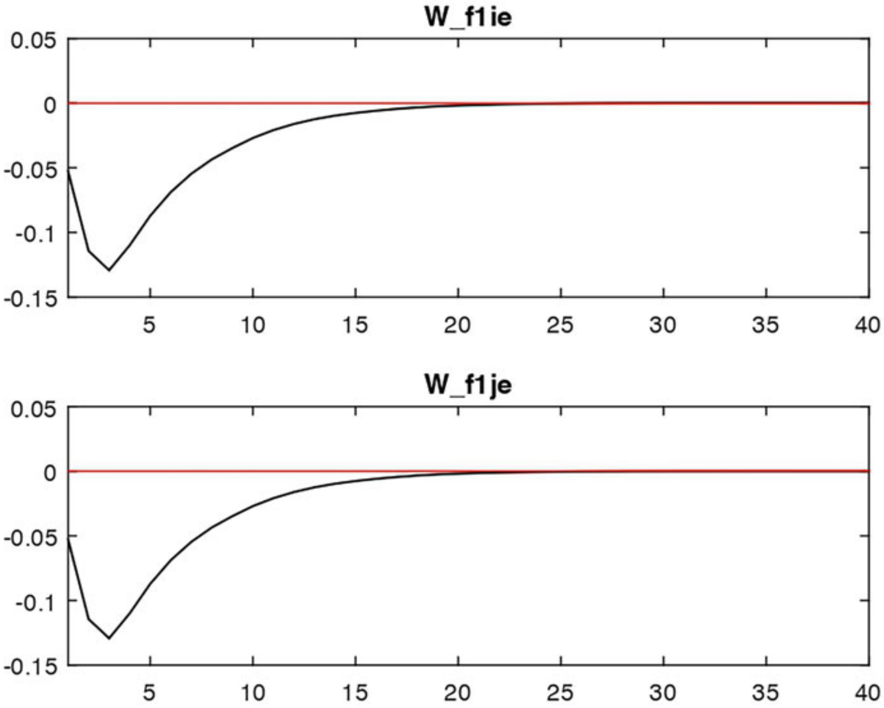

Fig. 2.20 IRFs of -30% shock on η, the labor mobility cost

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Chapter 3
Macroeconomic-Financial Policies and Climate Change Nexus: Theory & Practices

Muhammad AZAM, Ahmed Imran HUNJRA, and Dilvin TASKIN

3.1 Introduction

One of the most significant issues of the recent century is climate change and its adverse effects on human health, environmental well-being and sustainability. It is clear that immediate action is necessary to minimize the adverse impacts and a huge amount of funds is needed to fight the deteriorations in the environment. Global warming is 1.5 °C above pre-industrial levels and minimizing greenhouse gas emissions is a first step to coping with climate change (IPCC 2018). To cut down emissions all around the world a change in the policies of governments should change towards new technologies and financing of these technologies that will replace fossil fuel dependency with renewable energy usage. United Nations report suggests that every year a massive amount of investment $1.5 trillion is required to reach the goals of the Paris Agreement. It is apparent that governments will lead the financing of the projects to cope with climate change, thus macroeconomic and financial policies of the governments will shape the financial environment to ensure financing green technologies. Recently, many central banks report an additional duty to create an environment by influencing the money supply and credits in the economy (Campiglio et al. 2018; Baer et al. 2021) that will provide green financing

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for renewable energy technologies. Despite that green innovation projects of the firms enhance business performance (Farza et al. 2021), many firms especially in emerging countries are reluctant to show ecological responsiveness due to the high costs of these projects. Thus, it is inevitable that environmental financing should be backed by macroeconomic and financial policy adaptations of the governments.

The discussion in this chapter mainly rekindles the association between climate change and macroeconomic and financial policies. In this chapter, some principal ideas based on literature have been discussed in the context of the nexus between macroeconomic and financial policies and climate change and some important insights on the underlying theories, empirical evidence, methods adopted in previous studies to identify and discuss the association. This chapter also contextualizes the relationship in the form of monetary policy, fiscal policy dimensions and regulatory dimensions to provide useful contextualization for financial development and fiscal capacity in the financial system. Some crucial critical reflections on the extant to understand the macroeconomic and financial policy relationship add crucial debate in this chapter. It is important to discuss the debate on macroeconomic and financial policies and climate change nexus in the current paradigm. This discussion is based on multiple theories and empirical evidence to postulate and discuss that macroeconomic and financial policies influence climate change (Stern 2016; Pigou 1932). In contradiction, other studies from literature also mention insignificant association or no links between macroeconomic and financial policies and climate change (Deegan 2004; GonzalezBenito 2005; Cormier and Magnan 2007). Yet there is some evidence available that macroeconomic and financial policies adversely impact climate change (Murphy and Hines 2010; Batten et al. 2016).

This chapter further discusses a comprehensive overview of different theories and empirical evidence that have currently emerged in the literature about the studies focusing on the macroeconomic and financial policies and climate change nexus. Some conventional theories on macroeconomic and financial policies and climate change relationships need to be explored further to include policy coordination elements in models. Different concepts such as financial inclusion and financial sector importance through green financial derivatives have emerged in financial policy models and have gained significant importance by the United Nations climate change financial conferences on sustainable development. The literature has been revived macroeconomic and financial policies and climate change debate, both on a theoretical and empirical basis and identified the significance of various policies and channels at the global level. The consideration of macroeconomic-financial policies relevant to public policies is receiving tremendous attention and it has now become more popular under the current regime of COVID-19 pandemic crises around the globe. The adverse effects of the lockdown have created a devastating impact on the loss of jobs of people, financial investments in different projects and businesses, huge financial losses of the corporate sector due to poor performance of loans, and climate projects financial risk have been increased. If special repercussions are not taken, macroeconomic and financial policies and climate change in most economies will sharply decline and it can lead crises situation.

The chapter provides suggestions regarding a greater role for stabilization of financial-economic policy having balancing impact on environmental crises to encounter the adverse effect of the COVID-19 pandemic. The major importance of this discussion is to focus on financial policymakers and who can extract some important lessons on how macroeconomic and financial policies impact climate change and vice versa. Different green investment groups and individuals having a close connection to financial institutions and regional financial bodies supporting climate change mitigation projects and other statutory organizations such as financial loaning institutions and government may find close relevance of this discussion specifically encountering the upcoming financial crisis and recession which are also expected having a severe impact on climate change mitigation program due to COVID-19 pandemic. However, the major focus of this chapter remains around the discussion that macroeconomic and financial policies issues and their nexus with climate change can provide beneficial outcomes for financial-economic institutions in different parts of the world, especially in developing economies to support financial stabilization that would be advantageous for climate risk control. The chapter aims to contribute to the literature by providing an extensive discussion about macroeconomic, financial policy and environment nexus with an emphasis on developing countries. The chapter contributes to the literature by also considering the impacts of the unprecedented pandemic situation on this framework.

3.2 Climate Change

The literature on the climate change effect starts from the Fourier (1827) and Tyndall (1861) studies. For greenhouse gases factors identification, Tyndall (1861) finds that carbon dioxide and water vapor are major factors. For greenhouse effect identification as a major issue, which was first raised by Arrhenius (1896). Callendar (1938) extended the work after highlighting the temperature rise of 0.05 °C per decade relative to the previous century. Climate change comprises high temperatures of earth, acute hazards inform of high heat waves and rapid floods, the intensity level is rising day by day (Deryugina and Hsiang 2014, IMF 2017; Bathiany et al. 2018; Mersch 2018; Pigato 2019). The climate change impact on the socio-economic environment can be classified into different essential areas.

Plass (1956) extensively discussed 30% carbon emission concentrations in the twentieth Century. Plass further provided information regarding future temperatures rising by 1.1 °C relative to previous centuries. Climate change creates substantial physical impacts on geographical regions. The physical climate change risks are generally increasing around the globe, which alternatively has a positive impact on most economies like increased agricultural productivity level in Canada, as well as a different part of northern Europe and Russia. The spatial impact of climate change is also observed in geographical regions. Climate change affects the extreme level of human activities (Weitzman 2009). Climate change affects the earth system and makes it warmer, as mentioned in the report of the IPCC (2018). Climate change informs of physical resource degradation is dynamic. Climate change models based on physical resources degradation also predict continuous warming can increase socioeconomic technological inertia for carbon emissions reduction (IPPC 2018; IPBES 2019).

It has multiple effects in the form of exposure to multiple hazards, and vulnerabilities like the financial capacity requirement to investments, and heavy dependence on a sector that is victimized by climate hazards (Krogstrup and Obstfeld 2018). It has a direct impact on the socioeconomic and financial systems of the economy (Nordhaus 2014; Raworth 2017; Svartzman et al. 2019). For instance, a flooding area can not only have a damaging impact on houses but it can also raise financial burden in terms of high insurance costs. Many financial systems are designed in such a way that could add vulnerability to climate change issues. Climate change affects the social system (Aglietta and Espagne 2018). The most affected population in the world belongs to the poorest communities, which are the most vulnerable. Poorer communities in most parts of the world rely on natural capital as a major financial source (Pandey et al. 2017). Climate change can bring potential loss due to natural capital degradation, which could add costs to specific geographic locations. The potential impact of climate change is observed due to the under-preparation of climate disaster challenges. The communities around the globe have been working on climate change adaptation, the scale of climate change adaptation is likely to be slow and it can significantly increase to manage rising levels of physical climate change risk. Adaptation is likely to entail rising costs and tough choices that may include whether to invest in hardening or relocating people and assets. It thus requires coordinated action across multiple stakeholders.

Most economists believe that climate change mitigation is only possible through macroeconomic-financial policy intervention (Bhattacharya et al. 2015; Dasgupta et al. 2019; Campiglio 2016). There are multiple ways by which climate change can be mitigated through financial policy interference. Firstly, macroeconomic-financial policies can impact climate change projects through regulatory frameworks (Campiglio et al. 2018). Secondly, various financial instruments can be introduced to boost investment in climate change adaptation projects. Third, financial stabilization policy builds a fiscal capacity for national resource allocation to depute wealth for green investment projects. Financial capital accumulation can support cleaner technology to improve the positive outcomes of financial policy on climate change risk (Levine 1997). Fourth, a financial policy stabilization or uncertainty reduction policy can have a spillover impact on investors who are seeking green energy investments (Admati 2017). Finally, a borrowing capacity for the economy is improved for climate change mitigation through a stable financial structure.

3.3 Macroeconomic and Financial Policies

Macroeconomic and financial theories have been extensively discussed in economic literature for the last couple of decades. Various types of macroeconomic and financial policy models are discussed by public finance scholars (Grilli et al. 1991; Gelb 1989; Westerhoff 2016). A major group of scholars proposes fiscal theories that critically discussed the dynamic role of fiscal capacity that has a significant contribution to financial policy execution programs. Fiscal capacity means a rise in taxation and another income source of government over some time. A positive rise in fiscal capacity creates a greater level of national income resulting in forward-looking activities and execution (Besley and Mueller 2021). In financial stabilization, the economic literature in the fiscal context considers taxation revenue to GDP ratio and income tax share in total revenue as a fiscal policy stabilization (Olekalns 2000). Additionally, an extensive debate on financial policy models suggests that monetary policy regulations play a significant role through monetary transmission channels (Gertler and Gilchrist 1993; Barran et al. 1996; Ramey 1993). The major group of monetary scholars proposes monetary policy theories that critically discuss the dynamic role in financial credit disbursement and banking sectors' critical contribution for different financial projects. A credit theory posits that central bank intervention is required to ensure capital disbursement (Gertler and Gilchrist 1993). An efficient monetary policy supports credit generation. A low level of financial inclusion is the source of the poor interest rates (Kihombo et al. 2021). The level of the interest rate also affects businesses through delayed investment and monetary disruption mechanization. The inflationary theory also emphasizes an adverse impact of interest rates on the well-being of people (De Gregorio 1994). The financial inclusion theories highlight the innovative role of central banks to increase the financial literacy of residents which will accelerate deposits and savings for new investments (World Bank Group 2013).

The financial theories have been discussed in economic literature like physical resource acquisition risk discusses disruptions in investment projects due to low valuation and weak production potential that has financial regulation implications. Acemoglu et al. (2012) emphasize the deregulation and physical risk nexus in the financial policy risk framework. Macroeconomic and financial policy theories identify spillover effects on investment behavior due to market uncertainty as well as volatility through slow productivity. The recent literature also claims and discusses the same arguments (Admati 2017; Auffhammer 2018; Battiston and Monasterolo 2019). Financial policy stabilization issues are the fundamental cause of liquidity risks and it promotes the disruption in credit channels and creates legal proceedings difficulties in the economic system and corporate businesses, having outcomes in the form of financial instability in economies (Carney 2015; Campiglio et al. 2018). Recent literature focuses on the relationship between macroeconomic -financial policies and climate change.

3.4 Macroeconomic-Financial Policies and Climate Change

3.4.1 Underpinnings

Theories relevant to the association between macroeconomic-financial policies and climate change discuss whether macroeconomic financial policies are helpful to mitigate climate change. The seminal work in this context explains the theoretical underpinnings regarding the relationship between macroeconomic financial policies and climate change. Fiscal policy plays an important role in climate change. The fiscal policy theory in this area gives importance to Pigouvian taxes on emissions for climate change mitigation a research and development subsidization (Pigou 1932). The theory highlights that subsidies are required for positive co-benefits as well as mitigation actions, which could shift the consumption and investment habits of people toward more savings of natural capital. The fiscal policy theory in this context considers the carbon-pricing theory. The theory focuses on the significance of price allocation as environmental costs of environmental pollutants considering climate change due to local environment damages (Lagarde and Gaspar 2019; Farid et al. 2016).

Hence, an important notion of this theory is to identify the costs of carbon emissions having measurement problems. Rudebusch (2019) extended the carbon tax role of removing subsidies may be equally important. Farid et al. (2016) regard the carbon tax framework as an emissions trading system to boost firms towards the best-practice frontier, which raises innovative and clean technologies and decreases national expenditure. Alternatively, high carbon taxation does not contribute to the production of frontier innovation technology in case of other market failures in investment projects inform of heavy fuel taxation (Unruh 2000; Fay et al. 2015). The carbon taxation hypothesis is further combined with consumption redistribution. The carbon taxation perspective informs human population valuation is more critically debated considering carbon reforms through subsidization reduction on fossil fuels (Pigato 2019; Heine and Black 2019; Guillaume et al. 2011). Goulder (1995) extends the ideology for carbon tax revenues recycling is the carbon taxation debate to achieve economic efficiency.

However, some scholars have highlighted fiscal policy's role as spending and investment in public projects (Blanchard 2019; Dasgupta et al. 2019). IPCC (2018) report also emphasizes the importance of loaning schemes from banks and investment funds of the government. These mechanisms guarantee a higher level of private-sector participation in public projects. Public investment in projects seems to be a crucial factor in improving energy efficiency and renewable power generation essential for climate change mitigation. Arezki and Belhaj (2020) extend the infrastructure investment debate and further focus on public investment management systems' importance for climate change effects. Aglietta et al. (2015) suggest that fiscal policy through the tradable guarantee in the form of a climate certificate ensures a minimum agreed return. Dasgupta et al. (2019) emphasize the importance of climate certification in investment activities. To access the carbon emission for climate certification, transparency is required in this manner.

Macroeconomic financial policy theories mainly focus on financial markets as well as financial institutions' composite role for climate change through different channels. A low-carbon investment is a central concern of these financial policies theories (Dasgupta et al. 2019; Hoang et al. 2022). However, Campiglio (2016) suggested credit creation as well as allocation importance for carbon prices decision-making. Most scholars discuss carbon-pricing issues for long-term business agreements due to inconsistency in macroeconomic and financial policy (García-Álvarez et al. 2017; Lecuyer and Quirion 2013; Bhattacharya et al. 2015; Tahir et al. 2021). In particular, the macroeconomic financial policy requirements in literature have been discussed in dynamic ways considering the nature of climate change. Batten et al. (2016) focused on financial regulation as well as supervision to deal with climate risk through physical resource distortion associated with droughts, floods etc. which impact productive activities. An extensive theoretical debate is available regarding the significance of micro-prudential and macro-prudential regulations, credit allocations for structural transformation to mitigate the climate change effect (Meinshausen et al. 2009; McGlade and Elkins 2015; Dikau and Volz 2019; Fatica et al. 2021).

Additionally, few recent theories on macroeconomic financial policies proposed risk and uncertainty postulates during climate change mitigation strategies adaption have focused on transition risk (oil reserves loss), regulatory risks (legal actions effect on regulation) and liability risks (burden on firms) (Tracker 2013; Battiston et al. 2017; Campiglio et al. 2018; Carney 2015, 2019). Most economists focused on liquidity and capital requirements for climate change projects. Thus, climate change mitigation failure in most of the world is due to macroeconomic financial policies failure and reluctance towards financing green innovation. Following the literature theories about the nexus between macroeconomic financial policies and climate change several empirical pieces of evidence have been discussed and different conclusions regarding macroeconomic-financial policies and climate change have been reported as discussed in the next section.

3.4.2 Some Basic Facts and Empirical Evidence

The macroeconomic financial policies' role at the state level is an incontrovertible fact of the previous two centuries. To ensure the role of policies, fiscal and monetary tools have been adopted, which means introducing new taxes and revenue as well as financial development tools in the form of credit disbursement etc. A government can choose revenue from taxable income, but its level of taxable income is constrained by the financial capacity of the government. The economic structure is important to determine the financial capacity of the government via the level of income and government access to nontaxable income. However, the financial capacity varies across the countries. The richer economies in the world have more

Table 3.1 Matrix of correlations

Variables	(1)	(2)	(3)	(4)
(1) CLIM	1.000			
(2) FPU	0.015	1.000		
(3) DC2	0.400	0.015	1.000	
(4) BM1	0.366	−0.048	0.639	1.000

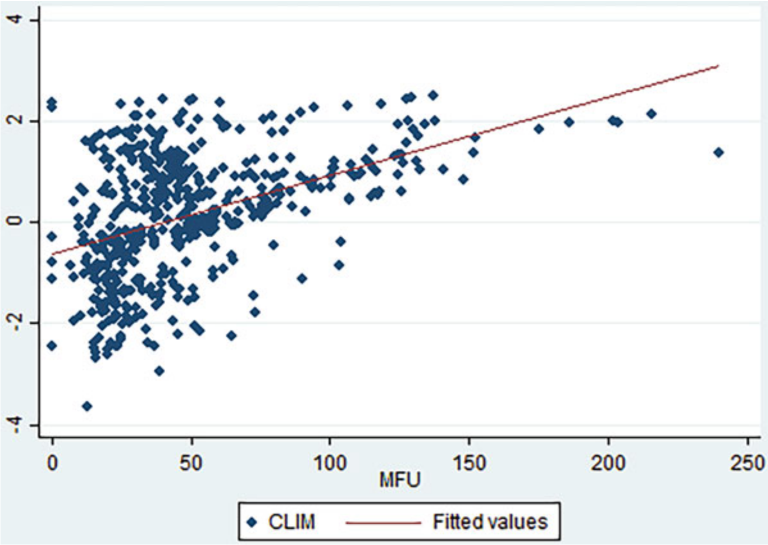

Fig. 3.1 Macroeconomic financial policies and climate change relationship

financial capacity and tend to generate more financial revenue relative to the world's poor economies. It is interesting fact to look at the relative relation of different macroeconomic financial policies about climate change.

To better capture the macroeconomic financial policy and climate change dynamics we considered the relationship between two variables. Table 3.1 shows a correlation matrix for four measures of climate change, financial policy uncertainty and monetary policy proxies. Not surprisingly, these proxies have a positive correlation. It reflects that financial policy uncertainty and monetary policy lead to climate change degradation. This also indicates the kinds of variables, we also have emphasized. However, there is clear differentiation among the measures used.

Figure 3.1 shows a particular relationship on how macroeconomic financial policy issues in the form of risk and uncertainty impact the underdeveloped world. We use a panel data set for 70 developed and developing countries for the period 1991 to 2020. We mainly focus on low-middle-income countries and upper-middle-income countries since climate change issues are more prevalent in these countries, and there is greater cross-country variation in Macroeconomic financial uncertainty (MFU). For the macroeconomic financial policy uncertainty index, we take the Data set of Baker et al. (2016). The MFU index is based on federal budget uncertainty, monetary policy uncertainty and legislative policy uncertainty inform of uncertain regulatory rules and regulation enforcement in the economy. In Fig. 3.1, on the vertical side, climate change (CLIM) proxy inform of carbon emission is taken. For climate change indicators, we collect annual data from the World Development Indicators (WDI) database of the World Bank. On the horizontal side of the figure, we also consider MFU data set. The graph indicates that there is a positive correlation between environmental degradation and macroeconomic financial policy uncertainty in these economies. It is evident that macroeconomic financial policy uncertainty is a major reason for environmental degradation.

Other measures for climate change are equally important, same as the temperature rise due to the carbon concentration. We thus obtain an interesting indication after plotting the graph. Climate change is shown on the vertical axis and macroeconomic-financial policies on the horizontal axis. The figure indicates the striking pattern of macroeconomic financial policies risk. It demonstrates the relationship based on data set 1990 to 2020 retried from the world bank of 80 countries and macroeconomic financial policies risk data set is based on Baker et al. (2016). Our sample selection is based on low and middle-income countries and lower-middle-income economies from the world.

Serious attention is not yet paid to risk factors associated with macroeconomic-financial policies. It is important to evaluate this relationship here. We observe clear and interesting facts that macroeconomic-financial policy uncertainty has a positive association with climate change. This fact demonstrates that public finance economists and policymakers have certainly paid less attention to develop a structure that facilitates the investors in clean innovative projects. However, the great reliance of investors on macroeconomic-financial policies in developing countries has been noted and discussed by Maynard et al. (2016). Many researchers have also found a positive association between macroeconomic-financial policies uncertainty issues and climate change (Yuan et al. 2020; Adams et al. 2020; Li et al. 2021). An early contribution by the dualistic theory presented by Higgins (1956) found that macroeconomic-financial policy risk hampers incentives for investors and governments to take initiatives for developing green financial structure as a strategy to bring back investors in climate change mitigation projects. In line with the literature, our facts support the dynamic behavior of macroeconomic-financial policy risk in poor economies. But the major key difference in our approach is that we report macroeconomic policy risk and uncertainty together with climate change.

In Fig. 3.1, the authors' own estimation is taken into consideration. We considered the Macroeconomic financial policy uncertainty index (MFU) based on Backer et al. (2016) data set on the horizontal side. The climate change (CLIM) inform of carbon emission is taken on the vertical side. The graph indicates a positive upward trend or positive correlation between carbon emission.

For further exploration, we have drawn a marginal graph of developing countries 'to evaluate whether MFU for CLIM matters or not. We have found interesting evidence that MFU does not matter for Developing economies. There are many reasons to explain no relationship between MFU and Climate change policy. The MFU is ineffective for climate change because market regulations have many flaws

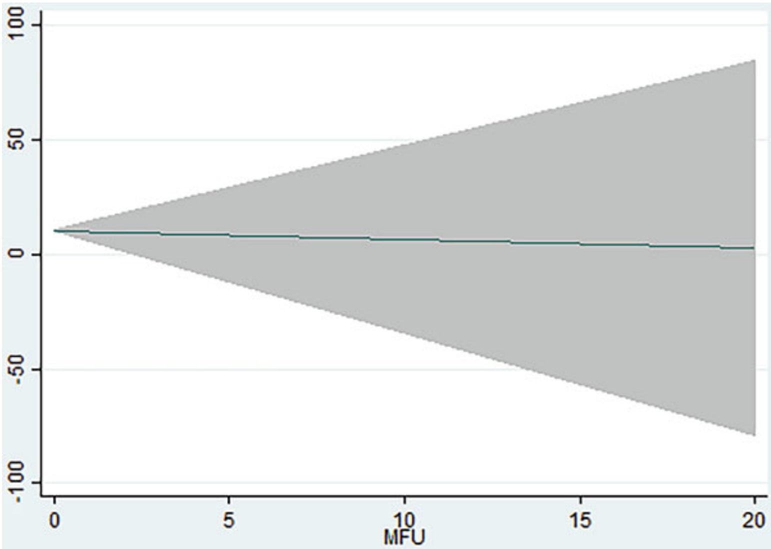

Fig. 3.2 The marginal graph of macroeconomic financial policies and climate change

in developing economies. The developing countries also face serious challenges due to no connectivity of rules and regulations with climate policy. The most important factor is that there is no regulatory structure and enforcement mechanism by which macroeconomic financial policy impact is transferred to climate change rules and regulations (Fig. 3.2).

Relationship after applying OLS Method based on developing countries data set. We considered the Macroeconomic financial policy uncertainty index (MFU) based on Backer et al. (2016) data set on the horizontal side. The climate change (CLIM) inform of carbon emission is taken on the vertical side. The marginal graph validates no correlation between climate change and MFU.

In Fig. 3.3, broader and deeper stylized facts are represented by considering the monetary policy dimension, which is closely connected with financial facilities for climate mitigation adaptation projects in poor economies. The figure demonstrates the relationship between monetary policy tools and climate change. We use two important monetary tools to observe interesting facts that monetary policy is associated with climate change. This points that monetary policy is positively related to climate change. Figure 3.3 also points to a positive association between credit channels used as monetary policy tools. We use two measures to proxy monetary policy tools that will impact climate change; domestic credit (DC) by financial institutions and broad money (BM), which are used to represent the liquidation by financial institutions. We plot this variable against climate change. The different behavior of a monetary policy is entirely in line with factual realities in poor economies. Most poor economies have an industrial structure that is based on fuel and oil, gas consumption.

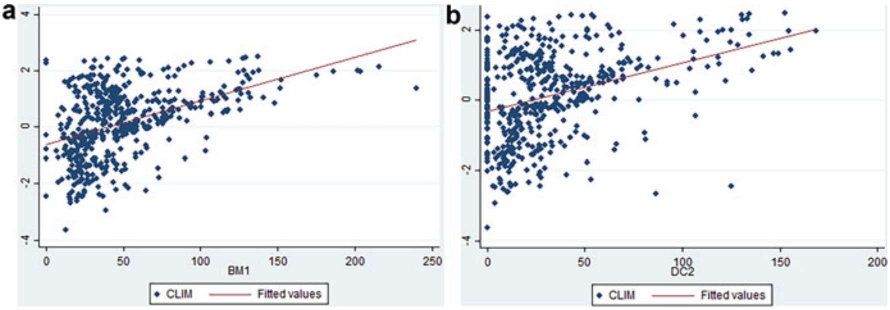

Fig. 3.3 Monetary policy and climate change nexus

The monetary policy and industrial structure have a connection in poor economies discuss the same idea that financial institutions policies are for non-renewable industries due to smooth financial flows (Page 2013). Alternatively, there are high failure possibilities for green innovative investment projects, validation of smooth income flows is a serious concern, leads to recover financial loaning by financial institutions in poor economies. As we show, it is far from clear that monetary policy will be fully exploited for climate change mitigation purposes, especially when financial decisions are taken based on industrial performance that can capture major benefit from financial sector loaning. The incentives of pollutants primitive industrial structure may cause climate change degradation in poor economies. The government in an economy with greater power to monetary instruments leads to inefficient production due to social wellbeing's viewpoint. A major contribution to the carbon concentration is due to the adaptation of monetary policies having reliance on pollutant industrial sector growth. Since the appearance of work by Lucas et al. (1992), extensive literature has emerged showing how a monetary policy legal system shapes the aspect of economic development due to pollutant industries. The interpretation of these facts is that macroeconomic financial policies' monetary dimension influence climate change due to the support of pollutant industrial structure in poor economies.

In Fig. 3.3, on the left-hand side, we consider the relationship between climate change (CLIM) on the ventricle side and broad money (BM1) as a proxy for monetary policy on the horizontal axis. We also consider domestic credit to private sectors (DC2) and climate change (CLIM) on the right side. We draw a correlation graph between monetary policy proxy and climate change proxy inform of carbon emission. The data set is taken from the World Developed indicator (WDI).

The impact of monetary policy on environmental pollutants is empirically evaluated in Shahbaz et al. (2013) on Pakistan's data set from 1971 to 2009. Many other studies investigate this relationship in developing countries contexts and report similar findings. Odhiambo (2020) identified credit importance for climate change for sub-Saharan Africa. Tamazian and Rao (2010) suggested that financial development is a crucial factor for climate change after analysis of 24 transition countries over the period 1993 and 2004. Some recent studies in this context also consider a dynamic modeling approach to validate the relationship between monetary policy and climate change. Ishiwata and Yokomatsu (2018) adopted a dynamic stochastic general equilibrium approach for Pakistan and found no empirical evidence regarding climate change's impact on investors' financial loaning and investment. In a recent study by Shobande and Shodipe (2019) monetary policy links through the monetary transmission mechanism with climate change are validated on the data set of (Nigeria, United States and China). Keen and Pakko (2011) validated that a high nominal interest rate level during a climate change after the adaptation of dynamic stochastic general equilibrium approach.

Brede (2013) used the Keynesian approach and revealed a low savings pattern of people due to climate change. Some recent empirical evidence highlighted fiscal policy as well as monetary policy importance for climate change (Sachs et al. 2014; High-Level Commission on Carbon Prices, 2017). Dafermos et al. (2018) calibrated an ecological model based on data set for the period 2016 to 2120 and concluded that climate change matters for macroeconomic-financial stability. Controversial empirical literature also exists regarding monetary policy and fiscal policy's role in aggregation or disaggregation. One strand of literature potentially supports monetary policy's role in climate change in a different part of the world. Shahbaz's (2013) study validates this argument. Shobande and Shodipe (2019) state that monetary policy and fiscal policy play a composite role in climate change in China, United States, and Nigeria. In contrast, Dafermos et al. (2018) confirmed monetary policy used as a tool for climate change can bring economic instability due to credit disruption. The literature also supports the carbon bubble theory due to the adaptation of monetary policy as an instrument for climate change mitigation (Murphy and Hines 2010; Batten et al. 2016). Empirical evidence also proves that inflation is directly connected with climate change issues (Heinen et al. 2019; Mukherjee et al. 2021).

3.5 Critical Reflections

A discussion on the association between macroeconomic-financial policies and climate change remains controversial based on evidence in the literature. While the extensive discussion in literature is based on macroeconomic-financial policy theories that strongly support this relationship, numerous studies also show an insignificant relationship between macroeconomic-financial policies and climate change. The literature argues that macroeconomic-financial policies are a critical concern to mitigate climate change. However, macroeconomic theories have been extensively debated from the last century, scholars have expressed their viewpoints, some evidence through empirical analysis also supports theoretical debates, while some macroeconomic financial policies are still questionable in the environment and social development perspectives.

The traditional macroeconomic-financial policies thinking, critically consider economic development perspective through economic growth and profitability and excluded welfare maximization ideology or no serious efforts for environmental impacts of macroeconomic policies. Most of the macroeconomic-financial policies revolve around the most prominent ones like classical and neo-classical theories, Keynesian and new Keynesian thought and monetarist schools of theories having central concern is economic growth through industrialization and mass production. Macroeconomic policies proposed by these theories have ignored the climate change cost of damages through economic progression. The wellbeing of climate change impacts is compromised in most of the theories.

Hence, macroeconomic-financial policies utilization in purely traditional economics theories excludes environmental relevance as a key concern. Although macroeconomic-financial policies are key indicators of financial capacity and financial machinery usage for the sake of climate mitigation programs. Since macroeconomic-financial policies impact societies. The classical economists mainly focus on less fiscal policy intervention for macroeconomic stabilization. Keynesian economists mainly focus on fiscal policy's role in demand generation in economies. Monetarist economists mainly focus on monetary policy as an important tool of government for the financial and economic development of different economies. New Keynesian and new classical economists focus on the active role of these two policies (fiscal and monetary policies) for macroeconomic financial policy adjustments at the national level.

In capitalist societies around the globe, an extensive discussion is available to determine the underlying objectives of the macroeconomic-financial policy adaptation. Macroeconomic-financial policy adjustments are purely a matter of economic stability. However, a major question of concern is whether these economies could achieve sustainable development objectives or not. Economies only formulate rules and policies with quantifiable impact. Most of the instrumental approaches are preferred over environmental and social considerations. Most of the macroeconomic approaches in these societies are based on capital valuation. Fiscal policy's major focus is on the taxable income of the government due to industrial progression. In addition, fiscal policy expansion in these economies should not only focus on economic progression. Governments must focus on the fiscal capacity extension to deal with some other issues. The policy leaders should mainly focus on carbon imposition of taxes during the economic progression phase. This climate protection approach should be a focal concern of these fiscal policies to remain on a sustainable path. Macroeconomic-financial policies relevant to monetary should be adopted by the central banks mainly in the context of climate change protection. Monetary policies recently require sustainable development dimensions.

Economic rationality remains a major concern in macroeconomic financial policy discussions in the last century. However, a critical consideration is of great necessity in current times with the COVID-19 pandemic issue. More than 16 million human life suffer from this disease around the globe, with adverse effects on most of the world economies. The economic rationality is based on macroeconomic-financial policies is currently a challengeable debate without considering the climate change issue, a macroeconomic-financial policy refinement is required in its directional aspect. There is a need for macroeconomic financial policies coordination due to the unpredictable climate challenge nature. The macroeconomic-financial policies mix for climate change mitigation has not to be considered so in the economic literature. These macroeconomic-financial policies should be based on market regulations, carbon prices allocations and green investment strategies. The major concern of macroeconomic financial policies should be energy efficiency strategies, carbon pricing strategies, and green technological policy strategies. In this way, sustainable development agendas can be merged with macroeconomic policies. Since the importance of sustainable development started in the 1980s to fulfill the next generation's requirements. Climate change and its issues were discussed by the United Nations members' countries in 1992, United Nations Conference theme was based on Environment and Development under Agenda 21, sustainable development received tremendous importance. In subsequent meetings UN conferences started from 1993 to the current period, macroeconomic-financial policies and climate change nexus have been acknowledged. During the same era, most of the scholars have presented their viewpoint regarding financial and monetary policy instruments for climate change mitigation in substitutes or complements forms. The COVID-19 pandemic has highlighted some uncertainty due to government failures as constrained for macroeconomic policy instruments to work. It is unclear up until now whether macroeconomic-financial policies would enable economies towards sustainable development solutions due to the collapse of economies based on severe climate change crises in the form of health in the twentieth century. If no proper solutions are figured out by policy experts, economic development may lead to the worst crises in the future. The societal well-being of macroeconomic financial policy implications should be based on political desirability and urgent action is required for climate change mitigation for the stability of economies after COVID-19 pandemic. This also requires adopting a new instrumental macroeconomic financial policy perspective, based on policy mix approach to consider such fiscal and monetary policies along with institutional approaches considering the circumstances of economies for efficiency achievement in climate change mitigation programs. In the future, the macroeconomic financial policies' survival lies in consideration of wellbeing approaches not capitalistic approaches, due to the emerging importance of socialist theories in upcoming days.

3.6 Conclusions

The macroeconomic financial policies have significant importance to mitigate upcoming challenges of the world. The major objective of this book chapter is to discuss the impact of macroeconomic-financial policies on climate change. By boosting green investments through capital savings, improving fiscal capacity through carbon taxation and carbon pricing as tools for fiscal policy, improving Prudential Financial regulation, credit channels and liquidation channels improvement as a monetary policy tool, and structural transformation in the macroeconomic financial system can work efficiently for climate change mitigation in different economies. The causal association between macroeconomic financial policies is crucial due to their wider impacts. One could claim macroeconomic financial policies should aim to increase and encourage investments in green infrastructure projects, and productive capacity and through innovation techniques development in economies. This chapter can help policymakers, especially from poor economies by providing practical directions where macroeconomic financial policies stand to mitigate climate change aspect. This chapter is fruitful to provide information regarding the underlying association between macroeconomic policies and climate change. This study will help policymakers in multiple ways for macroeconomic financial policy instruments can be utilized for climate change mitigation, especially in poor economies. A broad green financial derivative could be an option for policymakers. An efficiency in monetary and fiscal policies could strengthen the financial system to work smoothly and effectively to regulate investment in climate change mitigation projects.

Policymakers should be aware of the significance of the policy tools they can use to allocate some of the available funds to green projects. Especially, central banks should take a more active role and should reshape their objectives to create a financial environment for green financing. Despite theoretical and empirical exploration between macroeconomic financial policies and climate change, a macroeconomic policy mix is an unexplored area of research considering different macro, micro and institutional policies linkage for the effectiveness of climate change mitigation. In particular, the major failure of macroeconomic financial policy models avoiding climate change issues required urgency to be focused on the current paradigm. A new policy challenge due to climate change mitigation like pricing stability issues, inclusive approaches of development should be considered in the macroeconomic-financial policy framework.

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Chapter 4
Exchange Market Volatility Spillover in Time of Crisis: Evidence from a Smooth Transition Regression Application

Hassen RAÏS

4.1 Introduction

The role of the USD as an internationally-traded currency has been more challenged for several years, especially during the financial crisis. Many countries have fixed their currency to the USD, because or strategic considerations linked to market pressures, or for tactical reasons. The aim of this article is to explain these considerations by answering the following question: Is the high volatility a specific characteristic of the exchange rates since the start of financial crise in 2007. Scholars and literature on contagion adduce a positive answer to this question (Corsetti et al. 1999; Kaminsky and Reinhart 2000).

More specifically, this article attempts to address these questions by answering the following two questions: Have exchange rate policies been modified in the direction of greater flexibility since the onset of the financial crises? Is this development in line with what happened in previous crises? The various elements mentioned above indicate a positive answer to these questions.

Following Reinhart and Rogoff (2004), we start by considering that the exchange rate regimes can be proxied by the exchange rate volatility. Then, we analyze the relationships between currency volatility for a sample of countries and various proxies for stress on global financial markets. The volatility spillovers across financial markets are normal phenomenon in interconnected markets but it can take on abnormal turns during episodes of financial stress, which is a symptom of "contagion". Empirical analysis evidenced the contagion effect by different methods. Eichengreen et al. (1996) rely on different variables explaining the

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peculiarities of foreign exchange markets. Some scholars focus on independence when asset returns are extreme (Bae et al. 2003; Hartman et al. 2004).

In this article, a smooth transition regression (STR) and test for nonlinearities are used over a sample of 15 countries during the period from January 2005 to December 2018, for testing the exchange rate volatility spillover and contagion effects in different area. Our goal is to assess volatility overflows by testing for possible non-linearities. Indeed, tensions in global financial markets are likely to affect exchange rates in financial markets more severely when they reach high levels. We represent the tensions on the financial markets by different indicators. The tools enabling this is VIX, CBOE volatility index, which represents the implied volatility of the S&P 500 index. We also consider other indicators, based on the realized volatility of different market indices.

The contributions of this article are first, to investigate the links between currency markets in several countries and financial market strains in the global economy, with the hypothesis that the relationship between these two markets are amplified in episodes of financial crises. Second, it is develop and smooth transition regression model to test the intensity of volatility and regional contagions.

The rest of the paper is organized as follows. The second section presents the data and volatilities of exchange rates and financial markets, with a comparison of crisis episodes. Relying on the estimation of STR models. Third section presents the methodology of assessing the relationships between global financial stress and currency volatility, and regional contagion effects within different area by testing whether the intensity of such effects differs across crisis and noncrisis periods. The fourth section presents the empirical results of the two parts, relationships between global financial stress and, currency volatility and regional contagion effects. The last section concludes the study.

4.2 Data

The sample is an exchange rate of different currencies with US dollars. The period spans from January 2005 to December 2018, with monthly periodicity. It includes 15 currencies of different countries: Euros of Europe (EUR); in Asia: those of China (CNY), Indonesia (IDR), India (INR), Korea (KRW), Malaysia (MYR), Singapore (SGD); in the Middle East: Kuwait (KWD), Bahrein (BH), Jordan (JOD); in Latin America: those of Argentina (ARS), Brazil (BRL), Mexico (MXN), Colombia (COP), Venezuela (VEB). All series being extracted from Bloomberg.

All the currencies in the sample are more or less linked to the USD over the period under review, at least for some time. We also note that exchange rate volatility is a good gauge for assessing exchange rate regimes, as shown by a number of empirical works (Reinhart 2000; Calvo and Reinhart 2002; Levy Yeyati and Sturzenegger 2005; Reinhart and Rogoff 2004).

The volatility of exchange rates against the USD are measured in two ways: the squared monthly returns of exchange rates (in logarithms) and through the estimation of a GARCH model (the mean equation including only a constant term). Only the squared returns in all the following results are retained. They are retained because; first, the results are very close for the two measures of volatility; second, they are easier to interpret; and third, they do not require any calculations of parameters, which may increase the uncertainty on the coefficients estimated in regressions.

Financial stress is represented by different indicators as proxies of the volatility of financial markets: (i) VIX is the most used, it measures the implied volatility of the S&P500 index options for the next 30 days, calculated by the Chicago Board Options Exchange (CBOE). (ii) The world MSCI (MSCI_W), which is the stock index calculated by Morgan Stanley Capital International made up of 1500 stocks in the developed countries. (iii) The CRB, calculated by the Commodity Research Bureau, and the S&P GSCI, the commodity index published by Standard and Poors' and Goldman Sachs.

4.3 Methodology

Concerning the relationship between the volatility of the exchange rate and the financial crises, we can observe two facts. Financial theory expects it as positive. Second, due to uncertainty and crisis, investors transfer their assets from riskier investments into safer ones, this relationship is nonlinear (Baele 2005; Coudert et al. 2010). This research aims to investigate the nature and how strong is the relation between exchange rate volatility and financial crises.

4.3.1 Assessment of Currency Volatility and Financial Crises

This research follows models developed by Teräsvirta (1994, 1998) and Teräsvirta and Anderson (1992). In these models, two regimes with different volatilities specified the dynamics of the exchange rate. One variable is used for proxying the stress on financial markets and as a link between the volatility of the exchange rate and the stress on the financial markets.

The smooth transition regression (STR) model of order p that we consider is given by:

$$\sigma_t^2 = \alpha_{10} + \sum_{j=1}^{p} \alpha_{1j}\sigma_{t-j}^2 + \beta_1 S_t + \left(\alpha_{20} + \sum_{j=1}^{p} \alpha_{2j}\sigma_{t-j}^2 + \beta_2 S_t \right) g\left(S_t; \gamma; C\right) + \varepsilon_t \tag{4.1}$$

Where σ_t^2 is the degree of exchange rate volatility, proxied by the squared returns of the considered exchange rate series. ε_t is iid $\left(0, \sigma_\varepsilon^2\right)$, S_t is the transition variable and $g(S_t; \gamma; C)$ is the transition function which by convention is bounded by zero and one. $\gamma > 0$ denotes the slope parameter that determines the smoothness of the transition from one regime to the other, and c is the threshold parameter.

The STR model will be specified following three steps:

- Specifying the linear autoregressive part of the model. We use the Schwarz information criterion.

Testing the null hypothesis of linearity: $\gamma = 0$. We also test the null of linearity against the STR alternative by running the following auxiliary regression for all the potential transition variables $s_{i,\,t}(i = 1, \ldots 4)$.

$$H_0 : \theta_{1j} = \theta_{2j} = \theta_{3j} = 0 \;\; (j = 1, \ldots, p)$$

$$\sigma_t^2 = \theta_0' z_t + \sum_{j=1}^{p} \theta_{1j} \sigma_{t-j}^2 S_{i,t} + \sum_{J=1}^{p} \theta_{2j} \sigma_{t-j}^2 S_{i,t}^2 + \sum_{j=1}^{p} \theta_{3j} \sigma_{t-j}^2 S_{i,t}^3 + \eta_t \tag{4.2}$$

Were the transition variable $S_{i,\,t}$ $(i = 1, \ldots, 4)$ is one of the four measures of global financial stress: the VIX, the MSCI_W, the CRB, and the S&P GSCI.

$$z_t = \left(1, S_{i,t}, \sigma_{t-1}^2, \ldots, \sigma_{t-p}^2\right)'.$$

Once linearity has been rejected and the transition variable selected, by implementing test, we choose between the Logistic STR and Exponential STR specifications. There are two states in the economy, low and high volatility, with a smooth transition between them. They define two transition functions:

- Logistic STR model: $g(s_t; \gamma; c) = (1 + \exp(-\gamma(s_t - c)))^{-1}$
- Exponential STR model: $g(s_t; \gamma; c) = 1 - \exp(-\gamma(s_t - c)^2)$

The test sequence is following:

$$H_{01} : \theta_{3j} = 0, j = 1, \ldots, p$$

$$H_{02} : \theta_{2j} = 0 I \theta_{3j} = 0, j = 1, \ldots, p$$

$$H_{03} : \theta_{1j} = 0 I \theta_{2j} = \theta_{3j} = 0, j = 1, \ldots, p$$

If H_{01} is rejected, Logistic STR is selected. If H_{01} is accepted and H_{02} is rejected, then Exponential STR is selected. If H_{01} and H_{02} are not rejected, but H_{03} is rejected then Logistic STR is also selected.

After the selection of the nonlinear specification, the STR model can be estimated with several tests for misspecification.

4.3.2 Regional Contagion Modelling

Each currency is related to its geographical area G_i, and we use an indicator of contagion $\overline{\sigma}_{it}^2$

$$\overline{\sigma}_{it}^2 = \sum_{j \epsilon G_i, j \neq i} \sigma_{jt}^2 \tag{4.3}$$

We measure this coefficient for each group: The Asian area with: China (CNY), Indonesia (IDR), India (INR), Korea (KRW), Malaysia (MYR) and Singapore (SGD). The Middle East area with: Kuwait (KWD), Bahrein (BH) and Jordan (JOD). The Latin American area with: Argentina (ARS), Brazil (BRL), Mexico (MXN), Colombia (COP), Venezuela (VEB). We use the same methodology as in previous part, but with emphasizing the nonlinear effect, by estimating the following model:

$$\begin{aligned} \sigma_{it}^2 = \alpha_{i10} + \sum_{j=1}^{p_i} \alpha_{i1j} \sigma_{it-j}^2 + \beta_{I1} S_t + \delta_{i1} \overline{\sigma}_{it}^2 \\ + \left(\alpha_{i20} + \sum_{j=1}^{p_i} \alpha_{i2} \sigma_{it-j}^2 + \beta_{i2} S_t + \delta_{i2} \overline{\sigma}_{it}^2 \right) g_i \left(X_t; \gamma_i; C_i \right) + \varepsilon_{it} \end{aligned} \tag{4.4}$$

With σ_t^2 is the degree of exchange rate volatility, proxied by the squared returns of the considered exchange rate series. ε_t is iid $\left(0, \sigma_\varepsilon^2\right)$, S_t is the transition variable and $g(X_{it}; \gamma; C)$ is the transition function which by convention is bounded by zero and one. $\gamma > 0$ denotes the slope parameter that determines the smoothness of the transition from one regime to the other, and C is the threshold parameter.

4.4 Empirical Results

In this part, we analyze the regional contagion effect and how it changes over time and across financial crises. The underlying hypothesis is that a currency is affected by its close neighbors. Because of each country tries to let their own currency more related by their neighbors.

4.4.1 Currency Volatility and Financial Crises Relationships

In following table, we report the estimation of some coefficients involved in STR process. This table presents the main results of linearity related to nominal exchange rates series.

Table 4.1 concerns the series of nominal exchange rates and presents the results of the linearity tests for each country, as well as the estimation of the STR models (Eq. 4.1) and the transition variable used, corresponding to the variable with the higher rejection of linearity test.

In Table 4.1 several results appear. The null hypothesis of linearity is rejected for the majority of the currencies. The majority presents Logistic STR, so the exchange volatility follows two different regimes linked to the level of financial crise. Otherwise, Exponential STR is related with intermediate situation. The volatility presents the same level for different situation of crise.

Exchange rate volatility and financial crise present a positive nonlinear relationship. That means volatilities increase more than proportionally with crises. In other words, exchange rate flexibility tends to increase more than proportionally with global financial volatility: countries whose currencies are pegged to the US dollar tend to loosen their peg in times of increasing uncertainty in the financial markets.

The variable which governs the change of regime mainly reflects the volatility on the developed financial markets and that of commodity prices, fewer countries react to volatility in emerging financial markets. This may be related to the fact that the currencies of commodity exporters generally depend on the terms of trade of commodities. The transition variable is mainly the CRB index, as it gives more weight to raw materials (other than fuels) which are exported by these countries.

The threshold values vary with both transition variable and currency. For the Argentinean case, and its 2002 crisis, VIX presents a threshold about 35. This result shows that the volatility of commodity prices can affect not only the currencies of commodity exporters but also those of highly dependent countries. The speed of adjustment is quite high in most countries. This means that the flexibility of the exchange rate changes quickly from one regime to another, depending on the level of global financial stress. Countries are more exposed to international volatility, whether represented by volatility in international stock markets or in commodities markets, explaining that the transition from low volatility to high volatility can be rapid.

4.4.2 Regional Contagion Effect

We tested for regional contagion because we consider that a country is more likely to be subject to contagion effects from its own neighbors than from the rest of the world. This hypothesis can be supported for various reasons. First, countries may want to stabilize their exchange rates vis-à-vis their trading partners, often

Table 4.1 Estimation of STR models and tests of linearity: Relationship between exchange rate and financial crise

Exchange rate/ US Dollar	Model	Lags	Linear Coef. of St	Nonlinear Coef. of St	Transition variable	Slope parameter	Threshold	
EUR	Logistic STR	3	−0.034(0.02)	45.347 (0.67)	VIX	55.76	5.39	397.67
CNY	Logistic STR	3	−5.766(0.14)	54.856 (0.44)	MSCI_W	123.86	66.67	
IDR	Exponential STR	1	−6.768(0.64)	33.983 (0.03)	MSCI_W	37.96	9.45	197.33
INR	Logistic STR	3	−12.786(0.86)	23.785 (0.03)	VIX	56.93	32.56	
KRW	Exponential STR	2	−4.876(0.03)	45.654 (0.63)	VIX	74.77	67.43	
MYR	Logistic STR	2	−4.765(0.01)	31.486 (0.41)	CRB	94.56	12.56	653.67
SGD	Exponential STR	3	−0.067(0.35)	76.671 (0.01)	CRB	27.56	445.86	
KWD	Exponential STR	3	−0.643(0.34)	54.556 (0.04)	CRB	142.77	6.34	423.78
BH	Logistic STR	2	−3.785(0.74)	55.675 (0.03)	S&P_GSCI	118.86	65.86	
JOD	Logistic STR	4	−2.723(0.12)	26.875 (0.61)	VIX	98.54	31.74	
ARS	Logistic STR	3	−0.033(0.03)	11.543 (0.49)	VIX	22.67	35.2	
BRL	Logistic STR	4	−0.038(0.02)	23.785 (0.54)	MSCI_W	32.45	65.69	
MXN	Logistic STR	4	−34.783(0.25)	43.556 (0.76)	MSCI_W	67.85	175.89	
COP	Logistic STR	2	−0.563(0.04)	38.485 (0.26)	CRB	88.54	76.87	587.34
VEB	Logistic STR	2	−4.423(0.44)	27.674 (0.04)	S&P_GSCI	45.82	12.98	

their neighbors, which prompts them to simultaneously change their exchange rate policies. Second, market pressures can increase concurrently in a given region as investors have to update their preferences over an entire region if something goes wrong.

Table 4.2 present the estimated coefficients of the indicator of contagion $\overline{\sigma}_{it}^{2}$ (Eq. 4.3) in linear and nonlinear mechanism.

We can observe on Table 4.2 the linear and nonlinear present different dynamics, however Logistic STR is mostly observed. The contagion effect is positive and higher for the nonlinear effect. We observe for the Asian area and Latin American areas a nonlinear contagion effect, but a linear effect for the Middle East area. These results confirm the non-linear effects of contagion, which increase significantly in times of crisis. In other words, during quiet times, exchange rate volatility in a given country is linearly affected by that of neighboring countries, while the links between currency markets increase during times of crisis.

In most cases, the transition variable reflects the volatility of international financial markets. This shows the importance of global financial tensions in advanced economies on the contagion process. For some countries (Argentina, Mexico and Brazil), the contagion indicator itself acts as a transition variable, which means that contagion tends to operate only above a given threshold.

The speed of transition is generally high, although it varies from country to country. This means that exchange rate volatility shifts rapidly from one regime to another, depending on either the level of global financial stress or the level of contagion, a finding consistent with the process of increasing integration of financial markets.

4.5 Conclusion

This research measures the links between exchange rate volatilities and financial crises among different area. These areas are geographically and economically related. Smooth transition regression models have been developed to test these links.

The data confirm that the flexibility of exchange rates tends to increase more than proportionally with the indicator of global financial strains. So, exchange rate volatility and the financial crisis present a positive nonlinear relationship, meaning that volatilities increase more than proportionally with crises. We have also evidenced nonlinearities in the contagion effects spreading from several currencies to its neighbors.

The threshold values vary with both transition variable and currency. Second, for The Asian and Latin American area shows a nonlinear contagion effect, but a linear effect for the Middle East area. Thus, in this area exchange rate volatility is linearly affected by the neighboring countries. This means, that exchange rate volatility increases faster than the financial crises.

These results can allow the understanding of different policies and further research could explain the current role of the dollars in world trade. The special

Table 4.2 Estimation of STR models and tests of linearity: Effect of contagion

Exchange rate/ US Dollar	Model	Lags	Linear Coef. of $\overline{\sigma}_{it}^2$	Nonlinear Coef. of $\overline{\sigma}_{it}^2$	Transition variable	Slope parameter	Threshold	
EUR	Logistic STR	3	−0.764(0.05)	5.276(0.37)	VIX	34.87	67.89	
CNY	Logistic STR	3	−65.986(0.01)	4.116(0.00)	VIX	108.45	88.45	675.78
IDR	Logistic STR	3	−9.765(0.28)	67.861(0.00)	VIX	121.67	44.86	
INR	Logistic STR	3	−8.556(0.12)	11.864(0.01)	S&P_GSCI	143.78	5.78	
KRW	Exponential STR	4	−5.745(0.04)	75.867(0.04)	CRB	134.97	23.78	
MYR	Exponential STR	4	−76.443(0.05)	55.238(0.04)	MSCI_W	143.85	78.47	119.56
SGD	Exponential STR	3	−0.856(0.14)	41.867(0.02)	VIX	118.57	64.45	
KWD	Exponential STR	2	−0.354(0.00)	98.231(0.01)	CRB	13.83	4.89	287.56
BH	Logistic STR	1	−3.265(0.04)	45.982(0.12)	CRB	17.73	57.45	
JOD	Logistic STR	1	−2.672(0.00)	74.435(0.00)	CRB	17.23	8.96	
ARS	Logistic STR	4	−0.8798(0.56)	34.987(0.00)	VIX	75.98	11.85	398.56
BRL	Logistic STR	4	−0.216(0.45)	78.457(0.01)	S&P_GSCI	41.64	8.54	
MXN	Logistic STR	4	−26.765(0.21)	56.237(0.01)	MSCI_W	78.34	9.34	
COP	Logistic STR	3	−51.116(0.67)	107.486(0.01)	CRB	31.45	6.85	475.58
VEB	Exponential STR	3	−67.373(0.34)	12.78(0.01)	CRB	78.98	9.22	

role of the US dollar in the international monetary system has been increasingly questioned for several years, as the United States has continued to accumulate external debts threatening the long-term value of its currency. It could also be one of the reasons why countries are loosening their ties with the US dollar.

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Chapter 5
Bank Lending Procyclicality and Digital Technologies; Does the Structure of the Financial Sector Matter?

Małgorzata PAWŁOWSKA

5.1 Introduction

Cyclical factors have a significant impact on bank lending. Therefore the concept of bank lending procyclicality has been widely discussed in the literature on macrofinancial linkages concerning the relation between the business cycle and the behavior of banks (Levine 2004; Granville and Mallick 2009; Bouvatier et al. 2012, 2014; Leroy and Lucotte 2019; Kouretas et al. 2020). The procyclical nature of bank lending is one of the basic arguments for regulating the financial sector and the regulatory framework may contribute to the procyclical nature of bank lending (Dewatripont and Tirole 2012).

In the economy, the course of the business cycle may be strengthened by the processes that occur in the financial system. The banking sector plays a major role here due to the banks' important functions when financing enterprises' investment activities and individual clients' use of products and services. The phenomenon of lending procyclicality means the existence of a feedback loop between the financial system and the real economy—increasing lending by banks boosts the economic situation, whereas limiting loan supply, due to losses caused by the economic slowdown, makes it difficult to exit the recession (Goodhart and Hofmann 2008).

Financial market imperfections related to the asymmetry of information about borrowers contribute to this phenomenon, which leads to negative selection and moral hazard problems (Stiglitz and Weiss 1981; Bernanke and Gertler 1989; Kiyotaki and Moore 1997). Furthermore, by credit rationing during an economic downturn or extending credit. Excessively during an economic expansion, banks distort the real business cycle, which leads to unsustainable growth, such as deeper

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recession in downturns. In this way, relatively minor economic shocks can be amplified and propagated by procyclical changes in the lending market (Borio 2014). Furthermore, advances in information technologies (ITs) have transformed banking practices and products. In this era of a dynamically changing world, the young generation of consumers is receptive and open to digitization, freely using innovative solutions with electronic channels (Internet, mobile devices) that allow remote access to financial services. Undoubtedly, technical changes have a huge impact on the current status of retail and corporate banking (Philippon 2017; Boobier 2020; Beaumont 2020) and also have an impact on the market structure of the financial sector and credit procyclicality (FSB 2017).

Although the impact of new ITs on the development of finance is not a novelty, it has gained more importance in the digital age. Consumers in both developed and emerging market economies are increasingly turning to digital financial services that are more affordable and more convenient. In recent years, the FinTech sector has been growing faster than traditional finance and will therefore have a huge impact on the lending market. While the most noticeable change, due to the use of new technologies, took place in the payments segment, also FinTech companies gradually took up basic banking services, including lending activities. This phenomenon influences the business models of banks and the level of competition in the market (Claessens et al. 2018; Cornelli et al. 2020).

This study focused on the determinants of the loan from the supply side. However, the relation between the situation on the financial market and the macroeconomic conditions of the economy is dynamic and bilateral. The nature of the links between the financial sector and the real economy depends on the market structure measured by the degree of concentration (CR_5, HHI index), foreign presence (e.g., the share of domestic banks in assets compared with that of foreign banks); as well as other characteristics of the development of the banking sector, including the degree of risk exposure (share of non-performing loans (NPLs), the measure of leverage, and the ratio of loans to deposits (LTD) as macroprudential policy tools (Vivies 2016; Pawłowska 2021).

In this study, we analyze the phenomenon of procyclicality in relation to market concentration measures, that is, the share of the five largest banks in total assets (CR_5), and also in relation to new digital technology. An economic term or a financial indicator is considered to be "procyclical" if it tends to amplify the fluctuations of the business cycle. The concept of lending procyclicality has also been widely discussed in the literature on macrofinancial linkages, especially to the extent that it explains the cyclical behavior of the banking sector. According to this characterization, lending behaves procyclically if fluctuation of lending dynamics decrease during an economic downturn and increase during a recovery (Borio et al. 2001; Borio 2014). The research questions are the following: *Does the market structure has varying effects on bank lending procyclicality in different European Union (EU) banking sectors and for different types of loans? Does the new digital technology affect bank lending procyclicality for different types of loans*?

In case to answer above questions concerning the relations between the real and the financial spheres, dynamic panel regression with using the generalized methods of moments estimator (GMM),[1] is used (see Kouretas and Pawłowska 2020). An alternative econometric approach to dynamic panel models is the construction of a vector regression panel model (VAR/pVAR panel), whose structural parameters are also often estimated using the GMM estimator (cf., Canova and Ciccarelli 2013; Leroy and Lucotte 2019). The main contribution of this research in relation to the existing literature on the apparent link between the banking sector's structure and credit procyclicality (e.g., Leroy and Lucotte 2019) is that this paper considers the phenomenon of procyclicality separately for different types of bank loans (residential mortgage, consumer and corporate) and we take into account concentration and digitalization in the banking sector in EU. Findings of this paper are in line with the paper by Kouretas, Pawłowska, and Szafrański (2020) that confirms that concentration in the banking sectors impacts on credit procyclicality, but this effect mainly occurs for mortgage loans and consumer loans. Furthermore, this study was conducted on a larger sample and broken down into other groups of EU countries, and additionally confirms impact of digitalization on credit procyclicality. Finally, this paper also contributes to the macroprudential literature and support sectoral macroprudential policy in EU and confirms that foreign ownership also contributes to procyclical variations across banking sectors.

5.2 Literature Review

In supply-side models that incorporate information asymmetry, access to external financing is typically linked to the strength of borrowers' balance sheets and the value of collateral for easily marketable assets, especially liquid assets, such as cash (Besanko and Thakor 1987). For demand side, many studies have shown that even relatively large enterprises, including listed companies, suffer from adverse balance sheet fluctuations, which also negatively affect their investments, especially in periods of recession (Levin and Natalucci 2005; Blanchard 2009; Degl'Innocenti et al. 2019). Financial market imperfections also affect loans to households. Households may be limited in borrowing due to income fluctuations. Household loans usually dominate banks' portfolios. For this reason, the monetary policy of some EU countries' central banks and the macroprudential policy developed in response to the 2008 financial crisis are mainly aimed at minimizing the credit risk of households.

Research on loans to households can be divided into research on consumer loans and mortgage loans. Many empirical studies have confirmed that changes in aggregate consumption are positively correlated with delayed or predictable changes in income growth and with an increase in bank loans (cf. Love and Zicchino 2006). Ludvigson (1999) shows a statistically significant correlation between an increase

[1] For our estimations, we also used the GMM system, a two-step robust estimator (Arellano and Bond 1991; Arellano and Bover 1995).

in consumption and a predictable increase in loans. Changes in house prices have a significant impact on household debt and spending, and the analysis of these prices plays an important role in research on financial crises. It has also been shown that financial imperfections related to house markets have implications that go beyond individual households, for example findings of recent empirical studies emphasizing the importance of house price dynamics in shaping business cycles (Cecchetti 2008; Leamer 2007). Changes in house prices have a significant impact on household debt and spending, and the analysis of these prices plays an important role in research on financial crises. It has also been shown that financial imperfections related to home markets have implications that go beyond individual households. This was highly visible in the United States, where there was an expansion of subprime lending and securitization. The loosening of the lending policy resulted in an avalanche of unpaid mortgage loans, a drop in real estate prices, and a rapid increase in unemployment rate.

In the literature, there are many papers concerning the relation between the business cycle and credit market in a broad sense (i.e. Chaibi and Ftiti 2015, Cull and Martinez Pería 2013; Huizinga and Laeven 2019). However, empirical research on the impact of the market structure on the dynamics of loans has ambiguous results. While financial services have some peculiarities, their distribution channels are similar to those of other industries. In the theoretical model developed by Besanko and Thakor (1992), taking into account the fact that financial products are heterogeneous, they analyze the impact of competition on the cost of loans and deposits. They show that increased competition causes lower interest rates on loans and raises interest rates on deposits. There is evidence that a greater concentration in the deposit and loan markets can lead to a deterioration of conditions for clients, that is, an increase in the loan cost, although the strength of this impact varies widely and differs among banking sectors in given countries (Degryse et al. 2009, p. 119; Vives 2016, Azar et al. 2019). In empirical paper, Huizinga and Laeven (2019) for banking sector in euro zone countries find that loan loss provisions tend to be more procyclical at larger and better capitalized banks. Cull and Martinez Pería 2013, analyzed determinants of three categories of credit for households (mortgage, consumer) and for nonfinancial corporation and find the impact of bank ownership on credit growth in developing countries.

Research on lending procyclicality has become the main topic of many economic publications, also from the perspective of the market structure's influence on this phenomenon in Europe (e.g., Bouvatier et al. 2012, 2014; Leroy and Lucotte 2019). For example, using panel data from EU countries, Leroy and Lucotte (2019) show the non-linearity of the dependence of lending procyclicality on the variables characterizing the market structure. These results are confirmed by Kouretas, Pawłowska, and Szafrański (2020) for the years 2004–2017 in EU. Claessens and Kose present a comprehensive review of the existing empirical research on procyclicality in the context of macrofinancial linkages (Claessens and Kose 2018). The theoretical underpinnings of supply-side procyclicality, in particular with regard to the procyclical behaviour of the banking sector, have been extensively explained in Athanasoglou, Daniilidis and Delis (2014).

Furthermore, the new technologies also influence the bank loan market on both the demand and the supply sides. On the supply side, as computers' computing power increases, the use of application programming interfaces on the Internet, Big Data technology, and cloud computing also increases. The demand factors include changes in consumer behavior (related to the convenience of investing using online and mobile tools), demographic factors, and the level of the development of the economy and the financial market. Demographic factors driving the demand for FinTech services are related to the growing influence of the younger generation in the financial service market (FSB 2019, pp. 5–10). FinTech companies influence the structure of the financial service market through the number and the size of market participants, entry and exit barriers, and the availability of information and technology to all market participants (Feyen et al. 2021). According to Vives (2017), competitors from the FinTech sector put pressure on banks to adapt their traditional business model to current trends and demands. Compared with FinTech companies, banks have two competitive advantages in the financial market: they can borrow at low rates, have access to deposits, which explicit or implicit insurance by the government, they enjoy privileged access to a stable customer base (Vives 2017). This indicates that entering the intermediation industry with new technologies will depend heavily on government regulations and guarantees related to COVID-19. Along with the development of the FinTech sector, there is a growing number of studies on its impact on the bank loan market and the stability of the financial sector by influencing the structure of the lending market. Research efforts are directed at organizing the ever-expanding literature on the development of the sector (e.g., Thakor 2020) or focus on a narrow aspect of this phenomenon; for example, Morse (2015) has studied social loans, and Buchak et al. (2018) have analyzed the housing loan market. Ultimately, it has been found that despite the rapid development of the FinTech sector, public trust favors banks and provides them with regular customers (Thakor 2020, p. 12). According to Thakor (2020), such trust provides lenders with reliable access to finance, and a loss of investor confidence makes regaining trust dependent on market conditions and the reputation of the lender. Finally, also Fintech contribute to procyclicality (Financial Stability Board 2017, p. 15). With the emergence of fintech's providing credit through either direct lending or by matching investors and borrowers through peer-to-peer (P2P) platforms, credit provision could potentially become more procyclical. While banks have exhibited procyclical lending behavior in the past, there is potentially a higher risk of such lending with fintech's.

5.3 Model Description

In case to answer questions put in the introduction, in this chapter was presented the panel data analysis concerning lending procyclicality for different types of loans in the context of the market structure, foreign capital and new technology, that is, whether they prolong economic cycles and whether their impact depends on the type of loan and the size of the banking sector in EU. The panel data analysis was provided for the period 2004–2019 with using the GMM estimator.

The study presented by Kouretas, Pawłowska, and Szafrański (2020) shows that the banking sector's market concentration, that is, its share in total assets affects procyclicality. Foreign ownership also contributes to procyclical variations across banking sectors. In the face of a strong crisis in the financial market, foreign banks tend to cause more procyclicality in the economy than domestic banks. This study was conducted on a larger sample than that in Kouretas, Pawłowska, and Szafrański's (2020) study, additionally covered the data for years 2018 and 2019,[2] and took into account the impact of new technology on credit growth. Particular attention was paid to the impact of digitalization of banks (technical progress and new players from the FinTech sector) and of the market structure (concentration and the foreign ownership) in the EU banking sectors on the dynamics of various types of bank loans (residential mortgage, consumer, and corporate loans).

The nature of the links between the financial sector and the real economy is complex (Pawłowska 2021). In good times, equity providers often tend to be overly generous with funding, thus creating bubbles (also encouraging more lending before the bubbles burst). In bad times, the flow of credit to the market is stalled too abruptly, limiting economic activity and consequently, financing. In the case of banks, these swings in sentiment are known as fluctuations in the credit cycle. It illustrates the volatility of loan availability for borrowers throughout the business cycle. In the first phase of the credit cycle (growth), loans are readily available. The characteristic features of this period include low interest rates and lower credit requirements, which then increase the availability of loans. In the second phase, the availability of loans decreases. During this period, interest rates rise, which increases the interest rates on loans and tightens credit requirements, which means that fewer people can meet them. Therefore, procyclicality is influenced by factors related to prudential regulation. For example, if more regulatory capital is required during a stunting phase, banks must reduce leverage and lending. The situation becomes worse than necessary. After the financial crisis of 2007–2009, reformers of the financial system have looked for ways to alleviate this phenomenon.

The study used annual data at the level of individual EU banks and at country level data. The used panel data set[3] contained microeconomic and macroeconomic data in the form of the panel for 28 EU countries at the level of individual EU banks and at country level data. The microeconomic data contained balance sheet information from individual banks in EU countries at the level of individual data from the Orbis Bank Focus database and the Bankscope database.[4] The macroeconomic data from individual EU countries were obtained from publicly available

[2] Furthermore, this research was carried out for all EU countries and divided into other groups than in the paper Kouretas, Pawłowska, and Szafrański's (2020).

[3] These were cross-sectional and time-series data. Usually, the number of observed objects N is large in relation to the number of points in time t [Arlano, 2003; Baltagi 2005].

[4] Individual data from the Orbis Bank Focus database was combined with data from the Bankscope database, which contained data from before 2011.

online databases of international organizations, such as: the European Central Bank (Statistical Data Warehouse), Eurostat and the International Monetary Fund. As the coverage of the research period began in 2004 (i.e., the year when 10 countries became EU members, including Poland), the research on the determinants of bank loans in the EU was divided into groups: small banking sectors, large banking sectors, and all EU countries. Small banking sectors belong to the so-called new EU (Cyprus, the Czech Republic, Estonia, Lithuania, Latvia, Malta, Poland, Slovakia, Slovenia, Hungary, Bulgaria, and Romania). Large banking sectors come from the countries of the so-called old EU (Austria, Belgium, Denmark, Finland, France, Greece, Spain, the Netherlands, Ireland, Luxembourg, Germany, Portugal, Sweden, Great Britain, and Italy). However, the consolidation processes in the banking sector in Central and Eastern Europe (CEE) were largely a natural consequence of the earlier privatization of domestic banks, attracting strategic investors to them, which generally increased not only the competition in the sector but also its concentration. The above processes resulted from the fact that the banking sector in the EU is not homogeneous (Pawłowska 2016) because the basic features of banking sectors differ in the old and the new EU member states. First, an important feature of banking sectors in the new EU countries is a high level of concentration and a high share of foreign capital (Arena et al. 2007; Anginer et al. 2017) as opposed to banking sectors in Western Europe. Second, the banking sectors in CEE are small compared with those of the old EU, and banks use relatively simple, traditional business models and focus on deposit and lending activities for businesses and households. Based on the characteristics of the above sectors, the data panel for the EU was thus divided into two subpanels. The first contained data on the countries of CEE; Croatia was added to the new EU, but two countries—Malta and Cyprus—were removed from it (CEE-11). The second panel (EU-17) contained data from the banking sectors of the old EU. This group was extended to include Malta and Cyprus because they do not belong to the countries of CEE and have not undergone any systemic transformation. The research period covered the years 2004–2019.

An empirical model was built to test the lending procyclicality and impact of new technology, on the supply side. To check whether the market structure and new technology strengthened or weakened the procyclicality phenomenon, the model was further extended to examine the interactions between the market structure and new technology and the business cycle. In a linear model, the effect of cross-enhancement of the effects of individual variables can also be taken into account concerning bank performance such profitability, capitalization and the size. Moreover, the model takes into account a binary variable defining foreign capital (Chen et al. 2017; Wu et al. 2017). The following model is described by following equation:

$$\begin{aligned}\Delta Loan_{i,t} &= \gamma_i + \mu_t + \varrho \Delta Loan_{i,t-1} + \textstyle\sum_{j=1}^{k} q_j X_{i,t} + \alpha_1 MS_{c,t} + \alpha_2 MS_{c,t}^2 \\ &+ \alpha_3 DigTech_{c,t} + \left(\beta_1 + \beta_2 MS_{c,t} + \beta_3 MS_{c,t}^2 + \beta_4 For_{i,t} + \alpha_5 DigTech_{c,t}\right) \\ &GDP_{c,t} + \Delta I_{c,t} + \beta_0 + e_{it},\end{aligned} \tag{5.1}$$

where: β_0 denotes the constant in the model, γ_i, μ_t represent standard errors in the model, e_{it}-random effect and q_j, βj, α_j signify regression coefficients $j = 1, \ldots, 4$. The dependent variable $\Delta Loan$ represents the annual variation of three types of loans: residential mortgage loans (household lending for house purchases), consumer loans, and corporate loans (lending to non-financial corporations) for each bank *i* in year *i*.

The independent variables include the following:

$MS_{c,\,t}$ denotes the variables regarding the structure of the banking defined as the share of the five largest credit institutions in total assets (CR5) for each year *t* in country *c*.

$GDP_{c,\,t}$ signifies the country-specific GDP growth in year *t* in country *c*.

Furthermore, the interest rate is one of the main factors influencing the cost of credit by affecting the creditworthiness of households and businesses and credit availability. The interest rate cycle has a close positive correlation with the business cycle. It is now an era of low interest rates, and central banks are pursuing a snow policy based on quantitative easing (QE).

$\Delta I_{c,t}$ represents annual changes in interest rates for different types of loans (residential mortgage loans $Irhome_{ct}$, consumer loans $Ircons_{ct}$, and corporate loans $Ircorp_{ct}$) for each year *t* in country *c*, which measures the effect of the price of credit.

In the literature review, we suggested that increasing the bank market share may have two opposite effects on lending growth and that the impact of the market structure on the lending procyclicality may be non-linear (i.e., U-shaped). To take this possibility into account, in the base model described by Eq. (5.1), the market structure component raised to the second power $MS^2{}_{c,t}$. was also taken into account. Moreover, a binary variable defining foreign ownership was adopted as the measure of foreign capital. It was constructed on the basis of the information on the bank's ownership structure, which specified the bank's ownership type ($For_{i,t}$). The value of the variable is one if the bank is foreign; otherwise, the value is zero.

X is a vector of the following control variables that determine a bank's performance and macroprudential policy instruments, for each bank *i* for each year *t* in country *c*: – loan-to-deposit ratio (*LTD*), – loan-to-asset ratio (*LTA*), – cost-to-income ratio (*CTI*), – the bank's capital-to-asset ratio (*Tier1*), and – bank profitability ratio: return on assets (*ROA*) and return on equity (*ROE*).

Additionally, as a bank-specific variable, one describing its 'size' for each bank *i* for each year *t* in country *c* was used, defined as the logarithm of total assets (*LA*).

$DigTech_{c,t}$ vector is consist of the following of the variables that take into account the new technology in country *c* in year *t*:

- the individuals in the population using the Internet for online banking (by percentage of the population) (*Internet*),
- Internet access from a mobile device, such as a laptop or a notebook (by percentage of the population) *(Mobile)*.

To estimate the impact of the market structure and foreign capital on the lending procyclicality, the following interaction conditions were defined in the base model:

$(MS_{c,t} \times GDP_{c,t})$ and $\left(MS_{c,t}^2 * GDP_{c,t}\right)$, $\left(For_{i,t} * GDP_{c,t}\right)$, $\left(DigTech_{c,t} * GDP_{c,t}\right)$.

Based on eq. (5.1), estimations were made for three types of bank loans (residential mortgage, consumer, and corporate loans). The data panel covered the years 2004–2019. The estimation results, broken down into two subpanels, allow a comparative analysis of bank lending procyclicality in the CEE-11 countries versus all EU countries (EU-28).

5.3.1 Results of the Model

To answer our research questions, we hypothesized that the procyclicality of the market structure would depend on the loan type and on various groups of EU countries. We also attempted to confirm that the influence of concentration and foreign capital on the procyclicality of a bank loan would differ, depending on the type of loan considered (residential mortgage, consumer, or corporate). The model estimation results according to eq. (5.1), with using GMM estimator, are presented in the Table 5.1. In order to check the correctness of the model described by the eq. (5.1), several tests proposed by Arellano and Bond (1991) and Arellano and Bover (1995) were used. Among the tests used should be mentioned: the Hansen test of over identifying restrictions, which tests the overall strength of the instruments for a two-step estimator; and the Arellano-Bond tests for AR(1) and AR(2) in the first differences.

Table 5.1 shows a negative and significant α_1 coefficient for the CR_5 index (estimation 1). This means that concentration, measured by the five largest banks' share in assets, has had a negative impact on the growth of mortgage loans, mainly in the EU-17 countries. In contrast to a negative and significant α_1 coefficients were found only for the EU-28 countries for consumer and corporate loans (estimations 6 and 9). This means that competition has had generally a positive impact on the growth of corporate and consumer loans in the EU countries. Moreover, we found that the impact of the market structure on the growth of lending was U-shaped, as a positive and significant α_2 coefficient was obtained for the ${CR_5}^2$ index for the EU-17 countries for mortgage loans (estimation 1) and also for growth of corporate and consumer loans in the EU countries (estimations 6 and 9). This may mean that in countries with lower concentration, the impact on credit growth is negative, versus the positive impact on countries with high concentration, but it depends on the type of bank loans.

Next, we examined whether economic growth had an impact on the dynamics of various types of loans in the context of lending procyclicality. It has been shown that the market structure mainly influences the procyclicality of mortgage loans. This result confirms a different relation between the concentration and the procyclicality of different loan types. Additionally, Table 5.1 shows a significant and positive coefficient β_2 for CR_5 for mortgage loans in the EU-17 countries (estimations 1

Table 5.1 Results of the GMM model for mortgage, consumer and corporate loans

	EU-17	CEE-11	EU	EU-17	CEE-11	EU	EU-17	CEE-11	EU
	Mortgage loans (morloans)			*Consumer loans (conloans)*			*Corporate loans (corloans)*		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Loans_{t-1}$	−0.28*	−0.29***	−0.32***	−0.11	−0.53***	−0.43***	−0.51***	−0.55***	−0.58***
Tier1	−1.04**	−2.76	−0.91**	−0,87*	−1.256	−0.48	−0.68	−0.75	−0.11
ROA	4.796	10.81	3.37	6.247**	10.25**	3.28	0.29	15.86***	1.63
LIQ	−6.87***	16.72	−5.82	−2.7	7.98	2.7	12.67***	1.95	7.82**
LTA	−0.987	1.299	−0.686	1.672*	3.40	1.58**	0.746	1.27	2.49***
LTD	0.036	0.211	0.261*	−0.226	−2.894*	−0.094	0.242	0.277	−0.26
CTI	−0.25	0.274	−0.29**	0.606*	0.038	0.167	−0.073	−0.245	−0.33**
LA	−4.88***	7.208	−7.71***	−8.15**	−4.18	−6.72*	−2.82	6.899	3.49
MS	−2.97**	−3.29	−2.18	−2.27	−1.425	−7.17*	−1.92	−4.61	−3.35**
MS^2	0.03**	0.06	0.02	0.02	0.009	0.057*	0.016	0.043	0.021*
GDP	0.09	0.09*	0.12**	10.628	−66.93*	16.11	4.58	16.145	3.88
*MS*GDP*	−1.19***	−1.23	−1.47***	−0.318	1.625	−0.69	−0.206	−0.416	−0.255
MS^2*GDP	0.013***	0.009	0.015***	0.002	−0.010	0.006	0.003	0.002	0.003*
*For*GDP*	0.06	−0.01	−0.26*	−14.401*	−0.702	2.962	−3.684	4.984*	4.06*
FinTech	−0.00	−0.00	−0.00*	0.02	−0.38**	0.03	0.00	0.00	−0.00
*FinTech*GDP*	0.02	−0.01*	−0.00	−0.00	0.01**	−0.00	0.00	0.00	−0.00
No. of observations	1763	228	1991	1867	498	2365	1225	472	1697
No. of ID	776	87	863	815	183	998	486	172	658
AR(1) test	0.273	0.503	0.071	0.273	0.503	0.168	0.927	0.479	0.793
AR(2) test	0.741	0.731	0.159	0.741	0.731	0.049	0.147	0.818	0.133
Hansen test	0.622	0.269	0.427	0.622	0.269	0.517	0.460	0.963	0.332

Source: authors' own calculations

Notes: The dependent variable *Loans* denotes the growth rate of mortgage loans, consumer loans, and corporate loans. GMM is a two-step generalized method of moments estimation, a two-step difference GMM estimator. *MS* is the CR_5 ratio (the five largest credit institutions' share in total assets). *For* is the foreign bank dummy variable. *Tier1*, *ROA*, *LIQ*, *LTA*, *LTD*, *CTI*, and *LA* denote banking control variables. *GDP* denotes GDP growth yoy. Interest rates (*Irhome*, *Ircons*, *Ircorp*) are inserted but not reported. AR(1) refers to the Arellano-Bond test for AR(1) in first differences. AR(2) refers to the Arellano-Bond test for AR(2) in first differences. The Hansen test is the test for over-identifying restrictions in GMM. Robust standard errors are in parentheses, $***p < 0.01$, $**p < 0.05$, $*p < 0.1$

and 2). Also, Table 5.1 shows a significant and positive coefficient β_2 for CR_5 for mortgage loans in the EU-17 countries (estimations 1 and 2). Table 5.1 shows a positive and significant coefficient β_1 only for consumer loans (estimations 4). They therefore suggest a different procyclicality effect that may change as concentration increases, in the case of household loans (for mortgage and consumer loans).

Based on the estimation results, we found that on one hand, foreign ownership had an impact on procyclicality mainly in the case of mortgage loans and consumer loans; the β_4 coefficient for the EU-17 countries turned out to be significant and negative for consumer loans and for all EU for mortgage loans (Table 5.1, estimations 3 and 4). On the other hand, foreign ownership had a positive impact on the procyclicality of corporate loans for the CEE-11 countries and all EU countries based on the GMM estimation (Table 5.1, estimations 8 and 9). Finally, based on the estimation results, we found that new digital technology mainly had a positive impact mainly on the procyclicality of consumer loans and negative impact of mortgage loans in the case of CEE-11.

The estimation results also showed different responses to microprudential and macroprudential policies, depending on the group of EU countries and the type of the loan under consideration. However, capitalization as measured by the Tier1 ratio had a negative impact mainly on the growth of mortgage loans from EU-17 banks (see Table 5.1, estimations 1 and 3). The results confirmed that the deleveraging process in EU banks contributed to the growth of mortgage loans. Profitability and liquidity also contributed to increasing lending in the EU. Profitability had a positive impact mainly on the growth of mortgage loans in the case of EU-17 banks, and liquidity had a positive impact mainly on the growth of corporate loans in the case of EU-17 banks (see Table 5.1, estimations 4 and 8). However, in case of profitability for corporate loans for CEE-11. Also, the results also showed that the ratio of total deposits to total net loans had a positive and significant impact mainly on mortgage loans. Summarizing all of the above results, evidence showed that macroprudential instruments and new capital regulations contributed to lending growth in the context of the business cycle. Moreover, the size of the bank, measured by the amount of total assets (*LA*), positively influenced the growth of mortgage loans in the CEE-11 countries and negatively did so in the EU-17 countries. This finding is confirmed that bank size is an important factor in loan growth.

Finally this study showed that the market structure variables had the greatest impact on the dynamics mainly of residential mortgage home loans. In the case of consumer and corporate loans, the variables determining the structure of the banking sector turned out to be insignificant. Additionally, this this study's findings have shown that at the microeconomic level, there are non-linear dependencies between market concentration and lending procyclicality, mainly in relation to household loans. The results suggest that the procyclicality effect of lending is U-shaped and may change as the concentration increases.

The results of this research also contribute to the literature on the subject of the impact of macroprudential policy on bank lending procyclicality. They may also prove that the deleveraging process in EU banks reduces lending procyclicality. All of the above results confirm that the determinants of the growth of different types of loans in both groups of countries (CEE-11 and EU-17) differ. The impact of concentration and foreign capital on the growth of lending varies, depending on the type of loan (residential mortgage, consumer, or corporate loans). These results also confirm the heterogeneity of the banking sectors in the EU. Finally, this study's findings show a negative impact of new technology on the growth of bank loans, particularly consumer loans, in EU countries. Which means that competitors from the fintech sector are taking some of the customers away from traditional banks.

5.4 Impact of COVID-19 on Bank Lending

EU governments, central banks, and international institutions (the International Monetary Fund, the World Bank and the European Investment Bank) took immediate action to reduce the negative effects of the COVID-19 pandemic in 2020. These activities applied to all areas of economic policy, including lending and the behavior of clients of financial institutions (Armantier et al. 2021). Regarding micro-prudential supervision, most of the activities of the EU countries concerned the banking sector, and their main goal was to maintain the flow of credit to the real economy. These included allowing the use of capital buffers to absorb losses, temporary non-compliance with certain capital requirements, and waiving of related sanctions. In the case of liquidity standards, these were allowing banks to temporarily operate below regulatory requirements; a flexible approach to the classification of credit exposures, including issuing guidelines for reducing the procyclical effects of applying International Financial Reporting Standard 9 (IFRS9); and reduction of operational burdens resulting from existing supervisory priorities or from reporting obligations. Recommendations were also issued regarding the suspension of dividends and the buyback of treasury shares. As for activities related to the banking sector, we should mention the introduction of statutory moratoria on loan repayments in some countries. The macroprudential authorities of the EU countries also took quick action, easing the parameters of the instruments already in force or withdrawing from the announced tightening of macroprudential measures. These measures were aimed at reducing the risk of a procyclical tightening of lending conditions by allowing banks to absorb losses through previously accumulated capital buffers. In particular, countries that previously had a countercyclical buffer decided to reduce its required level, sometimes to zero, or cancelled its increase. The macroprudential authorities of several EU countries have lowered (or fully released) the systemic risk buffer and the buffer of other systemically important institutions. At the same time, some countries have eased the parameters of tools not harmonized by EU law, such as loan to value limits (LTV) or on the burden of the borrower's current income with borrowing obligations or the costs of servicing them (Carletti et al. 2020, p. 18). It should be noted that monetary and prudential support caused that bank asset quality has been preserved despite the sharp recession. However, in fact, for the euro area, the non-performing loans ratio (NPLs) reached its lowest level on record at 2.7% in 2020, due to that banks reduced legacy portfolios (ECB 2022). It should be noted that at this stage of the data, the impact of COVID-19 on banks' lending activities is impossible to quantify. Although the study presented in this paper ended in 2019, the impact of COVID-19 on banks' lending activities cannot be overlooked in the model. However, Çolak, and Öztekin, (2021) evaluated the influence of the pandemic on global bank lending and identified bank and country characteristics that amplify or weaken the effect of the disease outbreak on bank credit and find that bank lending is weaker in countries that are more affected by the health crisis.

5.5 Conclusions

The results of the analysis makes it possible to conclude that for two groups of EU countries (CEE-11 and EU-17), the influence of the market structure and new technology on the lending procyclicality differs, depending on the type of loan (residential mortgage, consumer, or corporate). The results of the studies do not provide an unequivocal answer about the role of foreign capital; rather, they indicate the impact of bank concentration and size on lending procyclicality. However, the relation between bank concentration and loan availability is certainly not as simple as the relation between concentration and the product market in the real economy. Moreover, separate lending channels (for residential mortgage, consumer, or corporate loans) may differ in strength in spreading real shocks during business cycles. The dominant role of loans to households in the intensification of macroeconomic volatility is also confirmed, which speaks for the sectoral and the national approach in macroprudential policy. Furthermore, in this paper, we confirm the impact on new digital technologies on the growth of consumer loans.

A further direction of thus research could be the more deeper analysis of the influence of digitalization on procyclicality observed for various types of loans (especially the differences between consumer and residential mortgage loans). Another direction of research should be the enhancement of the bank-level database and the pandemic period in the context of the increasing role of digital technology FinTech. Futhermore, financial stability conditions have deteriorated due to higher inflation couse to politytical situation (ECB, Financial Stability Review, May 2022).

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Chapter 6
What Role for Macroeconomic Environment on Living Standards in Times of Crisis and Uncertainty

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6.1 Introduction

Macroeconomic uncertainty and economic downturns have been threatening living standards in the euro area for more than a decade!

The global financial crisis of 2007–2008 led to an economic crisis with unprecedented consequences in post-war history. The "financial-crisis-caused" economic downturn was followed by a sovereign debt crisis that spread quickly across the euro area. The debt restructuring of several euro area states, amid recession, spiked the levels of economic uncertainty and exacerbated the European economic environment. Estimates from the European Central Bank (2016, p. 72) indicated that the increase in uncertainty dampened real GDP growth for up to three quarters.

Presumably at the crisis end in 2017 (Buti 2017), most member states of the European Union (EU) reached their pre-crisis levels of GDP, half of them reached their pre-crisis levels of gross fixed capital formation, and only 10 reached their pre-crisis levels of employment (Vlachos and Bitzenis 2019). The effect of COVID-19 pandemic on economic activity eventually halted the slow pace of several euro area states' economic recovery, which had been accompanied by an increasing tax burden and the negative effects of austerity measures on human development. The COVID-19 (and the preceding prolonged economic) crisis spread economic insecurity across income groups and occupational classes, even in low-inequality, encompassing welfare European states (Ranci et al. 2021).[1] The estimates from

[1] For example, the COVID-19 pandemic has uneven effects on the self- employed because they are less protected by the social safety net.

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the European Central Bank indicate that uncertainty shocks may dampen real GDP growth for up to four quarters and that the spike in macroeconomic uncertainty is likely to have contributed significantly to the decline in euro area real GDP in 2020 (Gieseck and Rujin 2020, p. 64).

All these events have been major obstacles that prevented the achievement of Europe 2020 Strategy goals of employment and inclusive growth.[2] The Europe 2020 strategy had set the target of "lifting at least 20 million people out of the risk of poverty or social exclusion" by 2020 compared to year 2008. Since 116.1 million people were at risk of poverty or social exclusion in the EU-27 in 2008 (including the United Kingdom and excluding Croatia), the target value to be reached was 96.1 million in 2020.[3] Data from Eurostat indicates that people at risk of poverty or social exclusion in the EU were approximately 110 million in 2018 (including data for the United Kingdom).[4]

The aim of this chapter is to examine the impact of macroeconomic factors on living standards in times of macroeconomic uncertainty. The goal is to estimate and discuss the effect of macroeconomic factors on the living standards of euro area states that were mostly hit by this century's (henceforth) great recession. The findings will provide economic policy orientations to achieve Europe 2030 goals on poverty reduction.

The effect of COVID-19 pandemic on economic activity halted the anemic pace of economic recovery in member states who bore the brunt of the great recession, such as Greece, Italy, Portugal and Spain. Real GDP recorded for these economies in 2020, was still below their respective levels in 2007–2008.[5] The macroeconomic uncertainty which influenced their economic performance during and after the great recession, mainly due to public opposition and domestic political pressures (Cabral et al. 2013), will influence the speed of their economic recovery, this time due to the increase in uncertainty caused by the pandemic.

In light of recent evidence on the effects of macroeconomic uncertainty on economic growth and human development, such as Benigno et al. (2020. pp. 16–17)[6] who find that higher uncertainty causes declines in output, consumption, investment, and employment (hours worked) and support the findings of previous

[2] Banking and debt crises decrease the income of the lowest quintile in high-income countries by approximately 13% and 17%, respectively (Rewilak 2018).

[3] 2008 data for the EU-27 were used as the baseline year for monitoring progress towards the Europe 2020 strategy's poverty target. Please see the following link: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Europe_2020_indicators_-_poverty_and_social_exclusion&oldid=394836#cite_note-1 (accessed December 1, 2021).

[4] People at risk of poverty or social exclusion in the EU-27 were approximately 96 million in 2019. See https://ec.europa.eu/eurostat/data/database (accessed December 1, 2021).

[5] GDP in 2020, chain linked volumes (index = 2015). See https://ec.europa.eu/eurostat/data/database (accessed December 1, 2021).

[6] Paper prepared for the European Parliament's Committee on Economic and Monetary Affairs (ECON) as an input to the Monetary Dialogue of 19 November 2020 between ECON and the President of the European Central Bank.

studies on the economic impact of uncertainty (Bloom 2014, pp. 170–171), it is critical to assess the impact of macroeconomic factors on living standards in order to discuss the potential of the European Pillar of Social Rights Action Plan (EU 2030 target) to reduce the number of people at risk of poverty or social exclusion by at least 15 million.[7]

The focus on living standards requires the analysis of data on material deprivation rather than income poverty. According to Fusco et al. (2010, pp. 16–17):

- income does not measure adequately all available resources and wealth,
- standard of living or deprivation have a stronger link with permanent income, and
- the equivalised household disposable income addresses household size and composition but does not address differences in needs.

The macroeconomic factors that determine material deprivation will cover main indicators such as GDP or national income and unemployment.

The rest of the chapter is organized as follows. Section 6.2 describes the three main theoretical strands on the causes of poverty and indicates why poverty measurement has been linked with expenditures representing living standards. Section 6.3 discusses material deprivation, the EU approach to measuring living standards, and reviews selected empirical studies of macro-level determinants. Section 6.4 presents the empirical strategy. Section 6.5 presents the empirical results. Section 6.6 discusses the results and gives policy recommendations.

6.2 Poverty Causes and Measurement

Brady (2019) classifies the explanations of the causes of poverty into three broad families of theories: behavioral, structural and political. The distinctions between theories are provided by the answers to the following questions:

1. "How much are behaviors beyond individual control and dictated by structure?"
2. "How much can governments moderate the behavior-poverty link?"
3. "How much can governments moderate the effects of demographic and labor market contexts?"

The answer to the first question provides the distinction between structural and behavioral explanations: structure is more important than behavior if, for example, individuals exert limited control on whether they are poor during structural changes such as economic development. The answer to the second question provides the distinction between political and behavioral explanations: behavior is more important than politics if, for example, unemployment triggers poverty regardless

[7] See https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:The_European_Pillar_of_Social_Rights_Action_Plan_(EU_2030_targets)&stable=0&redirect=no (accessed December 1, 2021).

of the social policy and institutional context. The answer to the third question provides the distinction between structural and political explanations: structure is less important than politics if, for example, states can accomplish low poverty regardless of economic development.

Macro-level explanations of poverty indicate the level of poverty, and individual accounts indicate who becomes poor (Calnitsky 2018). Living standards indices for measuring poverty have been related to the utility concept of economic theory (Ngo 2018). Sen (1987) defines the standard of living in terms of functioning (achievements) and capabilities (the ability to achieve): what life people actually lead and the freedom people have in the choice of life. Based on this definition, Kakwani (1993) finds that the standard of living is less responsive to income per capita in richer countries. Furthermore, Boarini et al. (2021) indicate that income is a poor indicator of the social cost of the great recession: living standards of poor households fell by 5.3% annually, while GDP per capita stagnated across OECD countries.

The preference of consumption expenditures over measures of income is twofold. First, consumption expenditures relate needs with commodities. A reference budget standard is a specific basket of commodities which, when priced, can represent a particular standard of living. Large-scale surveys of poverty and deprivation are of particular importance in determining minimum living standards (Deeming 2017). Second, the income received in a given period may not be the source of consumption expenditures over that period. Under the consideration that economic crises magnify the role of assets in cushioning severe income shocks, poverty levels should be estimated by taking into account assets and debt (Kuypers and Marx 2021).

6.3 Empirical Studies of Country-Level Factors Determining Material Deprivation in the EU

The material deprivation rate is an indicator of the lack of (at least) three out of nine necessary and desirable items based on data from the European Union Statistics on Income and Living Conditions (EU-SILC). It measures the percentage of the population that does not have the ability to: (i) meet unexpected expenses; (ii) pay a mortgage, rent, utility bills or other loan payments on time; (iii) afford a one-week annual holiday away from home; (iv) adequately heat their dwelling; (v) afford a meal with meat, fish or a vegetarian equivalent every second day; (vi) purchase a range of durable goods such as a washing machine, (vii) a color television, (viii) a telephone, (ix) or a car. The severe material deprivation rate is an indicator of enforced inability with a threshold set at four lacks.[8]

[8] For definitions see Eurostat (2018, p. 141) and Eurostat statistics explained at https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Material_deprivation (accessed December 1, 2021).

The literature of material deprivation in the EU distinguishes between micro- and macro-level determinants. Bárcena-Martín et al. (2014) who investigate the effects of a larger set of macro-level variables find that country-specific factors are much more relevant than individual effects in explaining differences in material deprivation across European countries. Their finding suggests that the socio-demographic characteristics of individuals/households are shaped by institutional and structural country-specific factors, which have to be considered in order to design measures to reduce the difference in material deprivation among countries.

Nelson (2012) makes use of the EU-SILC data from 26 European countries for the year 2008 to assess the extent to which social assistance accounts for differences in the prevalence of material deprivation. The macro-level explanatory variables are the: level of social assistance benefits, GDP per capita, non-means-tested benefit expenditure, public service expenditure, activity rate, unemployment rate, long-term unemployment rate, educational expenditure and active labor market policy expenditure. The findings indicate that the material deprivation rate has a negative relationship with social assistance benefits, GDP per capita, and the activity rate, and a positive relationship with the unemployment rate and the long-term unemployment rate.

Bárcena-Martín et al. (2014) examine whether country differences with respect to material deprivation levels can be explained by differences in the micro- or the macro-level perspective, and make use of the EU-SILC data from 28 European countries for the year 2007. The macro-level explanatory variables are the: GDP ratio of total expenditure on social protection, long-term unemployment rate, income quintile share ratio s80s20, and GDP per capita. The findings indicate that severe material deprivation has a positive relationship with social policy expenditures and GDP per capita, and a negative relationship with long-term unemployment.

Duiella and Turrini (2014) investigate the determinants of severe material deprivation in EU-28 for the period of 2005–2012. The explanatory variables are the: lagged level of severe material deprivation, the lagged growth rate of GDP per capita, lagged change in unemployment rate, the lagged change in long-term unemployment rate, lagged change in at risk-of-poverty rate, lagged change in Gini coefficient, and a dummy for the post-2007 crisis period. The findings indicate that severe material deprivation has a tendency to converge to a stable value over time,[9] and can be seen as capturing the gradual depletion of households' resources over long-term unemployment. Duiella and Turrini (2014) also investigate the impact of social expenditure variables and find that expenditures on housing benefits, social assistance and unemployment benefits and social protection are associated with a decrease in severe material deprivation.

Ribeiro et al. (2014) assess deprivation in 24 EU Member States, from 2005 to 2012. They extend the methodology of the "index of multiple deprivation" for the United Kingdom (UK) to develop the "index of multiple deprivation for developed

[9] Lagged severe material deprivation rate has a significantly negative coefficient.

countries" and the explanatory variables are the: general government gross fixed capital formation (percent of GDP), GDP per capita, interaction of GDP per capita with Gini coefficient,[10] unemployment rate, general government total expenditures on social protection net of total taxes (percent of GDP), interaction of general government total expenditures on social protection net of total taxes (percent of GDP) with a dummy capturing the phase of the economic cycle,[11] average rate of change in the harmonized index of consumer prices, and Worldwide Governance Indicators[12] (WGI). The findings indicate that multiple deprivation is reduced as GDP per capita increases, is negatively associated with higher-quality institutional environments, and increases along with the unemployment rate.

Visser et al. (2014) investigate the effect of macroeconomic circumstances and social protection expenditure on economic deprivation. They make use of the European Social Survey data from 25 European countries for the years 2010–2011 and construct the dependent variable of economic deprivation in the 3 years before 2010–2011. The macro-level explanatory variables are the: unemployment rate, GDP per capita (expressed in PPS), relative changes in unemployment rate, relative changes in GDP per capita, social protection expenditure (percent of GDP), interaction of social protection expenditure with unemployment rate and interaction of social protection expenditure with GDP per capita. The findings indicate that economic deprivation is negatively associated with GDP per capita and social protection expenditure. The interaction effects reveal that economic conditions temper the influence of social protection expenditure on economic deprivation.

Crettaz (2015) investigates the extent to which macro-level factors affect the income and living standards of workers. Crettaz (2015) makes use of the EU-SILC data from 7 different countries for the years 2008, 2011 and 2012, and constructs the indicator of working material deprivation. The significant correlation coefficients of the association tests between changes in various macro-level factors (real GDP growth rate, GDP per capita in PPS, unemployment rate, income quintile share ratio S80/S20, Gini coefficient, decile ratio of gross earnings D5/D1, low pay incidence, and average rates of social assistance) and changes in working material deprivation indicate a negative relationship between working material deprivation and economic growth, and the share of low-wage workers, and a positive relationship between unemployment and working material deprivation.

Kis et al. (2015) examine the determinants of severe material deprivation rates and make use of the EU-SILC data from 27 EU Member States over the period 2005–2012 to construct country-level variables. The explanatory variables are the: average equivalised disposable income, difference between the median equivalised

[10] The purpose is to assess the marginal effects of growth on poverty at different levels of disposable income inequality.

[11] The purpose is to control for the impacts of redistributive policies on poverty in the different phases of the business cycle.

[12] Simple average (of six indicators): voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law, and control of corruption.

disposable income of people below the at-risk-of-poverty threshold and the at-risk-of-poverty threshold (expressed as a percentage of the at-risk-of-poverty threshold), interaction of disposable income with poverty gap, average social transfers, general government expenditure on education (percent of GDP), general government expenditure on healthcare (percent of GDP), general government expenditure on old-age pensions (percent of GDP), unemployment benefit (percent of GDP), family or child allowance (percent of GDP), employment rate (15–64 years), and household savings (percent of GDP). The findings indicate a positive relationship between severe material deprivation and disposable income, and the degree of income inequality (poverty gap), and a negative relationship between severe material deprivation and the savings rate.

Dudek (2019) investigates which country-level factors affect the severe material deprivation rate in 27 EU Member States, with data for the period of 2008 to 2015. The explanatory variables are the: GDP per capita (expressed in PPS), long-term unemployment rate, ratio of total expenditure on social protection in relation to GDP, median equivalised disposable household income (expressed in PPS), relative median at-risk-of-poverty gap indicator, Gini coefficient, and income quintile share ratio S80/S20. The findings indicate that severe material deprivation rates are negatively affected by GDP per capita, social protection, and disposable household income.

6.4 Data and Model Specification

The investigation of selected macro-level determinants of material deprivation is based on the findings of empirical studies discussed in the previous section. Considering that only one empirical study (Dudek 2019) explores data after 2012, recent developments are explored in this chapter for the cases of Greece, Italy, Portugal and Spain over the period 2005–2019.

Table 6.1 presents the dependent and the explanatory variables. The dependent variable is severe material deprivation and the panel data is analyzed with the following model:

$$Dep_{it} = X_{it}\beta + u_{it} \tag{6.1}$$

Where X is regressor vector of explanatory variables for each of the *i* member state at time *t*.

This is the general form of the fixed effects model whose selection is based on the results of the Hausman test for the panel data sample presented in Table 6.1. The explanatory variables are analyzed with the following model:

$$Dep_{it} = Inc_{it} + Exp_{it} + Ineq_{it} + Inst_{it} + Unem_{it} + u_{it} \tag{6.2}$$

Table 6.1 Variables and data sources

Variable	Source
Severe material deprivation, no. of persons	Eurostat
GDP per capita in PPS	Eurostat
Social protection benefits, euro per inhabitant	Eurostat
Gini coefficient	Eurostat
Unemployment, no. of persons	Eurostat
Long-term unemployment, no. of persons	Eurostat
Very long-term unemployment, no. of persons)	Eurostat
WGI[a]	World Bank

Sources: Eurostat database available at https://ec.europa.eu/eurostat/data/database (accessed June 28, 2021). World Bank databank available at https://databank.worldbank.org/source/worldwide-governance-indicators (accessed June 28, 2021)
[a]Simple average of six indicators as in Ribeiro, Silva and Guimarães (2014)

The dependent variables include income (GDP per capita), government expenditure on social protection (social protection benefits), inequality (Gini coefficient), institutional quality (WGI) and unemployment (general, for 12 months or more, and for 24 months or more). As mentioned above, the selection of all explanatory variables is based on the findings of studies discussed in the previous section. u_{it} denotes the error term.

6.5 Empirical Results

A brief discussion of the steps in the analysis of the panel data sample presented in Table 6.1 is in the Appendix. Table 6.2 presents the estimates of model (2) via the Weighted Least Squares (WLS) for heteroscedasticity correction of the fixed effects. The results agree with findings from previous studies (referred in brackets) discussed in Sect. 6.3. Social protection benefits (Nelson 2012; Duiella and Turrini 2014; Visser et al. 2014; Dudek 2019) have the greatest effect on severe material deprivation. Institutional quality (Ribeiro et al. 2014) and unemployment (Nelson 2012; Bárcena-Martín et al. 2014; Duiella and Turrini 2014; Ribeiro et al. 2014; Crettaz 2015) have a moderate effect (absolute value of coefficients <1) and changes in income distribution measured by the Gini coefficient have a lesser effect. Some of the previous studies discussed in Sect. 6.3, find that the degree of income inequality has an effect on deprivation: poverty gap for instance, in the case of Kis et al. (2015). However, there are no statistically significant findings reported for the Gini coefficient.

Finally, GDP per capita is positively associated but in contrast to the findings of previous research (Nelson 2012; Duiella and Turrini 2014; Ribeiro et al. 2014; Visser et al. 2014; Crettaz 2015; Dudek 2019), it is not statistically significant. Following the distinctions of Brady (2019) between theoretical explanations of the

Table 6.2 WLS for heteroscedasticity correction of the fixed effects (Greece, Italy, Portugal and Spain)

Explanatory variables & test statistics	1		2		3	
Constant	−5.10 ∗ ∗∗	(1.84)	−4.86 ∗ ∗	(1.85)	−3.99 ∗ ∗	(1.91)
Log GDPpc	0.76	(0.55)	1.04	(0.54)	0.86	(0.55)
Log socprotben	−1.51 ∗ ∗∗	(0.33)	−1.22 ∗ ∗∗	(0.33)	−1.31 ∗ ∗∗	(0.33)
Gini	0.04 ∗ ∗∗	(0.01)	0.03∗	(0.01)	0.02	(0.01)
WGI	−0.42 ∗ ∗∗	(0.07)	−0.35 ∗ ∗∗	(0.07)	−0.32 ∗ ∗∗	(0.07)
Log unemp	0.22 ∗ ∗∗	(0.05)				
Log lt unemp			0.26 ∗ ∗∗	(0.05)		
Log vlt unemp					0.24 ∗ ∗∗	(0.05)
R^2	0.90		0.89		0.89	

Notes: Robust standard error in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 6.3 WLS for heteroscedasticity correction of the fixed effects (Greece and Portugal)

Explanatory variables & test statistics	1		2		3	
Constant	4.85∗	(2.40)	5.71 ∗ ∗	(2.10)	7.25 ∗ ∗∗	(2.00)
Log GDPpc	0.47	(0.40)	0.24	(0.33)	−0.02	(0.31)
Log socprotben	−0.75 ∗ ∗∗	(0.16)	−0.57 ∗ ∗∗	(0.19)	−0.56 ∗ ∗	(0.21)
Gini	0.02 ∗ ∗∗	(0.01)	0.02 ∗ ∗	(0.01)	0.02 ∗ ∗	(0,01)
WGI	−0.44 ∗ ∗∗	(0.04)	−0.43 ∗ ∗∗	(0.04)	−0.45 ∗ ∗∗	(0,04)
Log unemp	0.26 ∗ ∗∗	(0.09)				
Log lt unemp			0.17 ∗ ∗∗	(0.06)		
Log vlt unemp					0.11 ∗ ∗	(0,05)
R^2	0.97		0.97		0.96	

Notes: Robust standard error in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

causes of poverty, the findings indicate that politics are more important (with regard to social protection benefits and institutional context) than behavior (in terms of unemployment) and structure (regarding the Gini coefficient and GDP per capita).

Table 6.3 presents estimates for Greece and Portugal and Table 6.4 for Italy and Spain. These are more homogeneous groups considering their size in terms of demand and output. Table 6.3 indicates similar findings to those of Table 6.2 with two notable differences. First, the coefficient of social protection benefits is almost half the size of the respective in Table 6.2. Second, the effect of unemployment weakens through time. Following the distinctions of Brady (2019), the results indicate that politics remain the most important factor explaining severe material deprivation. However, the weaking effect of unemployment through time requires for further investigation. A possible explanation could be that the very long-term unemployed receive income through undeclared work and reduce their level of deprivation.

Table 6.4 WLS for heteroscedasticity correction of the fixed effects (Italy and Spain)

Explanatory variables & test statistics	1		2		3	
Constant	11.73 ∗ ∗	(4.35)	10.84 ∗ ∗	(4.18)	12.02 ∗ ∗∗	(3.75)
Log GDPpc	−1.68 ∗ ∗	(0.81)	−0.98	(0.85)	−1.21∗	(0.65)
Log socprotben	−0.62	(0.71)	−0.09	(0.75)	−0.21	(0.59)
Gini	0.04	(0.03)	−0.02	(0.04)	−0.05	(0.04)
WGI	−1.15 ∗ ∗∗	(0.35)	−1.17 ∗ ∗∗	(0.34)	−0.98 ∗ ∗∗	(0.30)
Log unemp	−0.08	(0.19)				
Log lt unemp			0.20	(0.171)		
Log vlt unemp					0.27 ∗ ∗	(0.11)
R^2	0.91		0.92		0.93	

Notes: Robust standard error in brackets. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 6.4 presents a very different picture than Table 6.2. GDP per capita is negatively associated and has the greatest effect on severe material deprivation. The effect of institutional quality is much stronger (absolute value of coefficients ≥1). Only very long-term unemployment has a statistically significant effect on severe material deprivation. Following Duiella and Turrini (2014), this estimate can be seen as capturing the gradual depletion of households' resources over very long-term unemployment. Following the distinctions of Brady (2019), the results indicate that structure (in terms of GDP per capita) is more important than politics (in terms of institutional context), since these two states cannot accomplish low deprivation rates regardless of economic development. The differences in the results indicate that an one-size-fits-all strategy to reduce poverty is not efficient. Although the institutional context remains a statistically significant critical determining factor for both groups, differences in the productive capacity differentiate their results.

6.6 Conclusion and Policy Recommendations

Under the consideration that macro-level explanations of poverty indicate the level of poverty (Calnitsky 2018), this chapter revisits the macro-level determinants of living standards in the EU over a period of economic crisis and uncertainty. Consistent with Eurostat methodologies, living standards are investigated in terms of material deprivation.

The empirical results of the model of macro-level determinants of severe material deprivation support some of the findings of previous research. Although the size of the sample in terms of the number of economies examined is smaller than in previous research, the time-series consider developments not previously examined in four euro area member states who bore the brunt of the great recession. The results for the total sample indicate that in the bigger picture, the role of government expenditure in terms of social protection benefits and unemployment benefits, is critical to the size of severe material deprivation. This finding is in favor of the debate on redesigning EU fiscal rules (Blanchard et al. 2021). Their reinstatement due to the pandemic's end will require from governments to cut spending even if the evidence suggests that doing so would have negative consequences for living standards. In addition, severe material deprivation is negatively associated with higher-quality institutional environments. This finding indicates the requirement for states such as Greece to improve their level of institutional quality (Vlachos and Bitzenis 2022).

When the sample is broken-down into two groups, one consisting of the two relatively bigger and more industrial economies and one of the two smaller economies with less industrial production, the results indicate that an one-size-fits-all strategy to reduce poverty would not be efficient. The results for the group of Italy and Spain indicate that economic growth will contribute to the reduction of severe material deprivation by increasing labor demand, raising wages and reducing the rate of long-term unemployment. The results for Greece and Portugal indicate that GDP growth does not have the same effect on severe material deprivation. In contrast to the case of Italy and Spain, the effects of unequal income distribution (Gini coefficient) and social protection benefits are important. This may be due to the lesser effect of GDP growth on job creation.

The results also imply that the decrease of severe material deprivation rates will be less time consuming in economies with smaller income gaps. Shifts in income inequality are therefore necessary for the materialization of the European Pillar of Social Rights Action Plan 2030 target of poverty reduction in the EU. Otherwise, changes in poverty rates and income distribution specific to the intrinsic characteristics of member states will probably occur.

In conclusion, as the economies recover from the consequences of COVID-19 pandemic on economic activity, severe material deprivation rates will decrease. All efforts made at the member states level to reduce income inequality should be accompanied by a revised European macro-economic framework for fiscal discipline. The over a decade-long period of uncertainty caused by the pendulum between periods of economic downturn and anemic growth stresses the need for an immediate and effective response to secure a V-shaped post-pandemic recovery. This response should entail productive investment expenditures in human development (health and education) and infrastructure improvements that must be exempted from the existing EU fiscal rules framework.

Appendix

Log transformation is applied to all variables but the Gini coefficient and the WGI. The Im–Pesaran–Shin test statistic is not significant and the hypothesis that all cross-sections have unit root is rejected.

The model is estimated via 4 different regressions:

1. Pooled ordinary least squares (OLS) for testing whether the data should be analyzed with fixed or random effects. The variance inflation factors of all explanatory variables have values lower than 10. The results of the Hausman specification test indicate the selection of fixed effects.
2. Pooled WLS for heteroscedasticity correction of pooled OLS, following the White test results for heteroscedasticity.
3. Fixed (within) effects estimation. The Wooldridge test result does not reject the null hypothesis of no serial correlation.
4. WLS for heteroscedasticity correction of the fixed effects. The results of the Wald test of the fixed effects estimation indicate the presence of heteroscedasticity and for that reason a WLS is performed.

Across all 4 regressions, the Durbin-Watson test statistic indicates that the residuals are not autocorrelated and the normality test results indicate that the residuals are normally distributed.

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Part II
Financial Markets Behavior Under COVID-19 Crisis

Chapter 7
What Can We Learn from Statistical Regularities in Stock Returns? Insights from An Entropy-Constrained Framework

Emanuele CITERA

7.1 Introduction

The behavior of stock returns has been the object of an extensive literature, ranging from the original empirical studies on the Efficient Market Hypothesis (EMH) (Fama 1965, 1970) to the developments in behavioral finance, which has attempted to discredit the EMH on multiple grounds. The advent of simulation tools has allowed researchers to simulate artificial stock markets and provide further evidence of inefficiencies at both the individual and the aggregate level.[1] Yet, as found by Bhowmik and Wang (2020), the most widely used econometric technique in the last decade to assess stock market volatility and return analysis involves broad variations of generalized autoregressive conditional heteroskedastic (GARCH) models (uni- and multi-variate, linear and nonlinear, symmetric and asymmetric, and Markov-switching models). The main purpose of these techniques is to detect the presence of serial correlations in stock returns, and to understand whether they conform to a random walk model underpinning the EMH. However, the quest for serial correlations raises several issues from both a theoretical and empirical standpoint.

First, despite the considerable availability of daily stock prices, even in a relatively short time horizon, hundreds of observations might not be enough to distinguish an efficient market model from a relevant alternative. To see this, suppose we are attempting to distinguish a random walk from a continuous-time first-order autoregressive process. In the former, whether prices are too high or too

[1] Woo et al. (2020) provide an extensive literature review of models of stock returns starting from 1960.

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low has no ability to predict future changes. In the latter, when prices are too high relative to the mean they should tend eventually to fall (a sort of bursting of the bubble, though not a sudden catastrophic one). Yet, tests may have very little power to distinguish the two models, if the autoregressive parameter is close enough to one, even with a large number of minute to minute observations (Shiller 2015, p. 244).[2]

Secondly, as Fama (1965, p. 80) himself acknowledges, serial correlations models "only test for dependence which is present all through the data. It is possible, however, that price changes are dependent only in special conditions". Even though, generally speaking, the finiteness of economic data implies a lack of sufficient evidence to draw meaningful conclusions on the existence of serial correlations, the above claim sheds light on the question of statistical dependence. Indeed, a time series that has a dense amount of non-redundant economic information, such as stock prices, exhibits statistical features that are almost indistinguishable from those observed in a completely random sequence. This is a truly important point in order to understand the behavior of stock returns, given that in the presence of heterogeneous beliefs and positive feedback among investors' behavior, complex dynamics and chaotic outcomes can be an essential source of apparent randomness and statistical independence.

Finally, most of the econometric tests adopted to estimate the presence of serial correlations introduce strong prioristic assumptions in the structure of the error term, which considerably reduces the amount of information embedded in the data. Given the centrality of the informational content of stock prices, along with the difficulty in extracting a subset of economic information associated with some specific aspects (that is to say, to discriminate between noise and signal), we may wonder how we could make the best use of such information. In this sense, information theory (Golan 2018) can provide remarkable insights, as we will see through the rest of this paper.[3]

In light of this discussion, the purpose of this chapter is to develop a theory of statistical equilibrium based on an entropy-constrained framework, that can allow us to recover the distribution of stock returns over different market periods. The chapter is structured as follows. Section 7.2 focuses on the analysis and the properties of the collected data, discussing how we can interpret them in terms of statistical equilibrium. Section 7.3 develops the Quantal Response Statistical Equilibrium (QRSE) model, which is our theoretical framework to analyze the distribution of

[2] This is further exacerbated when we move to longer holding-period returns, in the order of decades, which still pose considerable econometric challenges (see Campbell et al. 1997, pp. 59–80, Fama and French 2018). In this case, not only the amount of available observations is drastically reduced, thus jeopardizing the reliability of the estimates themselves, but the difficulty of distinguishing between a permanent and transitory component prevents us from detecting potential sources of predictability in stock returns.

[3] The root of information theory can be traced back to algorithmic complexity theory developed by Kolmogorov (1968) and Chaitin (1966). According to this theory, a series of symbols is considered unpredictable if the information embodied in it cannot be reduced to a more compact form.

stock returns. Section 7.4 provides a discussion of the results of the model, whereas Sect. 7.5 draws the final conclusions.

7.2 Data Collection and Analysis

To build our dataset, we retrieve from Yahoo Finance the time series of daily closing prices, adjusted for stock splits and dividend distribution, for all the individual companies listed in the S&P 500 index. Our dataset spans the period 01/01/1988–12/31/2019.[4] We then compute daily rates of returns, $r_{i,t}$, at the individual company level as follows:

$$r_{i,t} = \log[p_{i,t}] - \log[p_{i,t-1}] \,. \tag{7.1}$$

The reason why we choose daily returns is twofold. On the one hand, it provides us with a significant amount of data points to make an inference on their frequency distribution. On the other, longer holding-period returns in the time domain are a convolution of a fixed kernel representing the holding period with the daily returns. Therefore, daily returns include a great deal of useful information.

Given that, for an untraded stock, the associated logarithmic return is 0%, a spike in the distribution at this level of return arises. To tackle this issue, we decide to remove all the observations corresponding to a 0% level of returns. Furthermore, since the range of daily returns is extremely wide, we only consider returns within the range [−15%/day; 15%/day], that is to say almost six and a half standard deviations from the mean. This allows us, on the one hand, to account for "black swans", which are defined as events within three standard deviations from the mean, and, on the other, to focus on the area where the majority of the information lies. After implementing this procedure, we get a dataset made of 3,004,150 observations.

It is important to note that we do not weigh the individual stock returns by the respective market capitalization. This is due to the fact that we are not creating a value-weighted portfolio (which is why we do not standardize the returns), but we assume that an investor is moving capital between different companies assigning to each of them the same weight (a sort of equal-weighted portfolio). To further understand the properties of our data, alongside our analysis we generate a time series of returns following an arithmetic Brownian motion sampled at regularly spaced unit intervals, as follows:

$$\log[p_{i,t}] = \mu_i + \log[p_{i,t-1}] + \epsilon_t, \quad \epsilon_t \sim i.i.d.\, \mathcal{N}(0, \sigma_i^2) \,, \tag{7.2}$$

[4] Given that, during this period, the inflation rate in the United States has been relatively constant, we only consider the nominal rate of returns.

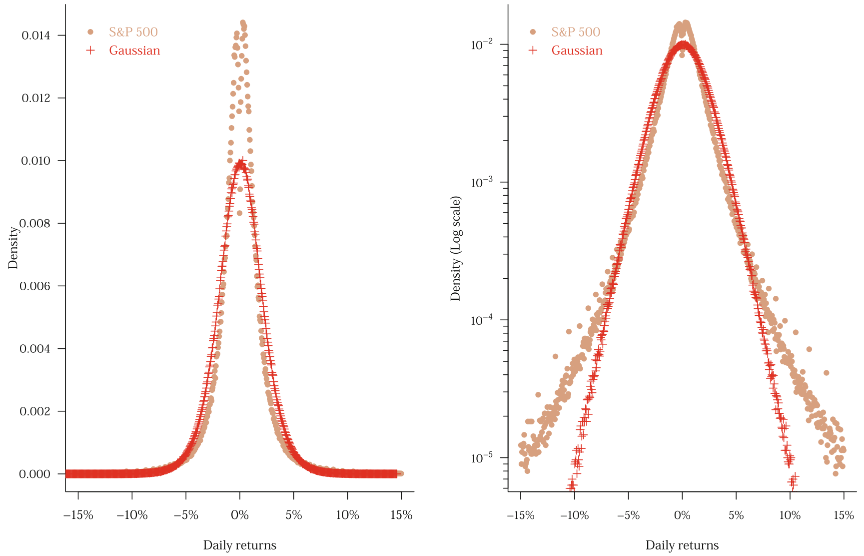


Fig. 7.1 Pooled distribution of stock returns. Empirical (S&P 500) and Gaussian simulated data are coarse grained into a histogram vector with a bin width spaced by a rate of return of 0.05%/day

Table 7.1 Moments of empirical and Gaussian returns (values expressed as %/day)

	Mean	Standard deviation	Skewness	Excess kurtosis
S&P 500	0.0547	2.2095	0.0322	5.7139
	(0.0525, 0.0572)	(2.2063, 2.2132)	(0.0187, 0.0445)	(5.6680, 5.7598)
Gaussian simulation	0.0575	2.2079	−0.0009	0.8728
	(0.0550, 0.0600)	(2.2062, 2.2097)	(−0.0037, 0.0019)	(0.8673, 0.8784)

Values in parenthesis refer to the 95% confidence interval, computed through ordinary bootstrap for empirical returns.

where μ_i and σ_i^2 respectively denote the mean and standard deviation of the daily returns computed at the individual company level. Figure 7.1 shows the pooled distributions of the S&P 500 and Gaussian simulated returns over the whole sample, whereas Table 7.1 summarizes the respective four moments.

As Fig. 7.1 shows, the empirical distribution of stock returns exhibits fatter tails as compared to a Gaussian Normal (an established result within the literature, which goes back to Fama 1965). Indeed, we can see that both the measure of skewness and kurtosis of empirical returns are both statistically significant, as shown by the respective confidence intervals computed for Gaussian simulated returns.[5] A

[5] The standard errors for skewness and kurtosis estimates under the null hypothesis of normality are $\sqrt{\frac{24}{3{,}004{,}150}} = 0.0028$ and $\sqrt{\frac{6}{3{,}004{,}150}} = 0.0014$ respectively.

particularly interesting thing to note is the single peak in the empirical distribution, which determines a precise central tendency, along with fluctuations around it. For the purpose of statistical equilibrium, this is truly important feature. Indeed, economic variables that exhibit statistical regularities (such as a central moment) can be considered in equilibrium precisely because there are negative forces that stabilize the distribution.

Since regarding thirty years of stock market events as a unique statistical equilibrium distribution is rather courageous, let us divide our sample into bull, bear markets, and corrections. Whereas bear markets are defined as declines of 20% or more over at least a two-month period, corrections are declines of 10% (but not greater than 20%) from the most recent peak. Figure 7.2 shows the cross-sectional distribution of stock returns over some specific periods, namely a bear market (solid line), a correction (dashed line), and a bull market (dotted line). Despite the differences in the modes of the distributions, we can acknowledge a similar variance and a clear central tendency. This is truly important in terms of statistical equilibrium, in that it shows us the presence of statistical regularities over different time horizons. To inspect this further, let us consider the four empirical moments of the cross-sectional distributions over each period of reference through the whole sample, as shown in Fig. 7.3.

By looking at the empirical moments, we can acknowledge two important features of our data. First, the distributions of returns do not show any specific trend in the mean. On the contrary, there seems to be a cyclical pattern, punctuated by wide

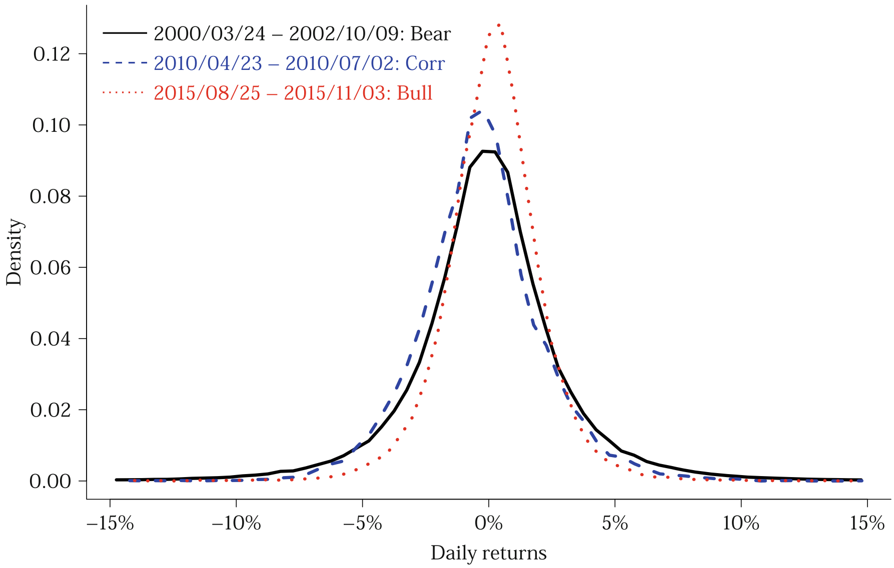


Fig. 7.2 Cross-sectional distributions over bull, bear markets, and corrections. The solid line represents the distribution of a bear market, the dashed line of a correction and the dotted line of a bull market

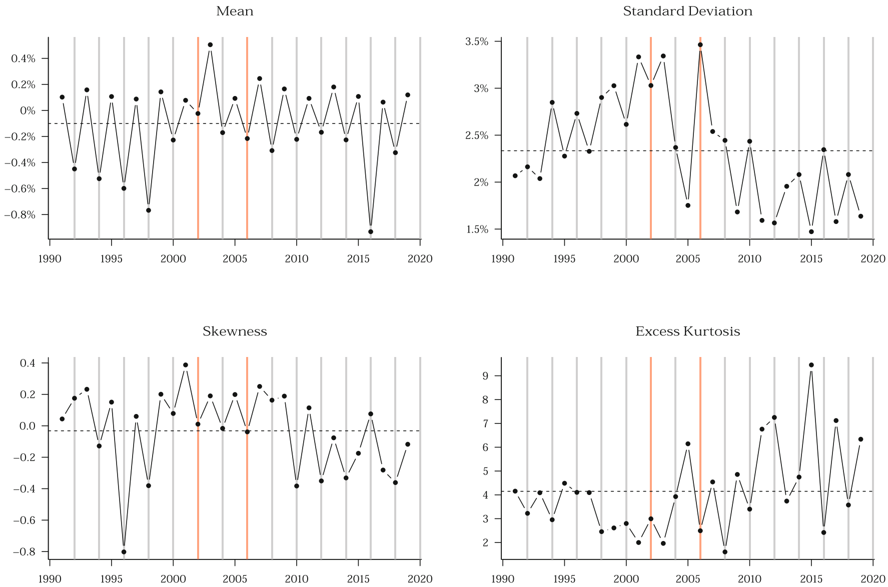


Fig. 7.3 Empirical moments over bull, bear markets, and corrections. The grey bars denote corrections, whereas the red bars bear markets. The dashed lines show the average value over the entire sample. Each moment is computed with respect to the cross-sectional distribution of stock returns over each period of reference. Mean and standard deviation are expressed as %/day

fluctuations, around the long-term average. A similar pattern can be acknowledged in the skewness, even though we can detect an increasing trend over the period 1996–2000, and a decreasing trend starting right before the Great Recession. It is also interesting to note how the average skewness over the entire period is almost zero, which implies symmetry in the associated frequency distribution. The second thing to note is the extreme volatility of daily returns, especially before 2010. If we look at the standard deviation, we can witness an increasing trend before 2002, which then decreases after 2009. This pattern is reflected in the excess kurtosis, which moves in the opposite direction, meaning that returns are mostly concentrated around the average.

7.3 The Quantal Response Statistical Equilibrium Model

The Quantal Response Statistical Equilibrium (QRSE) model, originally put forward by Scharfenaker and Foley (2017), provides a method to explain the observed regularities in highly complex systems by taking into account social interactions between a large number of heterogeneous individuals and their reactions to the economic variable of interest (in our case, the rate of return on stock prices). The main objective is to analyze the market dynamics in a rather simple fashion without relying on ad-hoc assumptions.

In the QRSE model, equilibrium takes the form of an information-theoretic probability distribution representing all possible states of the system. By adopting the Maximum Entropy Principle (Jaynes 2003) as a method of inference, which we discuss in more detail in Appendix 1, the model introduces a general framework where the conventional general equilibrium outcome exists just as a special and highly unlikely state of the economic systems.[6] The underlying logic of the model is based on classical political economic theory (Smith 1776). However, in our paper, we apply it to the case of stock market returns as follows.

Investors, seeking above-average rates of return from their transactions, let us say in a specific company stock, generate a "tendential gravitation" around a certain rate of return as an unintentional result of their interactions with other actors. Therefore, their decisions in the process of competing for higher expected returns determine, at any point in time, the change in price level thus creating an average rate of price change in the market as a whole. This process, which can be interpreted as the statistical equalization of stock returns, generates statistical regularities that can be observed in the fat-tailed, single-peaked Laplace distributions characterizing stock returns over different time horizons.

If we relate the logic of our model to the behavior of the stock market, we can identify three components of crucial importance. First, investors' alertness to excess returns is an important determinant of the volatility of the market. Second, the unintended feedback of transactions on returns dictates how trading impacts liquidity, which in turn affects variations in the level of returns. Third, the role of investors' expectations determine whether transactions take place or not, thus relating individual beliefs to market outcomes. The QRSE model can be helpful in explaining the above features by accounting for (1) the assumption of quantal response behavior of the market participants, (2) the negative feedback mechanism (representing the impact of individual actions on social outcomes), (3) the role of expectations. Let us now turn to analyze each concept in more detail.

7.3.1 The Behavioral Constraint

The first component of the model represents a behavioral theory of the typical agent in terms of the probability that they will choose a particular action, $a = \{sell, buy\}$, conditional on the variable r, the rate of return, and is expressed in the conditional distribution $f[a|r]$. This conditional distribution expresses the response probabilities over the action set given r, and quantifies the impact of r on the individual action frequencies. Its functional form, whose analytical derivation is

[6] An interactive version of the model is available here: https://emanuelecitera.shinyapps.io/Shiny/.

shown in Appendix 1, is the logit quantal response distribution (with $\beta = \frac{1}{T}$):

$$f[buy|r] = \frac{1}{1 + e^{\frac{u[a,r]}{T}}} \qquad f[sell|r] = \frac{1}{1 + e^{-\frac{u[a,r]}{T}}} \tag{7.3}$$

The parameter T represents the attentiveness of the typical agent. As Fig. 7.4 shows, the lower the T, the more alert the individual is to differences in payoff, and the more closely the action approximates the unconstrained payoff-maximizing outcome.

While entropy-constrained behavior is a generalization of rational choice theory there are several important differences with crucial implications. Figure 7.5 shows the implications of entropy-constrained behavior and its impact on the inferred marginal distribution of outcomes, $\hat{f}[r]$. As argued by Blackwell (2018), these implications are far-reaching and worth analyzing in more detail.

In the limiting case where $T \to 0$ (Fig. 7.5a), the behavior of the agent becomes completely deterministic, meaning that agents will always choose to sell the stocks, whenever $r > \mu$, and to buy whenever $r < \mu$. In turn, the conditional distribution $f[a|r]$ approaches the Heavyside step function, and $\hat{f}[r]$ approximates a single-peaked Laplace distribution. When $T > 0$, individual agents' preferences no longer satisfy the assumptions of consistency and completeness, and there is a positive probability for each action an individual will make. In this case, $\hat{f}[r]$ will exhibit fat-tails similar to a Student's T distribution (Fig. 7.5b). Finally, as $T \to \infty$ the

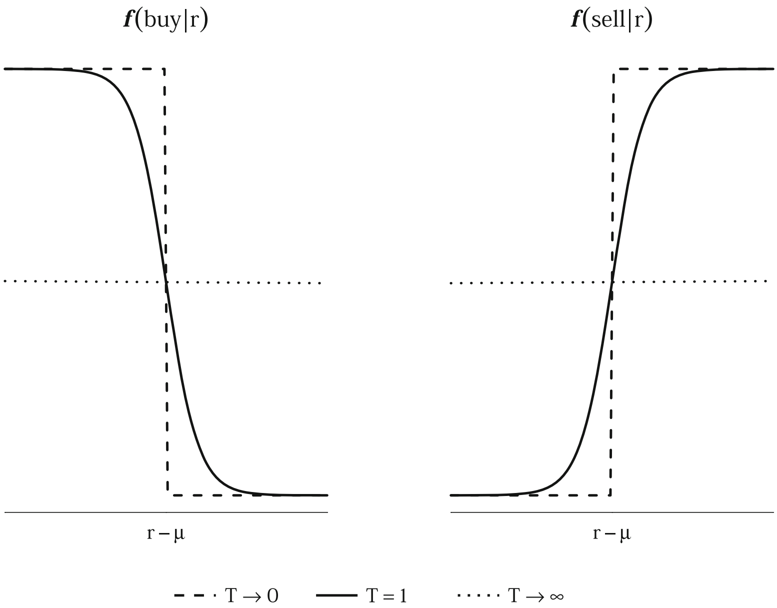
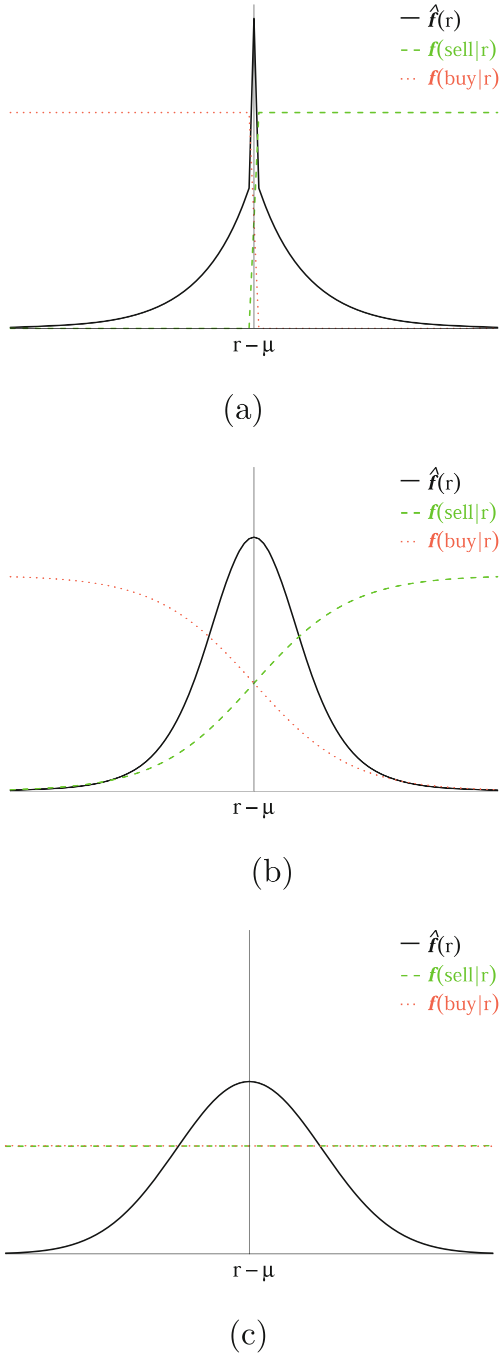


Fig. 7.4 Logit quantal response conditional probabilities. The functions are plotted for different values of T, while holding $\mu = 0$

Fig. 7.5 Relationship between T and $\hat{f}[r]$. The functions are plotted for different values of T, while holding $\mu = 0$. (**a**) $\mu = 0$, $T = 0.0001$. (**b**) $\mu = 0$, $T = 1$. (**c**) $\mu = 0$, $T = 1000$



actions are random and conditionally independent of the outcome r, and therefore $f[a|r] \to f[a]$. As a results, the QRSE marginal distribution $\hat{f}[r]$ converges to a Normal distribution, as shown in Fig. 7.5c.

In terms of investors' behavior, the above results have two implications. First, they dovetail with some behavioral theories, such as the Adaptive Market Hypothesis (Lo 2019), which calls for an adaptive and evolutionary investors' behavior as market conditions change. In our framework, this can be captured by changes in the degree of attentiveness, which allows for heterogeneous behaviors. Second, a characteristic of logistic behavior models is that the log odds of making two decisions is equal to the ratio of the expected utility of the two decisions, which implies:

$$\log\left[\frac{f[buy|r]}{f[sell|r]}\right] = \frac{r-\mu}{T}\,. \tag{7.4}$$

The above equation tells us something about the risk propensity of the agent. Indeed, since the parameter T denotes the standard deviation of the Sigmoid function (Eq. (7.3)), the higher the T, the higher the risk a trader is willing to accept in making investment decisions, and vice versa.

7.3.2 The Feedback Constraint

Economic variables that exhibit statistical regularities such as a central moment and stable endogenous fluctuations can be considered in equilibrium precisely because there are negative forces that stabilize the distribution. Indeed, whereas payoff maximizing agents are seeking rates of return above their expected fundamental valuation of the asset to sell, buyers look for stocks whose returns are below their expected fundamental rate of price increase. Unintentionally, actions of sellers cause a decline in stock returns, while the behavior of buyers causes an increase. Accordingly, the second component of the model reflects the impact of the action on the outcome variable, $f[r|a]$.

The conditional distribution $f[r|a]$ expresses a theory of the formation of social outcomes. If the actions of individual participants had no impact on the outcome, then $f[r|a] = f[a]$, as in the standard general equilibrium framework. However, in light of our previous discussion, we assume that actions do impact outcomes, which implies that the act of buying/selling a stock tends to increase/decrease its rate of return.

Given that statistical equilibrium in the joint distribution $f[a,r]$ implies that r is statistically regulated by a through a negative feedback mechanism, the buying and selling actions tend to push the market outcomes around a certain level of return, which we denote with α. Accordingly, we can write this condition as follows:

$$\int f[buy,r]r\,dr \le \alpha \le \int f[sell,r]r\,dr \tag{7.5}$$

Then, we have:

$$
\begin{aligned}
&\int f[sell, r](r-\alpha)\,dr - \int f[buy, r](r-\alpha)\,dr \\
=& f[sell]\mathbb{E}[(r-\alpha)|sell] - f[buy]\mathbb{E}[(r-\alpha)|buy] \\
=& \int (f[sell|r] - f[buy|r]) f[r](r-\alpha)\,dr \\
=& \int \left(\frac{1}{1+e^{-\frac{u[a,r]}{T}}} - \frac{1}{1+e^{\frac{u[a,r]}{T}}} \right) f[r](r-\alpha)\,dr \\
=& \int \left(\frac{1-e^{-\frac{u[a,r]}{T}}}{1+e^{-\frac{u[a,r]}{T}}} \right) f[r](r-\alpha)\,dr \\
=& \int \tanh\left[\frac{r-\mu}{2T}\right] f[r](r-\alpha)\,dr \geq 0
\end{aligned} \tag{7.6}
$$

Note that, if there were no impact of the actions on the outcome, the expectation of stock returns conditional on the buying action would tend to be higher than the expectation conditional on the selling action. However, the presence of the negative feedback tends to constrain this difference to a positive but finite value δ, implying that:

$$
\int f[sell, r](r-\alpha)\,dr - \int f[buy, r](r-\alpha)\,dr \leq \delta \tag{7.7}
$$

The parameter δ is an indirect measure of the dependence of a on r. The smaller the δ, the stronger the actions in changing the outcome. When $\delta = 0$, $\int f[sell, r]r\,dr = \int f[buy, r]r\,dr = \alpha$, which implies the actions have an infinite effect on stabilizing the outcome at the α level of stock return. Figure 7.6 shows the effect of the negative feedback through variations in δ.

Even though the feedback from agents' actions to the outcome is one of the foundational blocks of reflexivity theory (Soros 2013), the presence of negative feedback can be somehow questionable within the realm of financial markets. Indeed, asset bubble episodes are normally explained as positive feedback mechanisms which unfold by means of strategic complementarities. Despite Soros himself acknowledging negative feedback as the mechanism aligning individual beliefs with the objective reality, in our model it has a different implication, which concerns the liquidity effect.

If too many agents adopt the same trading strategy, then they effectively reduce the overall profitability of that trading strategy, generating a sort of crowding out effect. Accordingly, this endogenous process tends to push the market outcome towards a conventional rate of return which satisfies investors' behavior, thus explaining the observed peakedness in the distribution of stock returns.

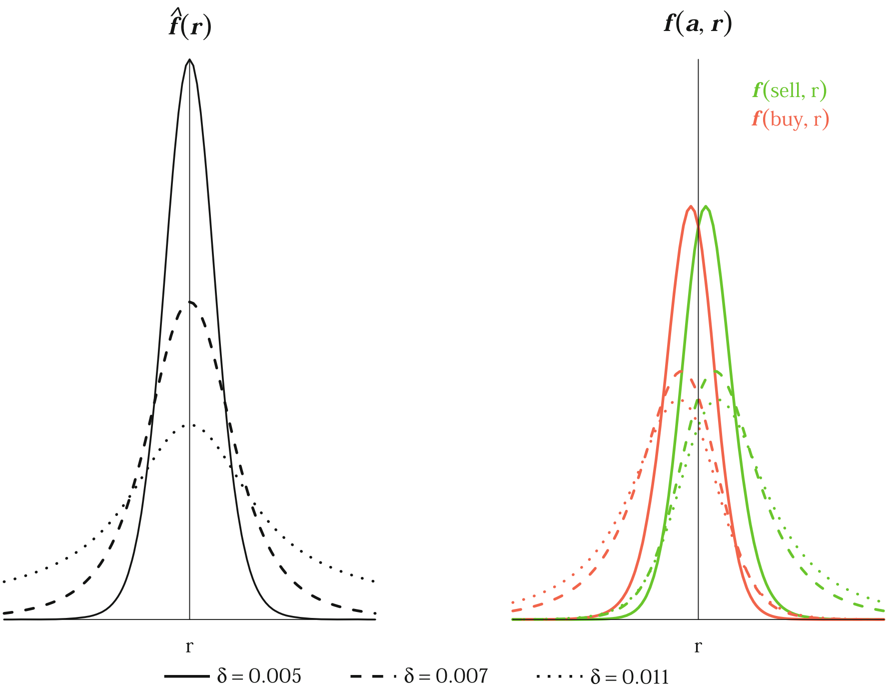


Fig. 7.6 Negative feedback mechanisms. The strength of the negative feedback is captured by variations in δ. As δ decreases, the marginal and joint frequency distribution, $\hat{f}[r]$ and $f[a, r]$, become increasingly leptokurtic, implying a stronger impact of the buying/selling action on stock returns

7.3.3 The Role of Expectations

Agents' actions are determined by the perception of the social outcome through their estimated fundamentals μ. Because their actions determine the outcome r, if individual expectations are self-fulfilling, that is to say, they are totally aligned with the central tendency of the outcome ($\bar{r}$), then $\mu = \bar{r}$. However, agents' expectations about their stock's fundamentals valuation do not necessarily need to be correct (a possibility foreclosed by the EMH). Accordingly, when $\mu \neq \bar{r}$, expectations are unfulfilled, and this provides an incentive for agents to reassess their estimate of the fundamentals through some type of market-based punishment for acting in contrarian fashion with the market. On the contrary, when expectations are fulfilled ($\mu = \bar{r}$), there are no market-based incentives for agents to change their estimate of μ (Foley 2020b).

An important implication of the degree of expectation fulfillment is that, whenever agents have mistaken beliefs, which implies that they are selling at too high or too low a rate of return relative to their expectations, the resulting statistical equilibrium distribution of social outcome becomes asymmetric. In our model, to understand the sources of skewness, we have to consider the relation between μ and α. When $\mu = \alpha$, meaning that the fundamental valuation exactly coincides with the level of returns towards which the buying and selling actions push the market outcomes, the resulting marginal distribution is symmetric. On the contrary, when $\mu \neq \alpha$, then we can either have positive ($\mu < \alpha$) or negative ($\mu > \alpha$) skewness.[7] Accordingly, we can distinguish between three different cases:

- $\mu > \alpha \Rightarrow \bar{r} > \alpha$
- $\mu = \alpha \Rightarrow \bar{r} = \alpha$
- $\mu < \alpha \Rightarrow \bar{r} < \alpha$

It is interesting to note that by comparing μ with α we are effectively analyzing the deviations of a subjective valuation from a "conventional" rate of return, resulting from the unintended consequences of investors' behavior. In particular, if $\mu = \alpha = \bar{r}$, then the center of gravitation around which market returns fluctuate is exactly the same as the average rate of return. Therefore, our model allows us to quantify the deviation of agents' expectations about fundamentals from the actual location of the market as follows:

$$\zeta = \mu - \alpha \tag{7.8}$$

This implies that we can think of ζ as a measure of expectation fulfillment, which allows us to compare actual market outcomes with the EMH proposition. Indeed, since the EMH assumes rational (self-fulfilling) expectations, which means $\zeta = 0$, we can detect the presence of "bubbles", in the sense of divergences of actual market values from fundamentals, and thus provide an assessment of the EMH.

Figure 7.7 shows the marginal, joint and conditional probability distributions for fulfilled and unfulfilled expectations. As we can see, positive skewness can be interpreted as a "market punishment for buyers", meaning that they are buying at a higher price increase as compared to the conventional market valuation. On the contrary, negative skewness denotes a "market punishment for sellers", whose willingness to sell declines as they expect a rate of return above the average. An important implication of this process is that it imposes costly market punishment mechanisms associated with the correction of expectations, which leads to inertia in the adjustment of the system (as opposed to the rational expectations hypothesis, which assumes that such adjustments are instantaneous and costless).

[7] Note that symmetry in the distribution is not a necessary criterion for the statistical equilibrium. However, it can be interpreted as an indicator of rapid appreciation/depreciation of stock prices in certain sub-markets before or after a crisis.

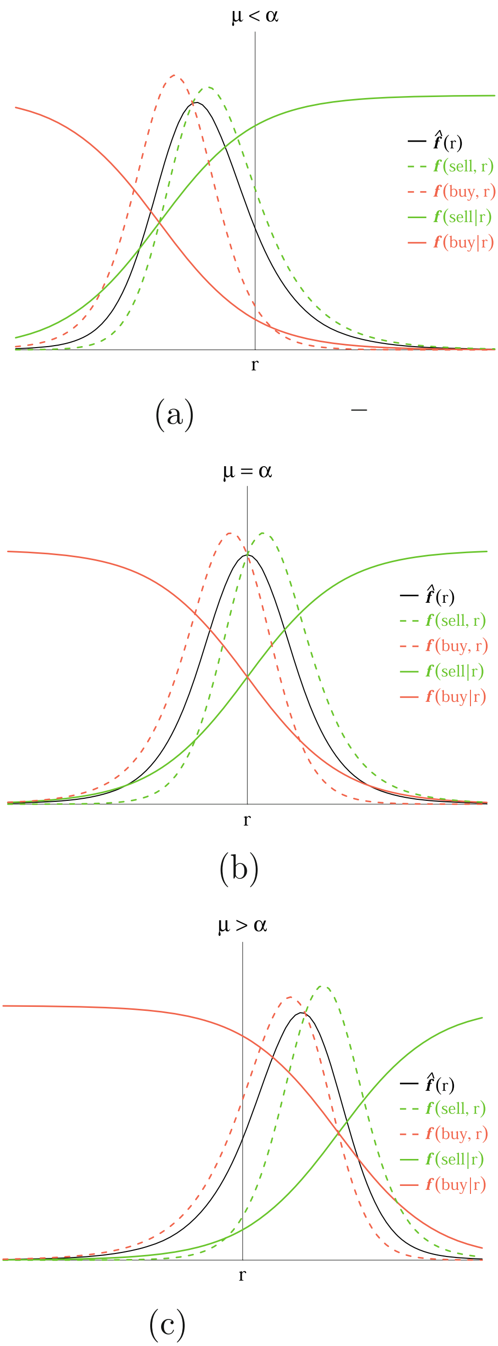


Fig. 7.7 Marginal, conditional, and joint frequency distributions for fulfilled and unfulfilled expectations. (**a**) Positive skewness: $\zeta < 0$ ($\mu = -2$, $T = 1$, $\alpha = 0$). (**b**) Symmetry: $\zeta = 0$ ($\mu = \alpha = 0$, $T = 1$). (**c**) Negative skewness: $\zeta > 0$ ($\mu = 2$, $T = 1$, $\alpha = 0$)

7.4 Model Inference and Results

To derive the statistical equilibrium distribution, the mathematical programming problem chooses marginal frequencies, $f[r]$, so as to maximize the Shannon entropy of the implied joint distribution, $f[a, r]$, subject to the feedback constraint (Eq. (7.7)) and the assumption that the conditional action function belongs to the class of logit functions with parameters μ and T. Accordingly, the maximum entropy problem that incorporates the behavioral and feedback constraints on the joint distributions reads as follows:

$$\begin{aligned}
\underset{f[a,r]\geq 0}{\text{Max}} \; \mathcal{H}[a, r] &= -\int \sum_{a} f[a, r] \log[f[a, r]]\, dr \\
\text{subject to} \int \sum_{a} f[a, r]\, dr &= 1 \\
\int \tanh\left[\frac{r-\mu}{2T}\right](r-\alpha)\, f[r]\, dr &\leq \delta
\end{aligned} \tag{7.9}$$

The solution to this maximum entropy problem gives the most probable distribution of outcomes, that is the marginal distribution $\hat{f}[r]$, which satisfies the constraints and has the following form:[8]

$$\hat{f}[r] = \frac{e^{\mathcal{H}_{T,\mu}[r]-\tanh\left[\frac{r-\mu}{2T}\right]\left(\frac{r-\alpha}{S}\right)}}{\int e^{\mathcal{H}_{T,\mu}[r]-\tanh\left[\frac{r-\mu}{2T}\right]\left(\frac{r-\alpha}{S}\right)}\, dr} \tag{7.10}$$

As we can see, in the marginal distribution we introduced another parameter, S, which represents the market temperature (scale) of the feedback constraint. This allows us to compare the effect of the individual and market temperatures on the marginal distribution.

Following the analysis developed in Sect. 7.2, we now estimate the QRSE model for each cross-sectional distribution of returns over different market phases: bull market, bear market, and corrections. Figure 7.8 shows the time series of the model parameters, whose values are reported in Table 7.3. Table 7.2 summarizes these results by showing the average values of the parameters for each subperiod. To better understand the results of our model, Fig. 7.9 shows some estimates of the cross-sectional distribution over different market periods (Table 7.3).

The behavioral parameter μ denotes the indifference points at which a typical agent would start investing at 50% probability. The first thing we note is that this value increases over prolonged periods of bear markets and corrections, and then decreases right after (exceptions made for the brief corrections in the early 1990s

[8] See Appendix 2 for the analytical derivation of the model.

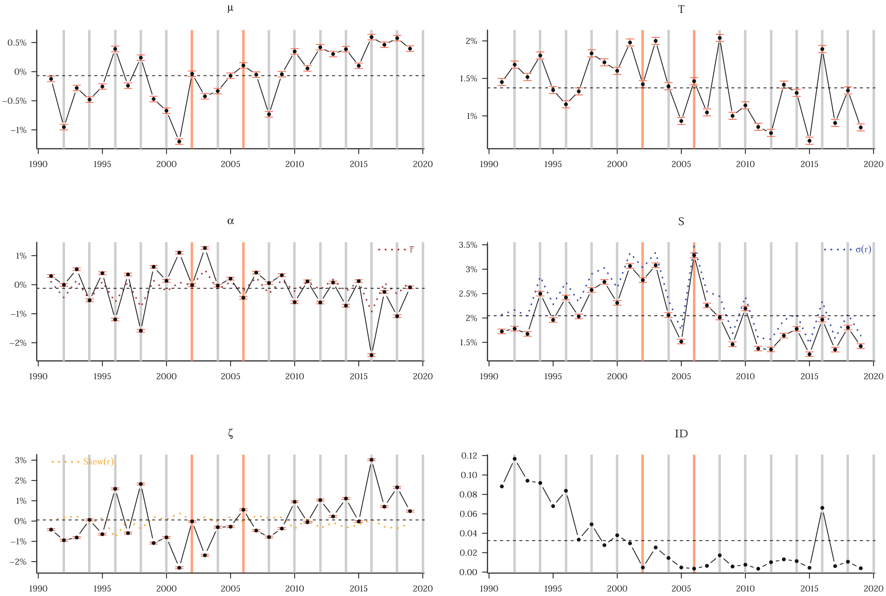


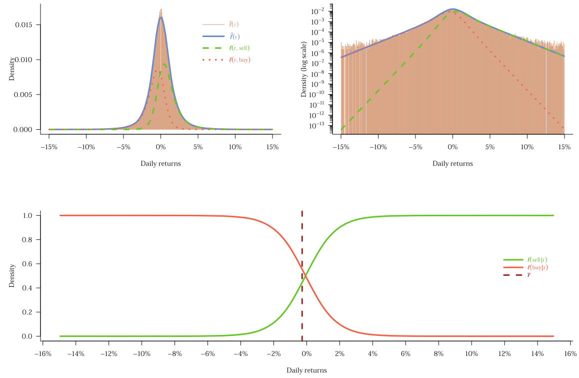
Fig. 7.8 Time series of parameter estimates (values expressed as %/day). The grey bars denote corrections, whereas the red bars bear markets. The red segments show the 95% credibility interval, whereas the dashed lines show the average value of each parameter over the whole sample

Table 7.2 Average values of parameters over market periods (values expressed as %/day)

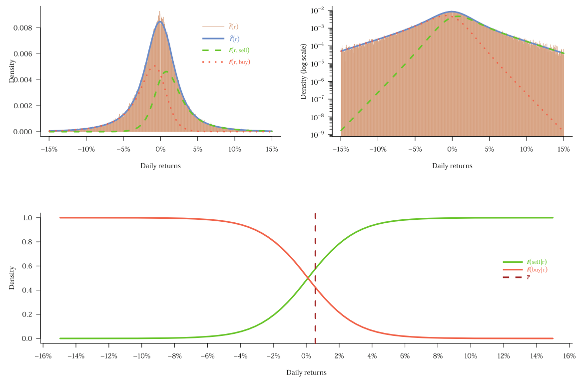
Market	ID	μ	T	α	S	$\bar{r}$	ζ	δ	$f[buy]$	$f[sell]$
Bull	0.0276	−0.1227	1.2665	0.3653	1.9026	−0.4880	0.1497	1.0196	0.4748	0.5252
Corr	0.0431	−0.0182	1.4965	−0.7183	2.0618	0.7001	−0.4101	1.0097	0.5486	0.4514
Bear	0.0042	0.0354	1.4422	−0.2337	3.0297	0.2691	−0.1198	1.7624	0.5152	0.4848

and right after 2010). This points to riskier investors' behavior leading to a market bust, which then tends to become more cautious in the aftermath. We can also acknowledge how, before the Great Recession, the value of μ exhibits signs of mean reversion, whereas after 2010 it starts to increasingly deviate from its long-term average, showing an upward trend. This seems to be the consequence of government intervention in the financial sector and the reduction in interest rates by the Federal Reserve, which pushed up stock prices by encouraging speculative behaviors.

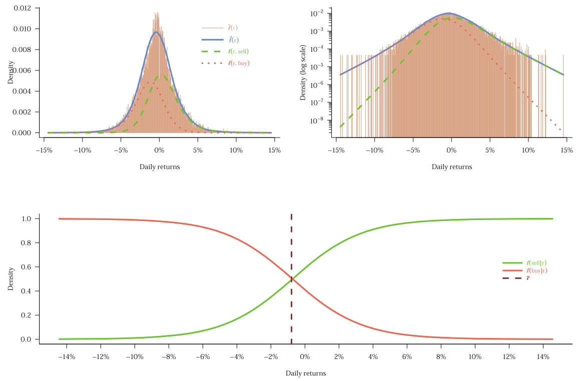
To understand how investors' behavior relates to that of the market, let us consider the bottom-left panel of Fig. 7.8, which captures the degree of expectations fulfilment in the market. As we can see, every decline in stock prices is associated with an increase in expectational disappointment, as a consequence of investors' euphoria and overreaction to periods of asset-price inflation. It is interesting to note how ζ widely fluctuates around its long-term average, without exhibiting clear signs of mean reversion, thus denoting the presence of unfulfilled expectations over the whole period considered. Let us recall that positive values of ζ denote negative



(a)



(b)



(c)

Fig. 7.9 Model estimates. (**a**) Bull market: 2003/03/11–2007/10/09. (**b**) Bear market: 2007/10/09–2009/03/09. (**c**) Correction: 2010/04/23–2010/07/02

Table 7.3 Parameter estimates (values expressed as %/day)

Market	Period	ID	μ	T	α	S	$\bar{r}$	ζ	δ	$f[buy]$	$f[sell]$
Bull	1988/01/04–1990/01/02	0.0882	−0.1243	1.4512	0.2975	1.7244	−0.4219	0.1026	0.9294	0.4713	0.5287
Corr	1990/01/02–1990/01/30	0.1166	−0.9526	1.6832	−0.0063	1.7795	−0.9462	−0.4499	0.8935	0.4436	0.5564
Bull	1990/01/30–1990/07/16	0.0941	−0.2805	1.5183	0.5309	1.6733	−0.8114	0.1580	0.8554	0.4468	0.5532
Corr	1990/07/16–1990/10/11	0.0918	−0.4799	1.8050	−0.5393	2.4980	0.0593	−0.5248	1.3810	0.5031	0.4969
Bull	1990/10/11–1997/10/07	0.0679	−0.2559	1.3439	0.3937	1.9592	−0.6495	0.1066	1.0682	0.4546	0.5454
Corr	1997/10/07–1997/10/27	0.0837	0.3904	1.1541	−1.1976	2.4198	1.5879	−0.5987	1.2089	0.6140	0.3860
Bull	1997/10/27–1998/07/17	0.0334	−0.2406	1.3267	0.3524	2.0305	−0.5929	0.0874	1.1228	0.4584	0.5416
Corr	1998/07/17–1998/08/31	0.0492	0.2405	1.8331	−1.5856	2.5738	1.8261	−0.7677	1.2117	0.5928	0.4072
Bull	1998/08/31–1999/07/16	0.0278	−0.4700	1.7141	0.6139	2.7393	−1.0840	0.1424	1.4630	0.4422	0.5578
Corr	1999/07/16–1999/10/15	0.0379	−0.6716	1.6012	0.1332	2.3093	−0.8048	−0.2276	1.2437	0.4527	0.5473
Bull	1999/10/15–2000/03/24	0.0297	−1.2009	1.9783	1.1020	3.0642	−2.3029	0.0777	1.3884	0.3946	0.6054
Bear	2000/03/24–2002/10/09	0.0048	−0.0357	1.4217	−0.0173	2.7759	−0.0183	−0.0238	1.6211	0.4989	0.5011
Bull	2002/10/09–2002/11/27	0.0254	−0.4241	1.9994	1.2640	3.0791	−1.6881	0.5049	1.5327	0.4228	0.5772
Corr	2002/11/27–2003/03/11	0.0145	−0.3336	1.3956	−0.0317	2.0588	−0.3019	−0.1707	1.1539	0.4796	0.5204
Bull	2003/03/11–2007/10/09	0.0048	−0.0702	0.9314	0.2077	1.5154	−0.2780	0.0924	0.8641	0.4726	0.5274
Bear	2007/10/09–2009/03/09	0.0036	0.1064	1.4626	−0.4501	3.2834	0.5566	−0.2159	1.9037	0.5315	0.4685
Bull	2009/03/09–2010/04/23	0.0065	−0.0511	1.0461	0.4168	2.2567	−0.4678	0.2452	1.3427	0.4623	0.5377
Corr	2010/04/23–2010/07/02	0.0173	−0.7334	2.0393	0.0558	2.0089	−0.7891	−0.3087	1.0346	0.4605	0.5395
Bull	2010/07/02–2011/04/29	0.0058	−0.0435	1.0005	0.3258	1.4597	−0.3693	0.1652	0.8096	0.4652	0.5348
Corr	2011/04/29–2011/10/03	0.0076	0.3465	1.1401	−0.6031	2.1944	0.9495	−0.2223	1.2086	0.5721	0.4279
Bull	2011/10/03–2015/05/21	0.0035	0.0560	0.8526	0.1144	1.3716	−0.0584	0.0925	0.7889	0.4937	0.5063
Corr	2015/05/21–2015/08/25	0.0102	0.4191	0.7713	−0.6127	1.3544	1.0318	−0.1680	0.6373	0.6168	0.3832
Bull	2015/08/25–2015/11/03	0.0131	0.3036	1.4156	0.0758	1.6371	0.2278	0.1799	0.8887	0.5160	0.4840
Corr	2015/11/03–2016/02/11	0.0113	0.3861	1.3066	−0.7223	1.7759	1.1084	−0.2264	0.8819	0.5803	0.4197

(continued)

Table 7.3 (continued)

Market	Period	ID	μ	T	α	S	$\bar{r}$	ζ	δ	$f[buy]$	$f[sell]$
Bull	2016/02/11–2018/01/26	0.0044	0.1013	0.6679	0.1235	1.2560	−0.0222	0.1074	0.7449	0.4971	0.5029
Corr	2018/01/26–2018/02/08	0.0661	0.5941	1.8908	−2.4253	1.9655	3.0194	−0.9319	0.4935	0.6523	0.3477
Bull	2018/02/08–2018/09/20	0.0062	0.4629	0.9054	−0.2473	1.3503	0.7102	0.0636	0.7022	0.5728	0.4272
Corr	2018/09/20–2018/12/24	0.0107	0.5754	1.3377	−1.0852	1.8031	1.6606	−0.3245	0.7680	0.6157	0.3843
Bull	2018/12/24–2019/12/31	0.0040	0.3961	0.8455	−0.0920	1.4215	0.4881	0.1193	0.7923	0.5523	0.4477

skewness in the marginal distribution of returns, and vice versa. This allows us to compare this parameter to the measure of empirical skewness, shown by the dotted line $Skew(r)$. Even though the magnitude of fluctuations in the empirical skewness is lower as compared to variations in ζ, we can see that the two time series behave in a similar fashion. Positive values of empirical skewness are associated with negative values of ζ, and vice versa. Furthermore, the average empirical skewness over the whole sample is negative (−0.032), in line with the long-term average of ζ (0.06%/day). In this respect, our results seem to validate the idea that expectations remain roughly consistent over long periods, in line with the EMH claim. On the other hand, the sustained excursions of ζ around the long-term average point to significant deviations of expectations from outcomes over extended time periods.

The last parameter capturing investors' behavior is T, which denotes the responsiveness of the typical agent to variations in the rate of return. As we can see, the recurrent increase during periods of price declines (exception made for the bear market of the early 2000s and the subsequent correction), testifies to a higher degree of uncertainty and risk propensity in investors' behavior as opposed to normal periods. On the contrary, market booms are associated with lower behavioral temperatures. This result can be interpreted as the anchoring of investors' expectations to an optimistic belief, that typically develops during bull markets. It is important to note that the parameter T has two behavioral implications. First, it measures the responsiveness of the action frequency to changes in outcome at the average outcome, because the derivative of the conditional action function at $r = \mu$ is $\frac{1}{4T}$. This indicates that an increase of one basis point in the rate of return in the region near the average rate would raise the frequency of selling by 0.2% on average. Second, T defines the region in which the action is sensitive to the outcome, since the value of r for which the conditional action frequency is P, with $0 < P < 1$, is $r[P, T] = T \log\left[\frac{P}{1-P}\right]$. This means that the region of stock return deviations in which the frequency of selling lies between 0.05 and 0.95 is $\{-4.045\%, 4.045\%\}$, on average. Given that we are dealing with daily returns, this is a wide range of fluctuations, but not really surprising given their considerable volatility.

Let us now turn to analyze the behavior of the market, captured by the parameters α and S. By looking at the time series of α, we can notice two things. First, it exhibits a cyclical behavior around the average over the whole sample, by declining during bear markets and corrections, and increasing during bull markets. Second, its path tends to track pretty well variations in the observed average rate of return, $\bar{r}$, though they differ in terms of magnitude. This is a truly important point for our analysis, given that it shows how the negative feedback tends to push the rate of return to a value which approximates the empirical average. This suggests, in turn, that the average rate of return can be thought of as a gravitational center for individual expectations, thereby acting as a market convention that stabilizes the system over different market phases.[9] An interesting aspect of this result is that we did not constrain the average of the theoretical distribution to be equal to the observed average return, as Scharfenaker and Foley (2017) did. Accordingly, this outcome can be considered as an emergent property of the model, resulting from the behavior of the system under consideration.

In this respect, we can interpret the similarity between α and $\bar{r}$ as the result of the goodness of fit, shown in the bottom right panel of Fig. 7.8 and captured by the information distinguishability criteria (ID) (Soofi and Retzer 2002).[10] As we can see, the average ID over the whole sample exhibits a high value (the closer to zero, the higher the goodness of fit), with a significant increase after 2000. This can be explained in terms of variations in the number of companies included in the index. Indeed, whereas during the early 1990s this figure averaged 260, it grows quickly over time, reaching the value of 500 after 2015. Given that we are not performing a sectoral analysis, but dealing with individual company observations, the variation in the number of observations has an impact on the goodness of fit of the model.

Finally, in terms of the scale parameter for market fluctuations, S, we can see that it moves in line with the observed standard deviation, $\sigma(r)$, though with a lower magnitude. One thing to note is that, after 2010, the volatility of returns tends to be more reduced as compared to before, showing a safer market environment. Given the similar behavioral implications, it can be helpful to compare S to T. Individual and market volatility are quite correlated with each other, though the latter fluctuates more as compared to agents' responsiveness. This implies that investors adapt their behavior to volatility changes.

7.5 Conclusions

The purpose of this chapter is to show how stock return distributions over different market trends can be explained as statistical equilibrium processes, resulting from endogenous fluctuations of investors' behavior which, through a negative feedback mechanism, generate stable frequency distributions with a well-defined center of gravitation. By deploying an entropy-constrained framework, we derive the QRSE model and provide estimates of the cross-sectional distributions of the S&P 500 individual companies' daily returns. Predicted parameters of the model μ, T, α, and S, reveal significant characteristics of the dynamics underlying the US stock market over the last three decades. On the one hand, our analysis shows regularity in investors' behavior over the entire sample, both in terms of their trading preferences and responsiveness to variations in the rate of return. On the other, it captures the variation in the conventional rate of return, which aligns with the average market

[9] For a detailed discussion on how conventions regulate financial markets see Citera and Sau (2021).

[10] See Appendix 2 for further detail.

rate, as well as the aggregate fluctuations of the stock market. Moreover, it allows us to capture the degree of unfulfilled expectations over time, thus providing a benchmark against the EMH.

For the sake of understanding the forces that push the stock market to the statistical equilibrium, it is crucial to keep in mind that the underlying dynamics involve social interactions of a large number of economic agents through socially and institutionally determined market structures, from which the statistical distribution of rates of return is determined. This is a rather important feature if considered within the realm of models of stock returns. Given the presence of multiple players who trade stocks on a daily basis with different degrees of knowledge, risk propensity, and limited capabilities in processing information, it is a rather arduous task modeling individual behaviors. In this respect, statistical equilibrium allows us to substitute a statistical model of the macroscopic system for a detailed dynamic description of the microscopic units.

Another important implication of the statistical equilibrium perspective relates to the stochastic structure of stock returns. Indeed, it allows us to explain that randomness in stock prices is not an accident of nature, but the unintended consequence of the action of market participants to profit from their information. If we relate this to the EMH, we can immediately acknowledge how it is possible to explain the same market outcome with completely different theoretical foundations. Whereas the EMH needs to resort to "smart investors" to justify the stabilizing impact of speculation, the QRSE model tells us that the system can spontaneously converge towards a market convention, without implying that agents' expectations are fulfilled.

The application of the QRSE model to financial markets has proved to be quite successful. Indeed, Ömer (2018) has been able to explain the statistical regularities observed in the housing market, and in particular the housing bubble leading to the great recession. Blackwell (2018) analyzed the dynamics of the US stock and bond market, whereas Dos Santos and Scharfenaker (2019) focused on the statistical regularities of the cross-sectional distributions of Tobin's q for US non-financial corporations. Finally, Scharfenaker (2020) provided an analysis of the US stock market annual returns from 1926 until 2019. This suggests that the QRSE model can be usefully deployed as a framework to explain statistical regularities observed in complex social systems like financial markets.

In conclusion, we should mention that the QRSE model is an equilibrium model, and as such it might not be able to produce powerful results for disequilibrium processes. However, to the extent that we can identify statistical regularities in the forces that push the system towards/away from equilibrium, we can still adopt it as a theoretical framework to study self-organizing patterns characterizing complex systems. This is exactly our case, where we find evidence of punctuated statistical equilibrium over multiple market periods, disrupted by structural changes in the financial system affecting the stock market. Finally, because of the adoption of entropy as a measure to study stock market volatility, the QRSE model allows us taking into account potential nonlinear relationships underlying empirical data, which are of crucial importance within the realm of finance.

Appendix 1

The Maximum Entropy Principle

The cumbersome task social scientists face is the mutual dependence of individual (subjective) actions and observable (objective) outcomes, which result from complex dynamics not directly observable from the data. This causes the problem at hand to be underdetermined, thus raising the importance of a method of inference to construct the interactions of human actions and outcomes, as expressed by their joint probability distribution.

One powerful approach to underdetermined problems of this type is the maximum entropy method, championed particularly by the physicist E. T. Jaynes (2003). Jaynes' general idea is to maximize the entropy of the unknown and underdetermined distribution subject to constraints expressing whatever information from observation or theory are relevant. Due to the strict concavity of the entropy function, as long as the constraints describing the available information represent a non-empty convex set in the space of distributions, the maximum entropy program will define some maximizing distribution that is a candidate statistical equilibrium of the model. The substantive interest of the resulting maximum entropy distribution depends on the information expressed by the constraints. At this stage, an important qualification is necessary.

Generally speaking, maximizing entropy maximizes the uncertainty of the system and gets the least informative state with no additional assumptions other than the existing knowledge of the researcher and observed data. However, constrained maximum entropy can be used either as a method of "rational inference"(Golan 2018), where maximization of entropy resolves the residual uncertainty once relevant information has been introduced via constraints, or as a "statistical equilibrium theory", which assumes that a system is observed in a state of equilibrium characterized by the decay of transients and is reaching a state of maximum entropy subject to constraints. Even though the formalism is the same for both methods, the interpretation of the results can be rather different. In our case, we deploy the maximum entropy principle as a statistical equilibrium theory.

The foundational concept in information theory is informational or Shannon (1948) entropy. In economic applications of information theory, entropy is most often described as a measure of uncertainty, but it is more helpful to think of entropy as the lack of predictability. Given a random variable $x \in X$, with probability distribution $f(x)$, the Shannon entropy, $\mathcal{H}[x]$ is defined as follows:

$$\mathcal{H}[x] = \mathbb{E}[-\log[f[x]] = -\sum_{x \in X} f[x] \log[f[x]] \tag{7.11}$$

Let the rate of return on stock be $r \in \mathbb{R}$ and $a \in \mathbb{A}$ the set of quantal actions of selling and buying stocks, $a = \{sell, buy\}$, respectively. Our objective is to determine the equilibrium joint distribution $f[a, r]$ with the marginal and conditional frequencies

$f[r]$, $f[a]$, $f[a|r]$, $f[r|a]$ such that:

$$f[r] = \sum_a f[a, r], \quad f[a] = \int_r f[a, r]\, dr;$$

$$f[a|r] = \frac{f[a, r]}{f[r]} \text{ if } f[r] > 0, \quad f[r|a] = \frac{f[a, r]}{f[a]} \text{ if } f[a] > 0.$$

We write sums over outcomes, r, as integrals with the understanding that in theoretical applications r is treated as real-valued. In empirical applications, however, measurements will inevitably be coarse-grained in a finite number of bins. We also omit the limits on integrals with the understanding that the sums are over the range of r.

If we were to maximize the entropy of the joint distribution $f[a, r]$, $-\int \sum_a f[a, r] \log[f[a, r]]\, dr$, without the introduction of any constraint (except the normalization of the sum of the joint frequencies to unity), we would find that the entropy is maximized when the aggregate outcome r is independent of the individual actions a. Since this result sheds no light on the process through which actions determine the outcome (it just returns the information already known through the observation of $f[r]$), we need to construct a theory of investors' behavior and how it impacts the social outcome by expressing it in terms of moment constraints.

Finally, we should note that Shannon entropy is only one of the possible models of entropy that can be adopted. Indeed, the financial literature has adopted both Rényi (1961) and Tsallis (1988) measures of entropy, that are generalizations of Shannon entropy. However, there are two reasons to prefer the latter over the generalized entropy measures. First, both Renyi and Tsallis provide parametric entropy measures, that attach completely different weights to extremely rare and regular events. As suggested by Batra and Taneja (2020), they might not be entirely appropriate to analyze stock market data series. Second, Shannon entropy has been most successful in the treatment of equilibrium systems, which is the intended purpose of our analysis.

The Derivation of Investor's Behavior

Let us assume that the typical agent's response probability $f[a|r]$ depends on the payoff u for choosing an action, which is the difference between the expected outcome variable r and the agent's expected average payoff, or fundamental valuation of r, which we call μ, such that we can write the payoff function as: $u[a, r] = r - \mu$.

If an investor chooses a mixed strategy $f[a|r] : \mathbb{A} \times \mathbb{R} \to (0, 1)$ to maximize the expected payoff $\sum_a f[a|r]u[a, r]$, then the informational entropy is:

$$\mathcal{H}[f[a|r]] = -\sum_a f[a|r]\log[f[a|r]] \tag{7.12}$$

The entropy maximization program reads:

$$\begin{aligned} \underset{f[a|r]\geq 0}{\text{Max}} & -\sum_a f[a|r]\log[f[a|r]] \\ \text{subject to} & \sum_a f[a|r] = 1 \\ & \sum_a f[a|r]u[a,r] \geq U_{min} \end{aligned} \tag{7.13}$$

Here we are imposing a constraint on our uncertainty of $f[a|r]$ for a set of agents subject to the condition that individuals have a minimum expected payoff for acting (a sort of "satisficing" behavior *a là* Simon 1955). The associated Lagrangian has the following form:

$$\mathcal{L} = -\sum_a f[a|r]\log[f[a|r]] - \lambda\left(\sum_a f[a|r] - 1\right) + \beta\left(\sum_a f[a|r]u[a,r] - U_{min}\right) \tag{7.14}$$

The solution to this program gives the maximum entropy distribution, which turns out to be the logit quantal response distribution (with $\beta = \frac{1}{T}$):[11]

$$f[buy|r] = \frac{1}{1+e^{\frac{u[a,r]}{T}}} \qquad f[sell|r] = \frac{1}{1+e^{-\frac{u[a,r]}{T}}} \tag{7.15}$$

Our assumption about the agents' behavior implies that choice decisions are best described as a probabilistic phenomenon as opposed to the deterministic rational theory of choice, which assumes choices are always associated with probabilities equal to unity. In this sense, an interesting feature of the informational entropy constrained model is that it gives meaning to the observed dispersion of behavior as the relative payoff of different actions, thus generating an "entropy-constrained behavior". Interestingly enough, entropy-constrained behavior leads to the logit quantal response distribution without imposing any prior distributional assumption on the errors that affect the decision-making process.

[11] It is important to note that there are other ways to derive the above result through entropy maximization, and this is just one of them. Foley (2020a) provides a thorough analysis of entropy-constrained behavior and its applications to economic theory.

Appendix 2

Model Derivation and Inference

The maximum entropy problem that incorporates the behavioral and feedback constraints on the joint distributions reads as follows:

$$\begin{aligned} \underset{f[a,r]\geq 0}{\text{Max}}\ \mathcal{H}[a,r] &= -\int \sum_a f[a,r]\log[f[a,r]]\,dr \\ \text{subject to} &\int \sum_a f[a,r]\,dr = 1 \\ &\int \tanh\left[\frac{r-\mu}{2T}\right](r-\alpha)\ f[r]\,dr \leq \delta \end{aligned} \tag{7.16}$$

To solve this maximum entropy problem, it is convenient to write the joint entropy as the entropy of the marginal distribution plus the average entropy of the conditional distribution and solve for $f[r]$:

$$\begin{aligned} \mathcal{H}[a,r] &= -\mathcal{H}[r] + \int f[r]\mathcal{H}_{T,\mu}[r]\,dr \\ &= -\int f[r]\log[f[r]]dr + \int f[r]\sum_a f[a|r]\log[f[a|r]]\,dr \end{aligned} \tag{7.17}$$

where $\mathcal{H}_{T,\mu}[r]$ denotes the binary entropy function:

$$\begin{aligned} \mathcal{H}_{T,\mu}[r] &= -\sum_a f[a|r]\log[f[a|r]] \\ &= -\left(\frac{1}{1+e^{-\frac{r-\mu}{2T}}}\log\left[\frac{1}{1+e^{-\frac{r-\mu}{2T}}}\right] + \frac{1}{1+e^{\frac{r-\mu}{2T}}}\log\left[\frac{1}{1+e^{\frac{r-\mu}{2T}}}\right]\right) \end{aligned}$$

The final maximum entropy program reads:

$$\begin{aligned} \underset{f[r]\geq 0}{\text{Max}}\ &-\mathcal{H}[r] + \int f[r]\mathcal{H}_{T,\mu}[r]\,dr \\ \text{subject to} &\int f[r]\,dr = 1 \\ &\int \tanh\left[\frac{r-\mu}{2T}\right](r-\alpha)\ f[r]\,dr \leq \delta \end{aligned} \tag{7.18}$$

This programming problem has the following associated Lagrangian:

$$\mathcal{L}[f[r], \lambda, \gamma] = -\mathcal{H}[r] + \int f[r]\mathcal{H}_{T,\mu}[r]dr - \lambda\left(\int f[r]\,dr - 1\right) + \\ - \left(\int \tanh\left[\frac{r-\mu}{2T}\right]\left(\frac{r-\alpha}{S}\right) f[r]\,dr - \delta\right) \tag{7.19}$$

The first-order conditions for maximizing entropy of the joint and conditional frequencies require:

$$\frac{\partial \mathcal{L}}{\partial f[r]} = -\log[f[r]] - 1 - \lambda + \mathcal{H}_{T,\mu}[r] - \tanh\left[\frac{r-\mu}{2T}\right]\left(\frac{r-\alpha}{S}\right) = 0 \tag{7.20}$$

The solution to this maximum entropy problem gives the most probable distribution of outcomes, that is the marginal distribution $\hat{f}[r]$, that satisfies the constraints and has the following form:

$$\hat{f}[r] = \frac{e^{\mathcal{H}_{T,\mu}[r] - \tanh\left[\frac{r-\mu}{2T}\right]\left(\frac{r-\alpha}{S}\right)}}{\int e^{\mathcal{H}_{T,\mu}[r] - \tanh\left[\frac{r-\mu}{2T}\right]\left(\frac{r-\alpha}{S}\right)}\,dr} \tag{7.21}$$

As we can see, in the marginal distribution we introduced another parameter, S, which represents the market temperature (scale) of the feedback constraint.

The predicted marginal distribution $\hat{f}[r]$ from Eq. (7.10) is a Kernel to the maximum entropy program, and together with the parameters μ, T, γ, α, and S provides a multinomial distribution for the model. From a Bayesian perspective, the empirical marginal distribution, $\bar{f}[r]$ can be thought of as a sample of a multinomial model with frequencies $f[r]$ determined by Eq. (7.10). We use the Kullback-Leibler (KL) divergence as an approximation to the log posterior probability for the multinomial model since it allows us to make posterior inferences about the parameter estimates (Scharfenaker and Foley 2017, p. 15).

The KL divergence measures the discrepancy between the empirical marginal frequencies, $\bar{f}[r]$, and the predicted marginal frequencies $\hat{f}[r; \mu, T, \alpha, S]$, inferred from the maximum entropy Kernel as:

$$D_{KL}[\hat{f}[r]||\bar{f}[r]] = \sum \hat{f}[r] \log\left[\frac{\hat{f}[r]}{\bar{f}[r]}\right] \tag{7.22}$$

As a result, the KL divergence provides us with a tool to compare the observed marginal frequency distribution with the predicted marginal distribution. If $\hat{f}[r] = \bar{f}[r]$, the D_{KL} becomes zero indicating that the two distributions are the same. Therefore, the smaller the KL divergence, the closer the observed distribution to the predicted one, and the better the fit is.

The set of parameters $\theta = \{\mu, T, \alpha, S\}$ are estimated jointly by minimizing the KL divergence.[12] To measure the closeness of the model fit, we use the information distinguishability criteria (ID) introduced by Soofi and Retzer (2002). The ID measure shows approximately how much of the informational content of the observed frequencies is captured from the results of the maximum entropy program and is defined as follows:

$$ID[\hat{f}[r] : \bar{f}[r]] = 1 - e^{-D_{KL}[\hat{f}[r]||\bar{f}[r]]} \tag{7.23}$$

Finally, to make posterior inferences about the vector of the model parameters θ, we compute the conditional distribution of each parameter holding all others at their maximum posterior probability estimate $\bar{\theta}$. Following Scharfenaker and Foley (2017), we approximate the conditional posterior probability of the parameters as follows:

$$P[i|\bar{\theta}_{-i}] \sim e^{-nD_{KL}[\hat{f}[r;\, \mu,\, T,\, \alpha,\, S],\, \bar{f}[r]]}, \tag{7.24}$$

where i denotes each element in the parameter set and n the number of observations. In the case of ζ, we vary only μ by holding $\bar{\theta}_{-\mu}$ at their maximum posterior estimates.

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[12] The optimization algorithm for the KL minimization is the Broyden-Fletcher-Goldfarb-Shanno (BFGS) algorithm, with the following initial conditions for the parameters: $\mu = 0$, $T = 1$, $\alpha = 0$, $S = 1$.

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Chapter 8
Has COVID-19 Pandemic Fear Affected Eurozone Stock Markets?

Carmen GONZÁLEZ-VELASCO and Marcos GONZÁLEZ-FERNÁNDEZ

The central rule in life is that it is much, much better to panic early than late. Nassim Nicholas Taleb

8.1 Introduction

"*Markets are usually driven by greed or fear. On mercifully rare occasions, they are driven by outright panic*" said *The Wall Street Journal* on March 9, 2020. The Opinion Editorial of *The Los Angeles Times* on March 12, 2020 titled, "*It's fear, not coronavirus, that's roiling world markets and upending daily life*". There are many more similar examples, but it is obvious that the coronavirus crisis has turned the world upside-down in 2020 and probably will in the future as well. The social, economic and, of course, public health consequences of this tragedy will take much time to heal (Arshad et al. 2020). Several papers associate the coronavirus with fear because the outbreak of novel coronavirus has led to negative emotions of fear and has revealed a rise in fears related to contracting the virus among individuals worldwide (Fofana et al. 2020; Martínez-Lorca et al. 2020; Mertens et al. 2020). The fear of coronavirus is likely due to its novelty and the uncertainties about its evolution in the future and it is much greater than fear of seasonal influenza, even though the latter has killed considerably more people (Asmundson and Taylor 2020). Furthermore, the fear spreads to all markets, as the greatest uncertainty in some markets is transmitted to global markets. (Smales 2022).

As the above headlines highlight, fear might have been the most important driver on the economic side of the crisis. Regardless of whether this fear is rational or irrational, it seems to have driven financial markets during the months after the

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outbreak of the coronavirus. The coronavirus outbreak does not mean that the economic system has collapsed from one day to another, but it triggers uncertainty and fear about future consequences (Simonsen et al. 2007). In this sense, the aim of this paper is to analyze the impact of that fear on stock markets. For this purpose, we selected four Eurozone countries, France, Germany, Italy and Spain, since they have been the countries that have faced the consequences of coronavirus to a greater extent. Ex ante expectations are for an inverse relationship between fear and the stock markets, i.e., an upsurge in fear would lead to a plunge in the market and vice versa. The intuition behind this expected result is that when there is a negative sentiment in the market, whether it is fear, pessimism, etc., although it is irrational, many investors will take short positions (sell) pushing down the prices of stocks or the indices themselves. Then, other mechanisms well addressed in the behavioral finance literature, such as the herding behavior, which is that some investors mimic the conduct of the prior, can deepen in the drop of the financial assets. Therefore, it is expected that in the face of a sharply increases of fear, whether it is rational or not, stock markets returns will decline. One key element of this study is how we can measure fear. In this sense, we use Google data, which have proven to be a good proxy for investor attention and fear (Da et al. 2015; Fernandez-Perez et al. 2020; Vozlyublennaia 2014; Zhang and Tao 2018; Fecht et al. 2019; Lyócsa and Molnár 2020; Lyócsa et al. 2020, among others).

We apply VAR model regressions as well as Granger causality tests and Impulse Response Functions. We focus on this methodology since we consider that it is adequate to our data, given that we are analyzing the relationship between two series of data (fear, proxied through Google searches and stock indices returns) which show a high frequency and encompass a reduced time span. We find that fear has a short-term effect on Eurozone stock market returns. However, one interesting finding is that this effect is different depending on the country. The impact is stronger and more significant in Germany, Italy and Spain, but it is not significant in France. In those first three countries, an increase in Google search volume of the keyword *coronavirus*, which serve as a proxy for fear, correlates with a drop in market returns during the following days. However, the results are not significant for France. The findings are in line with previous literature that indicates that negative investor sentiment negatively affects stock market returns (Baker and Wurgler 2006; Schmeling 2009; Zouaoui et al. 2011).

The contribution of the paper is threefold. First, to the best of our knowledge, this is one of the first papers to address the impact of the COVID-19 pandemic fear on Eurozone stock markets during the first stage of the pandemic. Second, we provide evidence that the number of searches on Google is a good proxy for fear, which can be considered in further research as an alternative to other measures that gauge fear, such as the VIX index (Sarwar 2012; Whaley 2000). Third, the empirical results show that higher fear levels lead to a drop in market returns in three of the four Eurozone countries analyzed but there are differences between the countries analyzed. It could be explained by the different composition of the stock indices of those countries. The remainder of the paper unfolds as follows. Section 8.2 summarizes the data and the methodology. Section 8.3 shows the empirical analysis and the main results. Finally, Sect. 8.4 offers conclusions.

8.2 Theoretical Background

Financial theory has relied for several decades on the efficient market hypothesis, the representative agent paradigm, and the rational expectations hypothesis, which establish that agents are rational in their decision-making (Fama 1965; Samuelson 1965).

However, in recent decades a series of crises have erupted that have produced anomalies in the markets and that have questioned these previous theories. For this reason, one of the latest financial theories based on behavioral finance has emerged, which states that investors are not rational since psychological factors (optimism, pessimism, confidence, fear, etc.) may influence their decision-making (Kahneman and Tversky 1979). Specifically, the investor sentiment paradigm would play a central role in explaining misalignments in asset prices and equity market dynamics (Namouri et al. 2018). In fact, while classical financial theory supports that asset returns are mean-reverting and fundamentals drive asset prices, behavioral finance theory holds that prices can be affected by psychological bias (Jawadi et al. 2018). Therefore, two bias might motivate the reaction of stock markets to investors' emotions (Louhichi et al. 2021): conservatism behavior, which translates an incredulous individual behavior into new evidence (Edwards 1968) and the representative bias that associates the similarity of an uncertain event with a past event (Kahneman and Tversky 1979).

From a theoretical and empirical point of view, a line of research developed since the 90s focuses on investigating the role of investor sentiment in different aspects of stock markets (trading volume, stock prices, price volatility, etc.). The relationship between investor sentiment and asset price dynamics is justified by the interaction between investors with different behaviors and expectations, such as noise traders, who follow their sentiments, and arbitrageurs, who rely on fundamentals (Jawadi et al. 2018). In this sense, two types of studies can be distinguished within this line of research: those that consider a linear or homogeneous model of investor behavior (Barberis et al. 1998; Baker and Wurgler 2006) and those that are based on heterogeneous agent models (De Long et al. 1990; Chiarella et al. 2011).

Another line of research has focused on analyzing how certain sentiments affect investor decision-making and, therefore, how they influence prices and volatility in financial markets (Tsai 2014; Kolaric and Schiereck 2016; Czudaj 2018; Economou et al. 2018; Zhu et al. 2019; Lyócsa and Molnár 2020; Lyócsa et al. 2020; Liu et al. 2021; Shear et al. 2021; Gao et al. 2021; Su et al. 2021).

Our paper focuses on this last line of research since it attempts to analyze whether the COVID-19 pandemic fear, measured through Google search volume of the keyword coronavirus, has affected investor decisions on stock markets and resulted in lower stock returns.

Su et al. (2021) indicate that previous studies usually consider two economic channels that could explain the effect of fear induced by the COVID-19 pandemic on stock market returns. The first channel is noise trading led by sentiment or mood, which leads to greater volatility. When uniform noise investors make decisions based on their sentiment or mood, changes in this sentiment or mood lead to more noise trading, greater mispricing, and excessive volatility (Black). The second channel is the liquidity boosted or restrained by irrational investors since they, during the COVID-19 pandemic, overreact to the information contained in the pandemic, which restricts liquidity in the following days.

In addition, Google search volume can be considered as a proxy for investor attention to predict stock returns (Da et al. 2011, 2015; Dzielinski 2012; Vozlyublennaia 2014; Smales 2020) because whether people search for some keywords on Google, it is clear that they are paying attention to that information (Shear et al. 2021).

The efficient market hypothesis states that stock prices include all available information. However, investors do not always collect all the information, but only what they are interested in because attention is a scarce cognitive activity in the real world (Kahneman 1973). In this sense, Barber and Odean (2008) propose the attention theory or price pressure hypothesis, which indicates that enhanced investors' attention may impact stock returns largely and positively and individual investors are heavily influenced by limited attention and past return performance in their purchase decisions (Barber and Odean 2013). However, other studies suggest that these impacts could be positive or negative depending on the nature of the information, the level of the market or the period (Vozlyublennaia 2014; Yuan 2015; Da et al. 2015; Dzielinski 2012). The spread of fear sentiment across many stock markets exacerbates the decline in asset price because the investor behaviors during recent financial recessions are extremely similar to the herding behavior (Tsai 2014) proposed by Masson (1998) as investors lose confidence when they receive negative information, which leads them to overestimate investment risks and consequently to decline the stock prices.

8.3 Related Literature

The literature on the impact of the COVID-19 pandemic fear on stock markets is scarce. Some studies are based on non-fundamental proxies to explain the impact of COVID-19 pandemic fear in financial markets. Ftiti et al. (2021a) examine the cryptocurrency volatility modelling and forecasting based on high-frequency data and, more specifically, they assess they dynamic of cryptocurrency volatility with different heterogeneous autoregressive models. They obtain evidence that the future volatility was explained by bad volatility during the COVID-19 period because turmoil periods led cryptocurrency market investors to be very stressed and over-react to negative news. Focused on the stock market, Ftiti et al. (2021b) investigate the impact of non-fundamental news related to the COVID-19 pandemic on Chinese stock market volatility, trading activity and liquidity risk with performed quantile regression on daily data. They obtain that the non-fundamental news, as the number of deaths and cases related to the COVID-19 pandemic, increased the stock market returns volatility and reduced the level of stock market liquidity, increasing overall risk, whereas fundamental macroeconomic news had less influence on stock markets. They explain these findings by a knock-on effect because the health system's inability to manage and threat a high number of COVID-19 patients in intensive care led the country to implement a lockdown and the global economy to largely shut down. These results indicate that the stock market reacts to health news, which leads to a change in investor sentiments because an increase in the daily number of cases or deaths will lead them to revise their expectations and be more pessimistic and insecure. Louhichi et al. (2021) analyze the effect of COVID-19 on the economic environment in the main cluster countries (China, France, Italy and US) by focusing on the main indicators: financial market performance, exchange rate dynamics and investor fear sentiment dynamic based on implicit volatility measures. Based on daily data from December 31, 2019, to July 31, 2020 they find that the co-movement of the investor fear sentiment exhibits a different pattern in China than in France, Italy and US because China only showed a short-term impact and the other countries faced long-term effects.

In other studies, the non-fundamental variable is based on Google search volume of some keywords related to COVID-19 pandemic. Lyócsa et al. (2020) analyze the predictive power of Google search volume on the volatility of the largest 10 stock markets during the COVID-19 pandemic and found that a high search volume on Google predicts high volatility in all of them. Su et al. (2021) consider a more precise set of keywords related to the COVID-19 pandemic to investigate the impact of fear of the pandemic on Chinese stock market from January 20 to August 31, 2020, and they find that COVID-19 pandemic fear has a negative and significant impact on Chinese stock market returns, and the impact is persistent. Shear et al. (2021) examine the impact of investors' attention to COVID-19 on stock market returns and measuring investors' attention with the Google search volume of the word *coronavirus* for each country. They find that investors' higher attention to COVID-19 pandemic led to negative stock market returns.

This work follows the latter line of research since it tries to analyze the impact of Google search volume of the word *coronavirus* on the returns and prices of stock markets. We consider that this measure represents better the dynamics of fear than traditional measures such as VIX, which is based on market variables. We focus our analysis on a set of four European countries which has been highly affected by the pandemic in its early stages and which represent the largest stock markets in Europe. Moreover, we focus our analysis in that first phase of the pandemic, during which financial markets were driven by uncertainty and fear, since we consider that is during this stage when fear is more likely to drive stock indices returns.

8.4 Data and Methodology

As stated above, we use the number of searches for the word *coronavirus* to proxy fear (Fofana et al. 2020; Martínez-Lorca et al. 2020; Mertens et al. 2020; Asmundson and Taylor 2020). The word *coronavirus* will be probably the most searched in the history of Google Trends (Lyócsa et al. 2020). Previous studies in which Google search volume is used to proxy fear are based on the construction of a fear index for many keywords (Da et al. 2015; Fernandez-Perez et al. 2020; Han et al. 2017; Khan et al. 2019; Kostopoulos et al. 2020). However, the current crisis is caused by a unique phenomenon that is very specific: coronavirus. Dzielinski (2012) states that the keyword must be simple enough, must not contain any noise and not to be used to describe any other concept. We consider that the keyword *coronavirus* meets all those requirements. We gathered the data from the Google Trends website, which is commonly named the Google Search Volume Index (GSVI)[1]. Specifically, we have gathered the Google search volume performed in each country for that keyword using the Google Trends filter, which enables the geographical restriction of searches depending on the users' IP addresses. The GSVI varies depending on the country. We must mention that the GSVI does not represent the total number of searches but is an index that ranges between 0 and 100, with the latter representing the maximum number of searches (Da et al. 2011, 2015; Dergiades et al. 2015; González-Fernández and González-Velasco 2020). We obtained the daily GSVI for the period between January 19 and March 20, 2020. Google uses a random sample of searches to increase response speed. Therefore, the GSVI gathered on two different moments of time might differ slightly (Carrière-Swallow and Labbé 2013; Da et al. 2015; McLaren and Shanbhogue 2011). However, our keyword is very robust to this sampling error. We have downloaded the series on different dates and their correlation is above 95% in all cases. For the stock markets, we obtained the daily data for the CAC40 (France), DAX30 (Germany), FTSE-MIB (Italy) and IBEX35 (Spain) for the same time horizon from Thomson Reuters Eikon. The selection of these countries is due to two reasons. First, as this paper was being written, these countries presented the largest numbers of patients infected by the coronavirus. Therefore, the fear related to the outbreak of coronavirus was reasonably present in them. Second, they represent the four largest economies and stock markets of the Eurozone.

The beginning point of the time horizon is not arbitrary, but it reflects the beginning of the outbreak of the coronavirus crisis in Europe. We select this time horizon considering that it includes the period of maximum financial distress; although stock markets still show a high volatility, the sharpest meltdown occurred in late February and early March, as shown in Fig. 8.1. Until January 21, 2020 the series for the GSVI are almost flat, and they slightly rise by the end of January, especially in Germany and Italy. Then, by February 20, 2020, all the GSVI series sharply rise and, simultaneously, the market's plunge. Therefore, we can see that the GSVI and the stock markets move in opposite directions, as expected.

In Fig. 8.2 we display the GSVI for each country along with the Cboe Volatility Index (VIX index) which is a measure of market risk and investors' sentiments (Qadan and Yagil 2012). The GSVI reflects a similar pattern with a correlation with the VIX index even above 90%, during those dates. Therefore, it seems that the

[1] Data will be available on request from the authors or https://trends.google.es/trends/?geo=ES

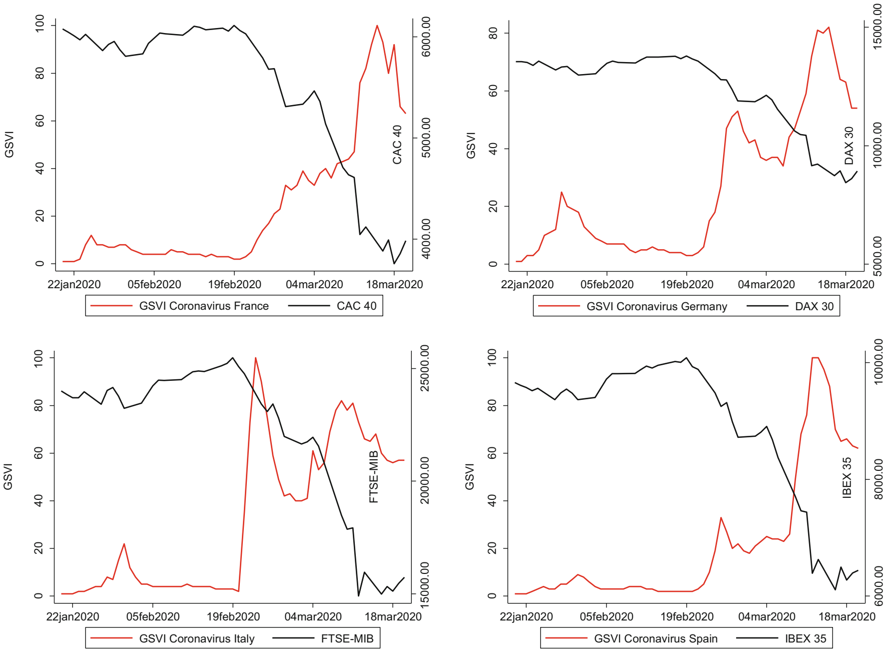

Fig. 8.1 Evolution of the GSVI and the stock markets of France, Germany, Italy and Spain between January 19 and March 20, 2020

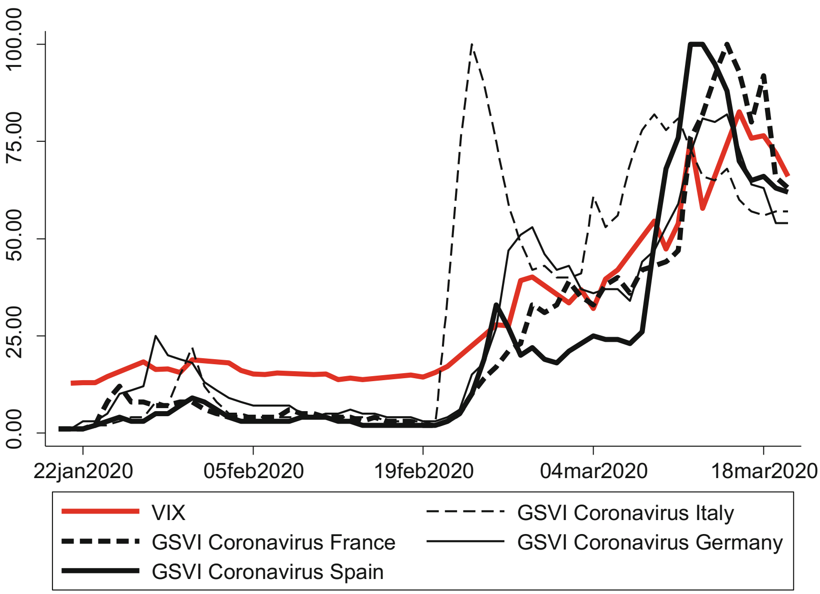

Fig. 8.2 Evolution of the GSVI *Coronavirus* in France, Germany, Italy, and Spain, along with the VIX index

GSVI reflects fear in the markets, similar to the VIX index. However, market-based measures such as the VIX index have the disadvantage that they are the result of economic forces, but they do not reflect investor attention (Da et al. 2015; Qiu and Welch 2006), while our proxy for fear might allow us to measure real attention and actual fear of the coronavirus outbreak. Moreover, although the VIX index is known as a fear-gauge index, several papers have separated it into a risk aversion and an uncertainty component (Bekaert et al. 2013; Bekaert and Hoerova 2014; Qadan and Aharon 2019) and we want to focus on fear strictly.

For the empirical analysis, we must consider that, unlike the GSVI, the stock markets do not provide data on weekends. Therefore, this might be a problem dealing with time series data and their lags. We can remove those observations or interpolate the values. We interpolate the values for Saturdays and Sundays because otherwise, we might ignore increases in fear levels during the weekends that might influence the stock markets on Mondays. This interpolation method is commonly employed when dealing with series in which some of them have values on weekends, such as bitcoin, FX markets or the GSVI, and others are not traded on weekends (Do et al. 2014; Klein et al. 2018). Thus, missing observations for stock markets are interpolated based on a cubic curve using two previous data points and two subsequent data points. Then, to test the relationship between stock markets and the GSVI, we run VAR models for each country with the stock market as the dependent variable. Following Vozlyublennaia (2014), we use the returns instead of the raw index prices calculated as log differences. Table 8.1 provides a description of the returns and the GSVI. All stock market returns show negative means, indicating that during this period, they faced a meltdown. Moreover, the mean values are quite similar, and the standard deviation indicates no large differences between stock markets. The GSVI also shows similar results in the four countries, except for Italy, which shows a higher amount of attention and a higher variation.

Regarding the stationarity of the series, the ADF and KPSS results indicate that the market returns are stationary, while the GSVI is nonstationary. We include both

Table 8.1 Descriptive statistics

	Source	Mean	St. Dev	ADF	KPSS
CAC40 returns	Thomson Reuters Eikon	−0.0070	0.023	−7.739[a]	0.078
DAX30 returns	Thomson Reuters Eikon	−0.0069	0.022	−7.262[a]	0.080
FTSE-MIB returns	Thomson Reuters Eikon	−0.0070	0.030	−8.966[a]	0.070
IBEX35 returns	Thomson Reuters Eikon	−0.0067	0.026	−8.812[a]	0.076
GSVI France	Google Trends	24.27	28.40	−1.736	0.609[a]
GSVI Germany	Google Trends	26.37	24.60	−2.757	0.314[a]
GSVI Italy	Google Trends	32.18	31.02	−3.166	0.122[c]
GSVI Spain	Google Trends	22.18	28.62	−2.623	0.337[a]

Notes: the table shows the descriptive statistics of the variables included in the analysis along with the source of the data. ADF and KPSS indicate the Augmented Dickey Fuller and Kwiatkowski-Phillips-Schmidt-Shin tests to test for a stationarity-in-time series
[a]Significance at 1%; [b]Significance at 5%; [c]Significance at 10%

the ADF and KPSS tests since the ADF test can provide weak results (Kling and Gao 2008). Thus, the inclusion of the KPSS test helps to remove those doubts since both tests point in the same direction. Therefore, since the returns are I(0) and our proxy for fear is I(1), the series cannot be cointegrated, but we can analyze the short-term relationship through VAR models (Kling and Gao 2008). Thus, we perform the VAR models according to the following specification:

$$\begin{aligned} \text{Returns}_t &= \alpha_0 + \beta_1 r_{t-1} + \beta_2 r_{t-2} + \cdots + \beta_j r_{t-j} + \gamma_1 \text{GSVI}_{t-1} \\ &\quad + \gamma_2 \text{GSVI}_{t-2} + \cdots + \gamma_j \text{GSVI}_{t-j} + e_{1t} \end{aligned} \tag{8.1}$$

$$\begin{aligned} \text{GSVI}_t &= a_0 + b_1 \text{GSVI}_{t-1} + b_2 \text{GSVI}_{t-2} + \cdots + b_j \text{GSVI}_{t-j} \\ &\quad + c_1 r_{t-1} + c_2 r_{t-2} + \cdots + c_j r_{t-j} + e_{2t} \end{aligned} \tag{8.2}$$

where r denotes the returns, GSVI represents the volume of Google searches for the keyword coronavirus, which is our proxy for fear, and j denotes the number of lags. Then, we calculate the Granger causality test to analyze whether fear causes changes in returns, and finally, we perform impulse response functions (IRFs).

8.5 Analysis and Discussion of Results

Table 8.2 reports the results for the Granger causality tests to check whether the GSVI causes changes in stock market evolution and vice versa. The upper p-value refers to the null hypothesis, i.e., changes in GSVI do not cause changes in the stock market, and the lower p-value refers to the null hypothesis, i.e., changes in the stock market do not cause changes in GSVI. Therefore, a rejection indicates a Granger causality relationship. As in Vozlyublennaia (2014), we use different lag specifications: two, four and six lags. We also include the number of lags selected according to Akaike's criteria.

Considering the results from Table 8.2, we observe that for Germany, Italy, and Spain, the GSVI causes the stock market returns. Moreover, this result is robust to the lag specification. These results are in line with Khan et al. (2019), who build a fear index based on Google data in a similar fashion as Da et al. (2015) and find that it causes stock return changes. It is worth noting that when selecting six lags or Akaike's criteria, there is a feedback relationship in Germany and Spain, i.e., in these cases, changes in the stock market also cause changes in the GSVI. France seems to show different behavior, where it is observed that changes in the GSVI do not cause changes in the stock market regardless of the number of lags selected, but the changes in the stock market causes changes in the GSVI in most of the lag specifications. We hypothesize that the different result for France is due to the composition of its stock market, in which consumer goods companies have a higher weight.

Table 8.2 Granger causality tests

	CAC40	DAX30	FTSE-MIB	IBEX35
GSVI *coronavirus* (2 lags)	0.423	0.010	0.002	0.078
	0.047	0.467	0.801	0.246
GSVI *coronavirus* (4 lags)	0.789	0.032	0.085	0.001
	0.222	0.366	0.789	0.129
GSVI *coronavirus* (6 lags)	0.163	0.004	0.184	0.005
	0.000	0.022	0.967	0.043
GSVI *coronavirus* Akaike's	0.352	0.008	0.002	0.002
	0.001	0.034	0.801	0.047

Notes: The table shows the *p*-values for the Granger causality tests between stock market returns and the GSVI for the keyword *coronavirus* in each country. The upper *p*-value indicates the null hypothesis that changes in the GSVI do not cause changes in the stock market, and the lower *p*-value indicates the null hypothesis that the changes in the stock market do not cause changes in the GSVI. Following Vozlyublennaia (2014) we use models with two, four and six lags. The last row shows the specification with the number of lags selected according to Akaike's criteria: eight lags for CAC40, eight lags for DAX30, two lags for FTSE-MIB and five lags for IBEX35

However, causal analysis does not provide the direction of the relationship. Therefore, we complete the analysis with the display of the VAR models, where we use the four-lag specification for conciseness (Table 8.3). Focusing on the results in the first column of each stock market, in which the dependent variable is the returns, we can observe that the first lag of the GSVI is significant in Germany and Italy. Therefore, stock market returns in those countries are negatively affected by the GSVI on the previous day. Additionally, Spain provides significant results, but these are quite different. In this country, the third and fourth lags show significant results with opposite signs, indicating that returns are positively influenced by the searches performed 4 days earlier but negatively influenced by the searches conducted just 3 days earlier. In France, we find no evidence for an impact of the GSVI on CAC40 returns. The results meet ex ante expectations for a negative relationship between fear, measured through the GSVI, and stock market returns, except for France. The findings are in line with previous studies such as Kostopoulos et al. (2020), who point out that fear has a short-term impact on stock returns, or Vozlyublennaia (2014), who also determines a negative short-term relationship between investor attention and stock indexes.

Finally, in Fig. 8.3, we display the IRFs of the VAR models from Table 8.3 for each stock market. The impulse variable is the GSVI, and we check the response on market returns. First, we can see no significant impact on returns in France, as expected from the previous results. However, it is shown that in Germany and Italy, their market returns are negatively influenced by the GSVI from the previous day, and the response is stronger in Italy. This effect is a short-term effect, the returns increase after the first day, and the response is no longer significant. For Spain, we can see that an upsurge in the GSVI leads to a significant drop in the returns after 3 days, and subsequently, the market returns rise again on the fourth day.

Table 8.3 VAR models for stock market returns and GSVI for the keyword *coronavirus*

	CAC40		DAX30		FTSE-MIB		IBEX35	
	$Return_t$	$GSVI_t$	$Return_t$	$GSVI_t$	$Return_t$	$GSVI_t$	$Return_t$	$GSVI_t$
$Return_{t-1}$	−0.123	30.38	−0.266	−29.44	−0.288[c]	−29.98	−0.418[a]	54.62
	(0.227)	(56.24)	(0.161)	(35.97)	(0.149)	(42.27)	(0.147)	(36.74)
$Return_{t-2}$	0.259	−101.79[c]	−0.225	−33.05	−0.099	−23.90	0.031	−45.95
	(0.226)	(56.14)	(0.169)	(37.68)	(0.162)	(45.69)	(0.147)	(36.78)
$Return_{t-3}$	0.086	−71.76	−0.039	−60.00	0.040	−15.86	0.037	−51.30
	(0.227)	(56.32)	(0.171)	(38.19)	(0.162)	(45.90)	(0.151)	(37.86)
$Return_{t-4}$	0.081	−23.50	−0.160	29.01	0.056	35.73	0.238	24.53
	(0.192)	(47.60)	(0.179)	(40.13)	(0.155)	(43.71)	(0.154)	(38.54)
$GSVI_{t-1}$	−0.0004	0.986[a]	−0.001[b]	1.215[a]	−0.001[b]	1.530[a]	−0.0006	1.639[a]
	(0.0008)	(0.218)	(0.0007)	(0.161)	(0.0005)	(0.143)	(0.0006)	(0.171)
$GSVI_{t-2}$	0.001	−0.077	0.0003	−0.172	0.001	−0.711[b]	0.0006	−0.836[a]
	(0.001)	(0.330)	(0.001)	(0.238)	(0.0009)	(0.267)	(0.001)	(0.307)
$GSVI_{t-3}$	−0.001	0.293	−0.00008	−0.048	−0.0006	−0.035	−0.002[c]	0.241
	(0.001)	(0.362)	(0.001)	(0.237)	(0.0009)	(0.269)	(0.001)	(0.306)
$GSVI_{t-4}$	0.0007	−0.291	0.0008	−0.072	0.00008	0.147	0.002[a]	−0.088
	(0.0009)	(0.233)	(0.0006)	(0.152)	(0.0005)	(0.145)	(0.0006)	(0.165)
Constant	0.004	1.389	0.001	1.824[c]	0.006	2.723	−0.004	1.267
	(0.004)	(1.114)	(0.004)	(1.072)	(0.006)	(1.793)	(0.003)	(0.973)

Notes: The table reports the VAR models for stock market returns and the GSVI for the keyword *coronavirus*. The models have been estimated using a small-sample correction, and all of them include four lags. The data covers the daily time span between January 19 and March 20, 2020. The first column of each stock market represents the VAR model in which market returns are the dependent variable. In the second column, the GSVI is the dependent variable. Standard errors are shown in parentheses

[a]Significance at 1%; [b]Significance at 5%; [c]Significance at 10%

In short, the results above confirm that our proxy of fear, based on Google search volume, has demonstrated to be a good proxy for this sentiment. In this sense, the VAR models, the causality tests, as well as the IRFs show how changes in Google search volume adversely impact stock indices returns. This finding reinforces the theoretical arguments of Su et al. (2021) that the COVID-19 pandemic introduced fear in the financial markets and that the transmission mechanism between those variables occurred through two channels. The first is the noise traders' channel, which leads to an increase in the volatility. This has also been highlighted by Peri et al. (2014) who indicate that the effect of noise traders enhances after negative shocks. Thus, this mechanism of transmission has been intensified due to the COVID-19 pandemic. The second channel is related to liquidity, and according to it, fear constraints liquidity. Both channels precede a negative impact on stock markets returns.

Our results also confirm that the consequence of those channels is a drop in the stock indices analyzed, but that those declines occur in the short term and then they revert. Therefore, during the first months of the COVID-19 pandemic, fear had

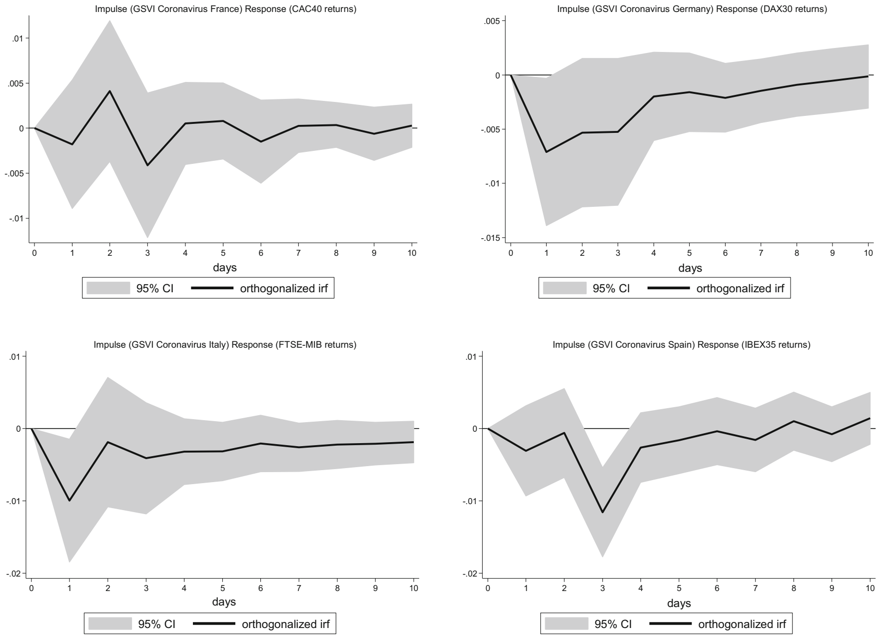

Fig. 8.3 Impulse response functions for the VAR models between stock market returns after a shock (standard deviation) in the GSVI for the keyword *coronavirus*

a negative a short-term effect on the stock returns of Germany, Italy and Spain. Moreover, these results are in line with previous studies such as Lyócsa et al. (2020) or Shear et al. (2021) confirming that fear leads to lower returns and that Google search volume is a good proxy of fear during the pandemic, but also with other studies not focused in the pandemic, which indicate that negative mood or sentiment, negatively affects returns (Baker and Wurgler 2006; Schmeling 2009; Zouaoui et al. 2011).

8.6 Conclusions

We analyze the impact of fear related to the coronavirus outbreak on the stock markets of four Eurozone countries: France, Germany, Italy, and Spain. For this purpose, we use the volume of Google searches for the keyword coronavirus in each of those countries to measure fear. Empirically, we test this relationship through VAR models, Granger causality tests and impulse response functions.

Our main findings suggest that changes in this fear measure cause changes in stock market returns in Germany, Italy, and Spain but not in France. Moreover, a feedback relationship is shown between fear and market returns for Germany and

Spain. Regarding the direction of that relationship, we find that in Germany and Italy, an upsurge Google search volume of the keyword *coronavirus* produces a significant decline in the stock market the following days. Therefore, searches for words related to fear, in this case coronavirus, have a significant predictive power on the price of the stock markets, may vary depending on the country considered and these findings are in line with previous literature indicating that bad news or catastrophic events enhance fear, which leads to a drop in stock markets in the short term (Lyócsa et al. 2020).

Therefore, with this paper we contribute to the growing research field of investor fear sentiment literature. This study has several economic implications for policymakers and investors. Regarding policymakers, the results demonstrate the sensitivity of stock markets to the COVID-19 pandemic fear. For this reason, policymakers can monitor these fear sentiment measures, such as Google searches, which also have the advantages of being transparent, easily accessible and at a very high frequency, to foresee jumps in the financial markets that could affect the economy. This would help financial authorities to better understand the relationship between fear and financial markets. Regarding investors, this study shows that Google search volume, can be a good complementary tool to know how stock markets react to the COVID-19 pandemic which will help them in their investment decision-making and diversification of their portfolios, especially during periods of financial turmoil. In this sense, practitioners can use trading strategies based on Google search volume related to fear which can outperform traditional trading strategies.

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Chapter 9
Financial Performance During the COVID-19 Crisis: The Role of Investment and Revenue

Hasna CHAIBI, Fatma HENTATI, and Ines GHZAOUANI

9.1 Introduction

It is undeniable that, recently, an upheaval has shocked the world. Actually, on March 11, 2020, the World Health Organization[1] declared the latest virus discovered in China in December 2019 as a pandemic. This virus, called the COVID-19, has had a severe impact on public health and a significant global economic effect. At the macro level, the COVID-19 epidemic triggered the most significant worldwide recession since the Great Depression of the 1930s, when the economy was destroyed (Shen et al. 2020). As for the company level, Ashraf (2020) studied this coronavirus effect on the stock market. Additionally, previous studies investigated firm performance in the energy industry (Fu and Shen 2020), oil prices (Narayan 2020; Akhtaruzzaman et al. 2020; Devpura and Narayan 2020) and health (Hagerty and Williams 2020).

On the one hand, due to the restriction of financial flows during the COVID-19 epidemic, investment activity was halted; as a result, firm investment declined (Jiang et al. 2021). In addition, it is shown that COVID-19 negatively affects sales

[1] The World Health Organization (WHO) is a United Nations specialized organization in charge of international public health. The WHO Constitution, which outlines the agency's governance structure and values, declares that its principal goal is "the attainment of the most significant attainable level of health by all peoples.

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revenue (Fairlie and Fossen 2021). Indeed, these two factors amplified the negative impact of the outbreak on firm performance (Shen et al. 2020). On the other hand, the disadvantage of evaluating this effect at the aggregate market level is that it assumes a homogenous influence on sectorial performance, implying that COVID-19 has the same impact across all sectors. According to Narayan and Sharma (2011), sectors are heterogeneous and react differently to market shocks. For instance, Shen et al. (2020) stated that the most affected industries in China are tourism, film and television entertainment, catering retail, and transportation.

The general objective of this study is to assess the impact of the pandemic of Covid-19, during the year 2020, on the financial performance of Tunisian listed companies. The specific objective aims to examine, on the one hand, the pandemic influence on corporate performance and via which channel it was affected. We will consider investment and revenue as moderating factors and examine if the COVID-19 impact is more pronounced when both decreased factors. On the other hand, we investigate the outbreak impact on firm performance through various industries to examine if particular sectors are affected more than others are.

Our research aims at studying the economic effect of significant public health emergencies. For this reason, the choice of the subject is guided as follows: not only because it is topical but also because it is a futuristic subject since the COVID-19 pandemic unfortunately persists. Indeed, this study is crucial since performance is a company's major aim in retaining its market, developing its operations, and winning the trust of internal and external personnel. As a result of this research, company executives will be able to reassess their predictions, re-evaluate their scenarios, and strengthen their detection and reaction capabilities when confronted with a crisis. Furthermore, they may understand the immediate financial impact of COVID 19 and, as a result, initiate measures to meet the needs of each sector of the economy, allowing listed companies to survive in the current economic circumstances while also contributing to the economy's long-term growth.

Few studies investigated corporate performance during the COVID-19 crisis (e.g., Fu and Shen 2020; Kabir and Bin Saleh 2020; Aifuwa et al. 2020). Therefore, this study contributes to previous research by assessing an impact on financial firm performance using the Difference-in-Difference method. Indeed, this analysis is new in that it highlights the influence of an epidemic, for the first time, on the financial performance of listed Tunisian companies in different sectors. In addition, it highlights the impact of containment and measures taken by the Tunisian government to control the pandemic on the performance of firms.

The following is the outline of this research: Apart from the introduction and the conclusion, it is divided into three chapters. The first one will discuss our main concepts. Thus, it will consist of two sections. The first section emphasizes firm performance, and the second one will briefly discuss crises. The second chapter highlights the influence of the COVID-19 pandemic on firm performance. We will provide a literature review and formulate our hypotheses. Finally, the third chapter will empirically verify our hypotheses using the difference-in-difference (DID) method.

9.2 Literature Review and Hypotheses Development

The COVID-19 pandemic provides an intriguing scenario in which an unanticipated shock produces significant effects incorporate performance compared to managers' expectations just a couple of months before the crisis. Previous studies revealed that due to this epidemic, corporate performance is significantly impacted on corporate performance. Using the financial data of Chinese listed firms, Shen et al. (2020) showed that COVID-19 negatively affects their performance. They also found that COVID-19 has had a significant adverse effect on corporate performance in the energy industry. Similarly, Kabir and Bin Saleh (2020) found that COVID-19 has a significant impact on the overall financial performance of the listed companies in Bangladesh. These studies are among the first to provide empirical evidence of the influence of this 2020 pandemic on corporate performance. Based on this analysis, we are proposing the following hypothesis:

H1: COVID-19 has a negative impact on financial performance.

Nonetheless, how does the COVID-19 affect firm performance?

In the following two parts, we will highlight two main factors that influenced corporate performance during the pandemic, namely investment and sales.

9.2.1 The Role of Investment

Multiple theories have been proposed to explain corporate investment behavior. According to Tobin's Q hypothesis, enterprises invest when attractive growth opportunities. Following the asymmetric investment theory,[2] financial markets imperfections cause businesses to confront variable degrees of financing restrictions and, as a result, make investments at varying levels (Kasahara 2008). Both theories anticipate a decrease in assets during a financial crisis since this one is referred to as lower growth opportunities and increased financial restrictions. According to agency and trade-off theories, businesses would be more inclined to keep cash on hand during a pandemic as a precaution or to take advantage of attractive investment opportunities (Keynes 1936).

Studying the coronavirus impact on firm investment using a sample of Chinese publicly listed companies, Jiang et al. (2021) revealed that the COVID-19 crisis has hampered internal and external financing, affecting investment, financing and dividend distribution behavior. Investment in fixed and current assets are practical uses of corporate capital, with decisions of investment serving as the primary driver of the company's growth. On that account, investment is critical for future cash flow growth, profitability, operational risk reduction, and future development

[2] "Asymmetric investment theory is a particular form of standard investment theories".

opportunities (Myers and Majluf 1984). Furthermore, according to fundamental options theory, managers prefer to delay investments when uncertainty increases. Thus, profitable projects might be missed. COVID-19 increases external risks, prompting management to raise financial reserves in an emergency. More cash retention depletes investment funds and slows the pace of the long-term growth of businesses (Shen et al. 2020).

Based on the preceding discussion, we made the following hypothesis:

H1.1: COVID-19 has a more significant negative impact on financial performance when the firm's investment scale is lower.

9.2.2 The Role of Sales Revenue

Referring to Guerini et al. (2020), who studied the impact of Covid-19 on non-financial French firms, this pandemic's tight containment measures, the following slow re-opening, and the resulting drop in consumption and investment all reflect demand and supply shock at the same time. Furthermore, they stated that sales consequently have dropped in response to the sudden and massive demand shock that follows confinement.

According to Wijaya (2020), the pandemic has significantly influenced the Indonesian economy due to a significant drop in sales income. Furthermore, Fairlie and Fossen (2021) showed negative relationships between COVID-19 cases and sales growth. They stated that this relationship could be seen in businesses subject to tight lockout regulations and critical businesses like garden equipment stores and grocery stores.

According to Maslow's hierarchy of needs, the need for health and safety during the pandemic is much more important than the need for social interaction, which consequently causes a declining demand (Hagerty and Williams 2020). Thus, firm revenues decrease and then so perform as a result. The adoption of quarantine measures resulted in a dramatic drop in production and income for the firms, which ultimately led to a decline in performance (Shen et al. 2020). Based on the discussion below, we made the following hypothesize:

H1.2: COVID-19 has a more significant negative impact on financial performance when the firm's sales revenue is lower.

9.2.3 Industrial Impact

The disadvantage of examining the pandemic's effect at the aggregate market level is that it assumes a homogenous influence on sectorial performance, implying that COVID-19 has the same impact across all sectors (Shen et al. 2020). However, according to Narayan and Sharma (2011), sectors are heterogeneous and react to market shocks in diverse ways. Thus, the supply-demand relationship changes depending on the industry's characteristics during the epidemic.

Several research studies showed that the COVID-19 pandemic has a more significant impact on specific industries than others (Al-Awadhi et al. 2020; Shen et al. 2020). For example, Bartik et al. (2020) showed that retail companies are particularly at risk due to interruptions caused by the coronavirus. In addition, the pandemic's negative impacts were especially evident in China's tourist and catering businesses (Shen et al. 2020). Similarly, the transportation sector halted operations due to containment enforced in numerous nations, disrupting the supply chain of critical products, notably food (Reardon et al. 2020) and humanitarian relief is given by various organizations. Indeed, the pandemic may directly impact food supply and demand channels, indicating a drop in inventories and a rise in food prices. Furthermore, as the epidemic develops, purchasing power and the capacity to manufacture and distribute food will be harmed indirectly.

Dube et al. (2020) show that the restaurant sector has been negatively affected by the lockdown due to the COVID-19 pandemic in many countries, including the USA, Australia and Britain. Studying Chinese listed companies, Shen et al. (2020) found high-impacted industries: tourism, film and television entertainment, catering retail, transportation, realty business, construction, accommodation, and export manufacturing industries. They stated that the restrictions enacted in reaction to the COVID-19 epidemic had had a significant impact on these sectors, typified by high levels of personnel intensity, social contact, and cross-border commerce.

Based on what we have just discussed; we have come up with the following hypothesis:

H2: The COVID-19 pandemic has a negative impact on firm performance in high-impact industries.

9.3 Impact of COVID-19 on the Performance of Tunisian Listed Firms

On January 14, 2011, Tunisia has faced a similar situation to the pandemic economic impact. Indeed, it had experienced a revolution, overthrowing the country's 23-year-old constitutional dictatorship, which comes down to the first protest movements in December 2010, when citizens' dignity, labor, human rights, and social equality were all declared.

The Tunisian economy was in a precarious position during the Revolution. The country's growth has slowed. On the one hand, the revolution has accelerated the trend toward lower output levels, which has been exacerbated by "political instability", "social conflicts", and the "economic crisis". On the other hand, the international business climate has had a negative impact on Tunisian firms' performance. While on the subject, this last chapter aims to assess the outbreak impact on the performance of listed Tunisian companies. In this manner, we will be testing our hypothesis empirically using the difference-in-difference method. This section will include the presentation of our research methodology and empirical results.

9.3.1 Methodology

Our study is based on a sample of 40 companies listed on the Tunis Stock Exchange from 2016 to 2020. In order to assure the comparability of research objects, we eliminated from our sample the financial sector. On another note, the reason for which we chose the period 2016–2020 is that after the Tunisian Revolution that happened in 2011, the nation experienced a period of political instability. In actuality, with the writing of the first constitution following the revolution, legislative and presidential elections were held in 2014 and 2015. Moreover, it should be noted that the period 2016–2020 includes the COVID-19 pandemic. Therefore, we have two periods in this case: the pre-COVID-19 period from 2016 to 2019 and the COVID-19 period in 2020.

We used the financial data of non-financial firms listed on the Tunis Stock Exchange from 2016 to 2019 to predict corporate performance in the $t + 1$ period, i.e., 2017–2020. Then, we selected data for the first semester from 2017 to 2020 as the research sample to study the COVID-19 pandemic impact on firm performance in Tunisia. We collected our data from the Tunis Stock Exchange (BVMT in French) and the Financial Market Council (CMF). We also use financial data of Tunisian listed firms from 2016 to 2019 to forecast their performance in the first semester of 2020. Finally, we compare the predicted results to the actual value to track the pandemic's influence on firm-level performance in several industries.

Furthermore, we analyze the pandemic impact using financial data from the first semester of 2017–2020. First, to explore the mechanism of COVID-19 impact, we employ investment growth and total income as moderating variables. Then, per industry, we categorize the listed firms into high- and low-affected groups. Right after, we use the DID model to investigate the impact of the pandemic on corporate performance.

The following table will go through the definitions of the variables stated above and moderating and dummy variables (Table 9.1).

9.3.2 Empirical Results

We estimate the impact of COVID-19 on corporate performance through two techniques, Generalized Least Square (GLS) and Difference-in-difference method (DID). We first start our estimations using the GLS technique to estimate our first three hypotheses (H1, H1.1, H1.2).

Table 9.1 Presentation of the variables

Variable	Measure	Definition
NROA (net return on assets)	$\frac{\text{Net Income}}{\text{Total assets}}$	This ratio expresses an enterprise's ability to generate revenue from its resources.
ROE (return on equity)	$\frac{\text{Net Income}}{\text{Equity}}$	This ratio expresses the annual returns of capital assets in relation to profits earned.
Treated	1 or 0	If the company has belonged in a high-impact industry, the dummy variable "pandemic impact degree" is 1. Otherwise, it is 0.
Period	1 or 0	The dummy variable "outbreak time" is 1 following the outbreak and 0 otherwise.
CNCA	(fixed assets − fixed assets$_{-1}$)/fixed assets$_{-1}$	Growth rate (a variable's percentage change over time) of fixed assets.
SIZE	Log (Total Assets)	A firm's ability and the diversity and number of production capabilities or the quantity and multiplicity of services a firm can give concurrently to its consumers are considered firm size.
LEV	$\frac{\text{Debts}}{\text{Total Assets}}$	The total amount of debt relative to assets owned by a company. This ratio is critical in estimating a company's financial risk.
GROWTH	(revenue$_t$ − revenue$_{t-1}$)/revenue$_{-1}$	The growth rate of revenue measures how successfully a firm can increase its sales revenue over a certain period.
HF3	$H = \sum_{i=1}^{3} p_i{}^2$ p_i is the share (in %) of the capital held by shareholder i	The Herfindahl-Hirschman index, computed as the sum of the capital held by the three biggest shareholders, measures ownership concentration.
FCF	$\frac{\text{operating cash flow} - \text{Investmenet}}{\text{Total Assets}}$	The amount of money a firm may generate after it has spent the money required to maintain or expand its assets.
TR	(Revenue/Average trade receivable balance)/1000	The receivables turnover ratio is a metric that evaluates how efficiently a firm collects on its receivables or accords credit to consumers.
REV	Log (Total revenues)	The logarithm of total revenue for the current period

The results in Table 9.2 show that COVID-19 negatively affects firm performance, which verifies hypothesis H1, and in line with Shen et al. (2020), Kabir and Bin Saleh (2020) and Aifuwa et al. (2020). In the second column representing the results for investment, the significant regression coefficient of the core variable period is −0.008, showing that the COVID-19 outbreak has a significant negative impact on firm performance. On the other hand, the coefficient of our interaction variable CNCA*period is positive and significant, showing that high fixed asset investment will mitigate the negative impact of the outbreak on firm performance. Therefore, this confirms hypothesis H1.1, following the findings of

Table 9.2 GLS estimation results

Variables	Baseline	Investment	Revenue
Period	−0.0109***	−0.00802***	−0.0542*
	(0.00196)	(0.00229)	(0.0326)
CNCA*period		0.106***	
		(0.0353)	
CNCA		0.0230**	
		(0.0107)	
SIZE	−0.00158	−0.00225	−0.0291***
	(0.00409)	(0.00443)	(0.00817)
LEV	−0.0295***	−0.0289***	−0.0360***
	(0.00613)	(0.00616)	(0.00765)
GROWTH	0.0648***	0.0652***	0.0580***
	(0.00696)	(0.00702)	(0.00800)
HF3	−0.0288**	−0.0258**	−0.0269**
	(0.0113)	(0.0110)	(0.0123)
FCF	0.0423***	0.0408***	0.0396***
	(0.00993)	(0.0112)	(0.0116)
TR	−0.0110	−0.00275	−0.00869
	(0.0282)	(0.0265)	(0.0309)
REV*period			0.00800*
			(0.00426)
REV			0.0255***
			(0.00726)
Constant	−2.285*	−1.391	−1.105
	(1.360)	(1.562)	(1.694)
Observations	160	160	160
Number of id	40	40	40
Year	YES	YES	YES
Industry	YES	YES	YES

Period: “outbreak time” is equal to 1 following the outbreak and 0 otherwise; *CNCA* Growth rate of fixed assets, *SIZE* Firm size, *LEV* leverage ratio, *GROWTH* Growth rate of revenue, *HF3* Herfindahl-Hirschman index, *FCF* Free Cash-flows, *TR* Turnover ratio, *REV* Total revenue. Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Shen et al. (2020) and Jiang et al. (2021). Indeed, according to fundamental options theory, managers prefer to delay investments when uncertainty increases. Thus, profitable projects might be missed. Furthermore, COVID-19 increases external risks, prompting management to raise financial reserves in an emergency.

The coefficient of REV*period is 0.008 and is significant, showing that an increase in firm revenue will weaken the negative impact of the outbreak. This finding confirms hypothesis H1.2. According to Maslow's hierarchy of needs, the need for health and safety during the pandemic is much more important than the need for social interaction, which consequently causes a declining demand (Hagerty and Williams 2020). Thus, firm revenues decrease and then so perform as a result.

We will use the difference-in-difference technique following the GLS estimation to test our second hypothesis. Therefore, begin by testing if we could apply this method. According to the serial correlation test results, the difference between the treatment and control groups is significant at 1%, indicating that we can apply the DID approach.

After we can apply the DID method, we will estimate the COVID-19 impact by testing the industry impact. Since we classified the companies based on the COVID-19 effect by industry, in this manner, we have two groups, high-affected industries and low-affected industries. Our findings in Table 9.3 show that the COVID-19 pandemic has a tremendous negative impact on firm performance, which verifies hypothesis H2, like in Fu and Shen (2020), Shen et al. (2020) and Alam et al. (2020). Therefore, the leading cause of the outbreak resulted in a considerable drop in the performance of high-impact industries in Tunisia in 2020, namely Industrials, Basic Materials, Health and Telecommunications. Indeed, the quarantine restrictions affected the firms' productivity and revenue, which eventually led to a fall in performance.

We found that LEV, GROWTH and HF3 are statistically significant regarding the control variables. The regression coefficient of the asset-liability ratio is negative. In other words, LEV has a significant negative impact on ROA, consistent with Shen et al. (2020) and Fu and Shen (2020). As for GROWTH, according to our findings, it has a significant positive impact, in line with Shen et al. (2020) and Fu and Shen (2020).

We measure firm performance using the alternative variables Return On Equity (ROE) and Earnings Per Share (EPS) for robustness check. According to our findings, for both ROE and EPS, we show that the COVID-19 outbreak has, again, a significant adverse effect on financial performance in the high-affected industries. Therefore, hypothesis H2 is verified, consistent with Shen et al. (2020). Indeed, Apedo-Amah stated that regardless of country differences, industries, and the size of enterprises, there is a substantial heterogeneity impact within these groups, implying that comparable enterprises are affected variously and in differing ways. Furthermore, certain studies have shown that the COVID-19 pandemic has a more significant effect on specific industries than others. For instance, Bartik et al. (2020) showed that retail companies are particularly at risk due to interruptions caused by the coronavirus. Similarly, according to Shen et al. (2020), the pandemic's

Table 9.3 DID estimation results

Variables	NROA
Period	−0.0164**
	(0.0198)
Treated*period	−0.0423***
	(0.0109)
Treated	0.0354***
	(0.0133)
SIZE	−0.00498
	(0.0119)
LEV	−0.0391***
	(0.0128)
GROWTH	0.0747***
	(0.0254)
HF3	−0.0361*
	(0.0207)
FCF	0.00480
	(0.0577)
TR	−0.0283
	(0.0497)
Constant	−8.646
	(12.15)
Observations	160
R-squared	0.325
Industry	YES
Year	YES

NROA: Net Return on Assets ratio; Period: “outbreak time” is equal to 1 following the outbreak and 0 otherwise; Treated: if the company belongs in a high-impact industry, the dummy variable “pandemic impact degree” is 1. Otherwise, it is 0. *SIZE* Firm size, *LEV* leverage ratio, *GROWTH* Growth rate of revenue, *HF3* Herfindahl-Hirschman index, *FCF* Free Cashflows, *TR* Turnover ratio, *REV* Total revenue. Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

negative impacts were especially evident in China’s tourist and catering businesses. In contrast, Alam et al. (2020) found that the sector’s food, pharmaceuticals and healthcare have shown a sizable positive return compared to transportation and energy sectors that performed poorly in Australia.

Consequently, we should note that it has been dedicated to empirically verifying our hypotheses. Indeed, our findings show that the COVID-19 has a significant negative impact on firm performance, supporting H1. The results also demonstrated the mechanism through which the outbreak affected company performance. Indeed, both H1.1 and H1.2 have been supported. In other words, when a company’s investment or revenue's scale is decreased, COVID-19 has a more negative impact. As for the last hypothesis, the results indicate that the pandemic negatively influences firm performance in high-impact industries. Thus, companies in high-impact sectors are less efficient than those in other industries, supporting H2. In the first semester of 2020, quarantine measures in Tunisia slowed the spread of the virus.

Nevertheless, both production and consumption are constrained, resulting in the decline of firm performance. In such situations, managers must be aware of external environment changes and adapt their business strategy accordingly. Therefore, it is critical to make production and operation fit the "post-pandemic period" consumption pattern to recover operations as soon as possible.

9.4 Conclusion

It's become commonplace to remark that it's critical to evaluate performance, whether it's of companies, governments, or individuals, as this is particularly true since our cultures have become more performance-based. In this manner, this study analyzes the COVID-19 pandemic's influence on the performance of non-financial companies and its mechanism in detail, emphasizing firm-level performance. In addition, we examined the outbreak's industrial impact. According to our results, the outbreak has a significant negative impact on listed Tunisian companies by lowering investment and sales revenues, consistent with Shen et al. (2020). As for the industrial impact, we found that the outbreak negatively affects the firm performance in high-impact industries.

Furthermore, our findings show that Industrials, Basic Materials, Health and Telecommunications are high-affected industries. At the same time, Consumer Goods, Oil and Gas, Consumer Services and Technology belong to the low-affected industries. Therefore, the industrial impact is heterogenic, in line with Alam et al. (2020), Bartik et al. (2020) and others. The pandemic has a detrimental influence on industries' production, operation, and sales, resulting in a negative return rate, thus, on their performance.

In the first semester of 2020, quarantine measures in Tunisia slowed the spread of the virus. Nevertheless, both production and consumption are constrained, resulting in the decline of firm performance. In such situations, managers must be aware of external environment changes and adapt their business strategy accordingly. It is critical to make production and operation fit the "post-pandemic period" consumption pattern to recover operations as soon as possible. Nevertheless, due to missing data, this study does not investigate the outbreak impact on certain listed companies and non-listed.

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Chapter 10
U.S Stock Market and Cryptocurrencies During the COVID-19 Pandemic Outbreak

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10.1 Introduction

The COVID-19 pandemic has been transformed into a world economic and financial crisis. The general worldwide quarantine during the first then the second wave of COVID-19 caused by the rapid spread of infections and deaths, has significantly contributed to the degradation of the financial market. The COVID-19 health crisis has rapidly transformed into a worldwide financial and economic crisis.

After the first wave of COVID-19, several studies have been published to understand the financial and economic impact of the COVID-19 pandemic and the general worldwide quarantine. Most of these papers studied the specific impact of COVID-19 on financial markets' indices. They show that the rapid spread of COVID-19 has increased the risk level, caused financial losses, and increased equity market volatility (Zhang et al. 2020; Zaremba et al. 2020; Corbet et al. 2020; Akhtaruzzaman et al. 2020; Ashraf 2020; Sharif et al. 2020; Goodell 2020; Yousfi et al. 2021a, b; Managi et al. 2022).

Further, recent literature on the economic and financial impact of COVID-19, has discussed the transmission of shock from the Chinese market to the rest of the world. The main conclusion is that financial firms are likely to contribute more to the transmission of shocks from China to the rest of the world more than nonfinancial firms. These results confirm previous intuition that the general

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quarantine, to stop COVID-19 propagation, has affected basically financial markets. Cryptocurrency market becomes an emerging important market that offers several investment opportunities. However, transactions at the digital currency market have usually accompanied by numerous risks linked to its volatility and the global macroeconomic conjuncture. The main concern of the digital currency market literature is to analyze its volatility features and compared it to other financial assets (Dyhrberg 2016; Bouri et al. 2017; Baur and Dimpfl 2018; Klein et al. 2018). The literature generally concludes with useful recommendations in terms of risk management and portfolio diversification.

Despite the crucial impact of COVID-19 on digital currency return, papers that attempt to model and forecast cryptocurrency return in the era of COVID-19 are scarce. In this paper, we model and forecast the dynamic conditional correlations and hedge ratios between US stock market index S&P500 and the most capitalized cryptocurrencies (i.e., Bitcoin, Ethereum, Litecoin and Tether) during the COVID-19 pandemic outbreak. We show that the dynamic conditional correlation within market pairs is positive, which supports the contagion effects. In fact, in some periods, though short, the conditional correlation is low or negative for some pairs, indicating that investors must earn more gain from a portfolio diversification strategy. In addition, the correlation between cryptocurrencies is time-varying and highly volatile, suggesting that portfolio managers should change the structure of their portfolios over time. The hedging analysis exhibit that the most optimal hedge ratio between the couple pairs increase during the COVID-19 period compared to past period. Moreover, the hedging effectiveness also show a rise during the pandemic compared to the pre-COVID-19 period and we found that the Ethereum offer the high hedging effectiveness followed by the Bitcoin.

The rest of the paper is organized as follow; Sect. 10.2 presents data and their basic proprieties. The empirical method is described in Sect. 10.3. Finally, Sect. 10.4 presents modeling and forecasting results, before concluding the paper.

10.2 Data and Their Proprieties

We used a novel database describing four most capitalized cryptocurrencies, which are (Bitcoin, Litecoin, Ethereum and Tether), collected from CoinMarketCap (https://coinmarketcap.com/coins/). Returns are calculated using natural logarithm of the ratio of two consecutive prices. The data cover a large time period including the COVID19 pandemic. In addition, we collected daily closing prices in US dollars of S&P500 data from the website yahoo finance. The focus of this paper is to model and forecast dynamic conditional correlations between US stock market and cryptocurrencies during COVID-19 pandemic outbreak. The data covers the period from July 5, 2015 to October 12, 2020.

The summary statistics of daily closing returns of four cryptocurrencies and S&P500 daily return are presented in Table1. The highest average daily return is the average of Bitcoin the most capitalized cryptocurrency, then the Litecoin which

Table 10.1 Descriptive statistics of data

	S&P500	Bitcoin	Ethereum	Litecoin	Tether
N.obs	1314	1314	1314	1314	1314
Min	−12.765	−46.473	−1.364e+02	−44.906	−6.972e+00
Max	8.968	22.511	5.097e+01	53.984	5.661
Range	21.733	68.984	1.874e+02	98.890	1.263e+01
Median	0.064	0.251	−6.187e-04	−0.027	0.000
Mean	0.034	0.293	3.756e−01	0.196	3.355e−05
SE.mean	0.033	0.128	2.346e−01	0.178	1.692e−02
Var	1.511	21.564	7.233e+01	41.809	3.762e-01
Std.dev	1.229	4.643	8.504	6.466	6.133e-01
Coef.var	35.593	15.833	2.264e+01	32.923	1.828e+04
JB	23000***	7000***	170000***	9000***	65000***
ARCH LM	560***	34***	47***	78***	120***

Notes: S.E, Var, Coef. Var, and Std. dev., stand for standard errors, variance, coefficient of variance, and standard deviations. JB stats is the Jarque-Bera test. ARCH is the autoregressive heteroskedasticity test. ***, **, and * indicate the rejection of respective null hypothesis at 10%, 5%, and 1% level of significance

is the second capitalized cryptocurrency. The return distribution is positively skewed for Ethereum and Litecoin but skewed left for Bitcoin and Tether. Also, all returns are heavy tailed with kurtosis more significant than a normal distribution. As shown in Table 10.1, the Jarque-Bera test confirms the leptokurtic behavior of our digital currencies.

The average daily returns of different series before and during the COVID-19 pandemic are positive. The variation coefficient indicates that Litecoin has the highest variability. However, Bitcoin has the lowest variability. The lowest standard error is the one of the Tether and the highest one is of the Ethereum. Finally, Jarque-Bera test shows that series are not normally distributed.

The dynamic of cryptocurrencies returns and S&P500 daily return is illustrated by Fig. 10.1. As we can see a higher volatility is characterizing all series which indicates the relevance of the GARCH model to model and forecast daily returns. However, the impact of the COVID1-19 worldwide crisis is clearly significant. All series are characterized by a down peak during the first quarter of the COVID-19 pandemic when the World Health Organization (WHO) has announced the corona virus outbreak as a global emergency on January 30, 2020.

Further, after the first quarantine following the first wave of COVID-19, the situation was slightly ameliorated, and we can clearly see this impact on the upward describing the S&P500 index after the first quarter of 2020. This effect can also be observed from the daily returns of the different cryptocurrencies.

Further, we present the Pearson correlations in Table 10.2, and we find that the S&P500 index is positively correlated with Bitcoin, Ethereum and Litcoin, whereas, it is negative correlated with Tether. In fact, the same case for Bitcoin, Etherum and Litcoin which are negative correlated with Tether. Notice that in each sampled

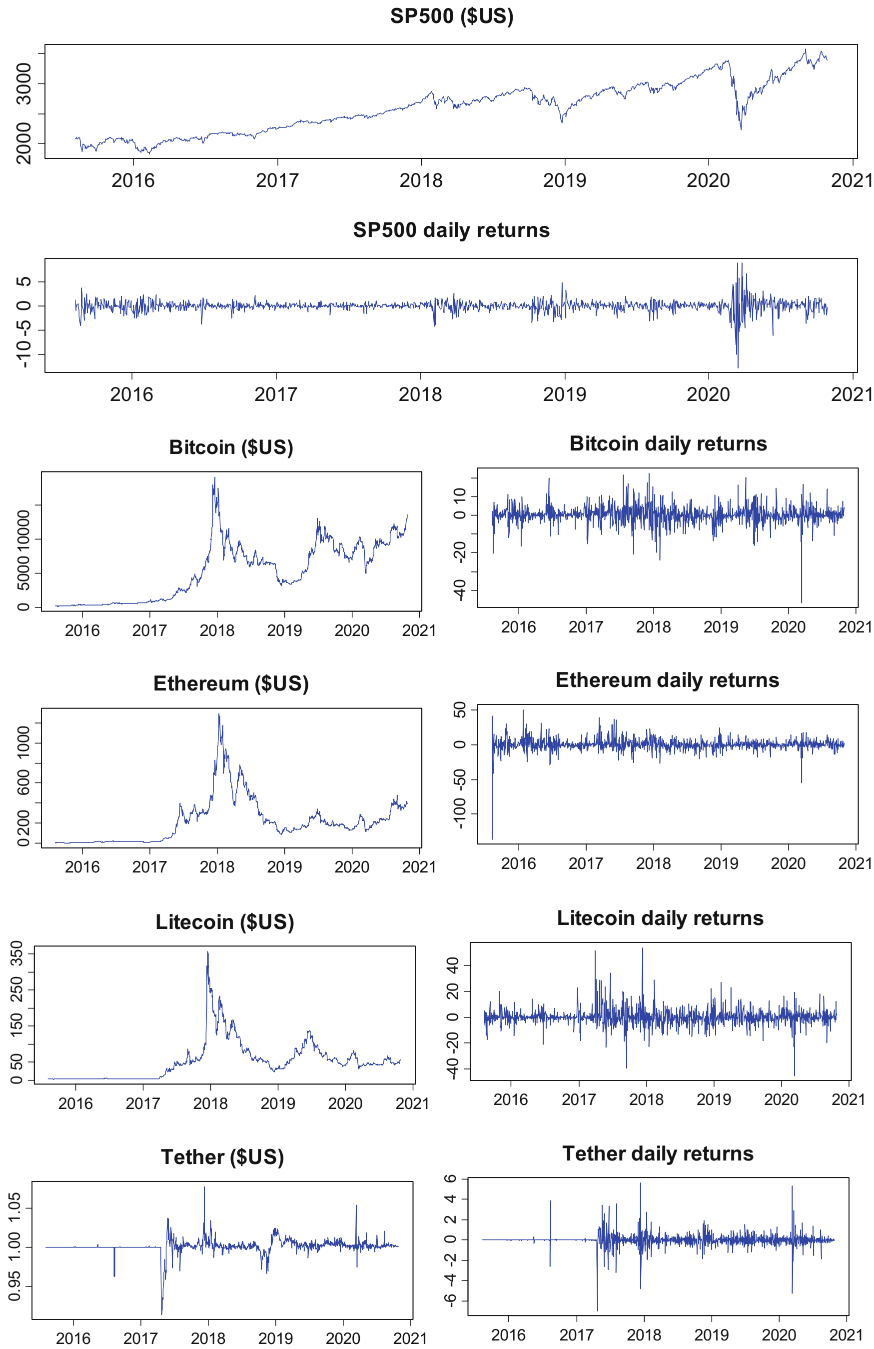

Fig. 10.1 Closing prices and returns of the most capitalized cryptocurrencies and S&P500. Notes: The data sample period span from July 5, 2015 to October 12, 2020, including the COVID-19 pandemic period. The daily returns are calculated as follows 100 × $ln\ (p_t/p_{t-1})$, with $p_t$is the daily closing price

Table 10.2 Matrix of Pearson correlation

	S&P500	Bitcoin	Ethereum	Litecoin	Tether
S&P500	1000				
Bitcoin	0,165***	1000			
Etherem	0,123***	0,469***	1000		
Litecoin	0,161***	0,646***	0,441***	1000	
Tether	−0,17***	−0,039	−0,033	−0,069**	1000

Notes: ***, **, and * indicate the rejection of respective null hypothesis at 10%, 5%, and 1% level of significance

series, the strongest correlation is between S&P500 and Bitcoin followed by the Litcoin. However, for the correlation between crypthocurrency markets, we find that the high nexus is between the Bitcoin/Litcoin followed by Bitcoin/Ethereum pairs.

10.3 Empirical Methodology

10.3.1 DCC Model

Modeling and forecasting dynamic correlations with high frequency data like financial daily data should mobilize the most adequate time series models. To model volatility, several empirical papers have extensively used multivariate GARCH model (Generalized Autoregressive Conditional Heteroskedasticity), DCC (Dynamic Conditional Correlation) of Engle (2002), BEKK (Baba et al. 1990), and VARMA-GARCH of Ling and McAleer 2003). In this paper, we follow the GARCH modeling approach, and we apply the DCC model of Engle (2002).

An easier presentation of this model can be presented as follow:

Let $r_t$be a n × 1 vector of assets return of the sample and ARMA (p,q) be a process in the mean equation for $R_t$and$\varepsilon_t$conditional on the set of information and residuals can be written as:

$$r_t = u + \varphi It - 1 + \rho\varepsilon_t \tag{10.1}$$

The residual specification can be illustrated by the following Eq. (10.2):

$$\varepsilon_t = H_t^{1/2} z_t \tag{10.2}$$

H_t is the conditional covariance matrix of R_t. z_t is a random vector representing the error term.

The dynamic conditional correlation DCC was firstly presented by Engle (2002). This model is estimated in two steps. First, we estimated the multivariate GRACH parameters then we estimated the conditional correlation:

$$H_t = D_t R_t D_t \tag{10.3}$$

With D_t is a diagonal matrix with a time varying standard error in diagonal terms. H_t and R_t are determined successively as follow:

$$R_t = \text{diag}\left(h_{1.t}^{1/2} \ldots ..h_{n.t}^{1/2}\right) \tag{10.4}$$

$$D_t = \text{diag}\left(q_{1.t}^{-1/2} \ldots .q_{n.t}^{-1/2}\right) Q_t \,\text{diag}\left(q_{1.t}^{-1/2} \ldots q_{n.t}^{-1/2}\right) \tag{10.5}$$

h is the expression of the univariate GARCH model. Elements of matrix H_t in the GARCH (1,1) is expressed by:

$$h_{i.t} = \omega_i + \alpha_i \varepsilon_{i.t-1}^2 + \beta_i h_{i.t-1} \tag{10.6}$$

Q_t is a symmetric positive matrix that can be defined as follow:

$$Q_t = (1 - a - b)\,\overline{Q} + a z_{t-1} z_{t-1}' + b Q_{t-1} \tag{10.7}$$

Q_t is an n x n matrix of unconditional correlation of residuals $z_{i.t}$ $\left(z_{i.t} = \varepsilon_{i.t}/\sqrt{h_{i.t}}\right)$. a and b parameters are non-negative. These parameters are associated to the process smoothness used to construct the dynamic conditional correlation. In practice, the DCC model means return to the equilibrium if a + b < 1, the estimation of correlation is calculated through Eq. (10.8):

$$\rho_{i.j.t} = \frac{q_{i.j.t}}{\sqrt{q_{i.i.t} q_{j.j.t}}} \tag{10.8}$$

10.3.2 Hedging Analysis

The return on a portfolio of a spot position hedged by futures returns position can be represented as:

$$R_{H,t} = R_{S,t} + \varphi_t R_{F,t} \tag{10.9}$$

where $R_{H,\,t}$is the return of the hedged portfolio, $R_{S,\,t}$ is the return of the spot position, $R_{F,\,t}$ is the return on the futures position and φ_t is the hedge ratio.

When the investor is long in the spot position, the hedge ratio is equal to the number of futures contracts that must be sold. The variance of the hedged portfolio conditional on the information set at the time t_{-1}. The variance of the hedged portfolio is expressed by the following equation:

$$\text{Var}\ \left(R_{H,t} I_{t-1}\right) = \text{Var}\ \left(R_{S,t} I_{t-1}\right) - 2\varphi_t \text{COV}\ \left(R_{F,t}, R_{S,t} I_{t-1}\right) + \varphi_t^2 \text{Var}\ \left(R_{F,t} I_{t-1}\right) \tag{10.10}$$

The optimal hedge ratios are the hedge ratio φ_t which minimizes the variance of the portfolio. We can get these optimal hedge ratios conditional on the information set I_{t-1} by taking the partial derivative of the portfolio variance with respect toφ_t and then setting this expression equal to zero.

$$\varphi_t^* I_{t-1} = \frac{\text{COV}\ \left(R_{S,t}, R_{F,t} I_{t-1}\right)}{\text{Var}\ \left(R_{F,t} I_{t-1}\right)} \tag{10.11}$$

Following Kroner and Sultan (1993), the conditional volatility estimation of MGARCH models can be used to construct hedge ratios.

The hedging strategy is usually adopted by taking a long position in one asset i with a short position in second asset j. The hedge ratio between spot and futures returns is:

$$\varphi_t^* I_{t-1} = h_{SF,t} / h_{F,t} \tag{10.12}$$

where $h_{SF,\ t}$ is the conditional covariance between spot and futures return. $h_{F,\ t}$is the futures returns conditional variance.

The hedging performance of different optimal hedge ratio of different instruments obtained from different GARCH models is measured by hedging effectiveness (Chang et al. 2011; Ku et al. 2007).

$$\varphi_t^* I_{t-1} = \frac{\text{VAR}_{\text{unhedged}} - \text{VAR}_{\text{hedged}}}{\text{VAR}_{\text{unhedged}}} \tag{10.13}$$

A higher index could be generally associated by a higher hedging effectiveness.

10.4 Empirical Results

10.4.1 Regression Results and Forecasting Dynamic Conditional Correlation Analysis

We first model the ARMA (p,q) DCC-GARCH process between US stock markets (S&P500) and 4 cryptocurrencies (Bitcoin, Ethereum, Litecoin and Tether). The results are presented in Table 10.3. It should be noted that the lag order (1,2) is chosen by minimized information criteria including the Akaike information criteria and the Schwarz information criteria. The results of the mean equation show that coefficients of all the return series are significant at 1% level for the most returns series.

As shown in Table 10.3, the results of the conditional variation equation indicate that the ARCH (α) and GARCH (β) items are significant at 1% level during the sample period for each series. It means that the current volatility of the return series can easily be affected by the information of the previous period. The sum of the coefficients of short-term and long-term persistence coefficient is less than unity. In each case, the short-term persistence is lower than the long-term persistence (except Tether), which indicates that long-term volatility is more intense than short-term volatility. The statistical significance of ARCH and GARCH items show evidence of the clustering of volatility. We can see the volatility clustering for each return series in Fig. 10.1. The parameter Shape (λ) is equal to the degrees of freedom, we found that S&P500 have the highest estimated Shape. This means that the distributions of the cryptocurrencies have more massive tails than S&P500 stock. The parameter Shape is equal to the degrees of freedom when the number of degrees of freedom approaches infinity, the form of the distribution *t* approaches that of a normal. The estimated dynamic conditional correlation coefficients $\theta_1$and θ_2 are positive and statistically significant at the 1%. We noted that $\theta_1 + \theta_2 < 1$ which indicates that dynamic conditional correlations return to equilibrium (are mean reverting). We can conclude that the DCC model are reasonable for that the volatility of recent return has a significant influence on the dynamic relationship between S&P500 stock market and all variables, which can be observed for the considerable values of the coefficients θ_1. Nonetheless, the values of the coefficients θ_2 are significant and close to 1 for each series, indicating that the dynamic linkages between the equity market and cryptocurrencies are long persistent. Our results confirm the long-term relationship between the U.S. stock market and Bitcoin, Ethereum, Litecoin and Tether.

Using the rolling window analysis, we construct one-step ahead dynamic conditional correlations between US and Cryptocurrencies market as well as between each two cryptocurrencies. The estimation window is fixed at 1314 observations and 900 dynamic conditional correlations one-step ahead are produced. The GARCH model is refitted every 20 observations. Considering that the linkages between US and Cryptocurrencies change over time, we explore the time varying dynamic conditional correlation of each pair during the pre-COVID-19 and COVID-19 periods. The results of Forecast are presented in Fig. 10.2.

For each pair, we noted that the dynamic correlations are positive and very important especially at the beginning of the second quarter of 2020, which corresponds to the beginning of the spread of COVID-19 in the US. Moreover, after the announcement of as well as in the overall world and after the announcement of WHO on January 30, 2020 that the COVID-19 pandemic outbreak is a global emergency. Except for S&P500/Tethet, Bitcoin/Tether, Ethereum/Tether and Litecoin/Tether pairs, the dynamic conditional correlations very weak.

Table 10.3 Estimation result of the DCC-GARCH model

	DCC-GARCH (1,1)		
	Coefficient	Estimation	P-value
S&P500	μ	0.060	0.000
	AR	0.975	0.000
	MA	0.070	0.000
	ω	0.021	0.003
	α	0.202	0.000
	β	0.796	0.000
	λ	4.622	0.000
Bitcoin	μ	0.359	0.019
	AR	0.983	0.000
	MA	0.033	0.000
	ω	0.438	0.180
	α	0.148	0.000
	β	0.850	0.000
	λ	2.878	0.000
Ethereum	μ	−0.012	0.928
	AR	0.962	0.000
	MA	0.029	0.000
	ω	6.803	0.080
	α	0.286	0.000
	β	0.712	0.000
	λ	2.689	0.000
Litecoin	μ	−0.019	0.753
	AR	0.581	0.000
	MA	0.009	0.766
	ω	0.313	0.557
	α	0.115	0.002
	β	0.883	0.000
	λ	2.855	0.000
Tether	μ	0.000	0.999
	AR	0.958	0.000
	MA	0.519	0.000
	ω	0.000	1.000
	α	0.606	0.000
	β	0.376	0.000
	λ	2.970	0.000
DCC parameters	θ_1	0.044	0.000
	θ_2	0.953	0.000
Freedom parameter	λ	4.000	0.000
Information criteria	Akaike	16.654	
	Bayes	16.863	
	Shibata	16.651	
	H-Q	16.732	
	LL	−10,889	

Notes: DCC estimated using a multivariate normal (MVNORM) distribution. All specifications include a constant and an AR MA (1.2) term in the mean equation. The lag order is chosen by minimized information criteria

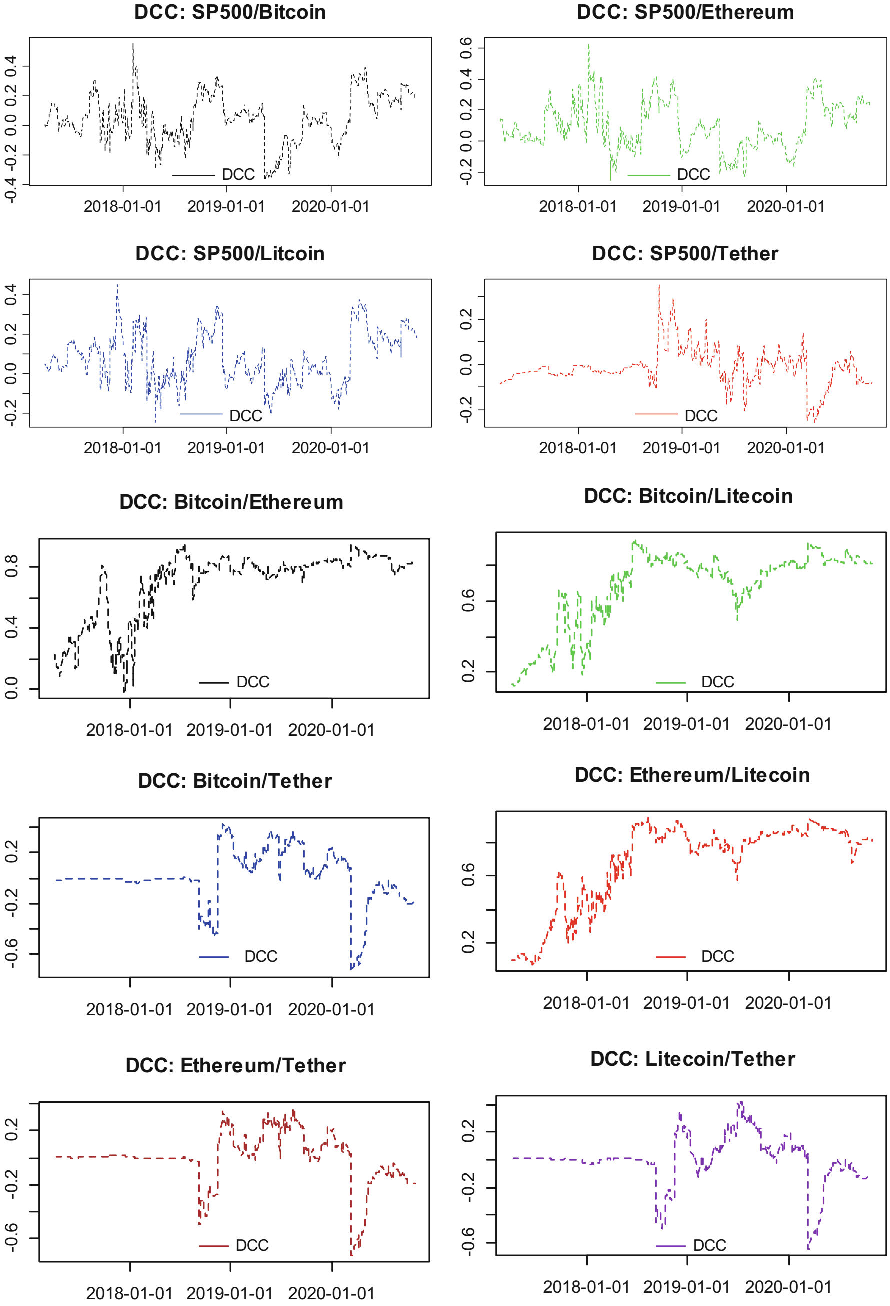

Fig. 10.2 Forecasting based on dynamic conditional correlation. Note: Dynamic conditional correlation calculated from fixed width rolling analysis which produces 900 one-step forecasts. DCC-GARCH model is refit every 20 observations

The results of the forecast time-varying conditional correlations show that the conditional correlation of all pairs fluctuates greatly during our sample period, which means that investors should adjust their portfolio structure frequently. During most of the sample period, the dynamic conditional correlation among market pairs is positive that supports the contagion effects. On the other hand, in some periods, though short, the conditional correlation is weaker or negative for some pairs, indicating that investors may gain more from a portfolio diversification strategy.

The S&P500/Tether, Bitcoin/Tether, Ethereum/Tether and Litecoin/Tether pairs, suggest the diversification benefits, because the dynamic conditional correlations are very weaker during the entire sample period. In sum, the correlation between the S&P500 stock market and all cryptocurrency as well as between each two cryptocurrencies is time-varying and highly volatile, which reveals that portfolio managers should change their portfolio structure over time. Our results may have some implications for portfolio managers and investors to reduce their risks by the diversification benefits strategy.

10.4.2 Hedging Analysis

We apply a rolling window analysis to calculate the out-of-sample hedge ratios. At period t, a one-period-ahead conditional volatility forecast for a period is established, these forecasts are used to build a one-period-ahead hedge ratio. The forecast hedge ratios are later used for the construction of the hedged portfolio. A rolling window size of 1314 observations is used to construct 900 one-period-ahead optimal hedge ratios. DCC-GARCH model is refitted every 20 observations. In this section we focus on hedging strategies for an investment in U.S stock and cryptocurrency markets.

10.4.2.1 Optimal Hedge Ratios

We first estimate the optimal hedge ratios between U.S stock market and each cryptocurrency and we present the results in Fig. 10.3.

Figure 10.3 shows the set of optimal hedge ratios calculated between S&P500 and a position in Bitcoin, Ethereum, Litecoin and Tether. We find that optimal hedge ratios have higher variability for almost every different pair, except Tether have lower variability. If we look at our window of the hedge ratios of S&P500/Bitcoin, S&P500/Ethereum and S&P500/Litecoin couple pairs, the visual inspection reveal that the hedge ratios fluctuate between positive and negative value. The negative values arising from the inverse relationship between each cryptocurrency and U.S stock indices suggest that the hedge is formed by taking either long or short positions for both assets.

For each pair, we can see that the higher levels of optimal hedge ratios are positive during the period of the substantial spread of the Coronavirus (COVID-

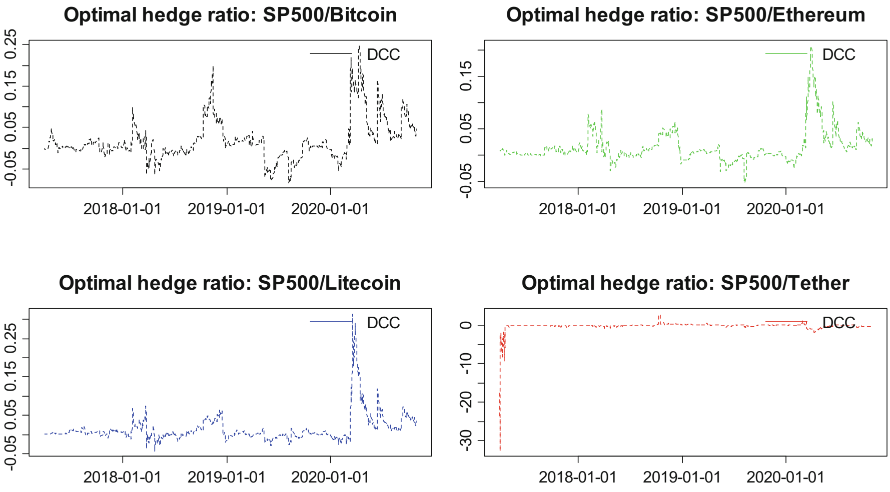

Fig. 10.3 Optimal hedge ratios. Notes: Hedge ratios calculated from fixed width rolling analysis which produces 900 one-step forecasts. DCC-GARCH model is refit every 20 observations

19 pandemic) in the United States. Except for S&P500/Tether, the optimal hedge ratios remain very weak. Which mean that during the pandemic the Crypto markets shows more benefits of hedging compared to pre-COVID-19 period.

10.4.2.2 Hedge Performance

Using the DCC-GARCH model in the hedging analysis will enable us to compare the hedging ability of the cryptocurrencies for the S&P500 index by considering their hedge performance. We compute the hedging effectiveness of the hedged positions between the U.S stock market and each virtual currency to infer how much it can reduce the risks of a combined portfolio. This comparison represents a very common instrument of portfolio risks assessment. Two this end, we calculate the hedge ratios summary statistics and hedging effectiveness between S&P500 index and the potential hedge assets. In Table 10.4 we decomposed our analysis into two panel; i) during the pre-COVID-19 pandemic period; and ii) during the CVID-19 pandemic period.

Before the COVID-19 pandemic, we find that the average value of hedge ratios between S&P500 and Bitcoin, Ethereum and Litecoin, while they are negative between S&P500 and tether because they are very weakly correlated. On another hand, we reveal the same results during the pandemic period. The average values of hedge ratios between S&P500 index and the cryptocurrencies are positive and very high compared to pre-COVID-19 period. The Tether still provide a negative average value of optimal hedge ratios. During both periods, S&P500 and Bitcoin have the high average of hedge ratio where it is 3 cents before the pandemic and 10 cents

Table 10.4 Hedge ratio summary statistics and hedging effectiveness (HE)

	Pre-COVID-19				COVID-19			
	Mean	Min	Max	HE	Mean	Min	Max	HE
S&P500/BITCOIN	0.0274	−0.1042	0.3034	0.1283	0.1041	−0.08522	0.3065	0.1951
S&P500/ETHEREUM	0.02015	−0.05534	0.2075	0.1479	0.06393	−0.0409	0.2774	0.2305
S&P500/LITECOIN	0.02222	−0.0459	0.2982	0.1191	0.07812	−0.05089	0.3262	0.1986
S&P500/TETHER	−0.1208	−1.685	1.443	−0.07125	−0.06348	−0.2758	0.1919	0.01766

Notes: Hedge ratios summary statistics and hedging effectiveness calculated from fixed width rolling analysis. DCC-GARCH model is refit every 20 observations during the pandemic indicating that a $1 long position in S&P500 can be hedged for 3 cents during the pre-COVID-19 crisis in the Bitcoin and 10 cents during the pandemic period. By comparison with the remains cryptocurrencies, the average value of the S&P500/Ethereum and S&P500/Litecoin hedge ratios is 2 cents before the health pandemic and 6 cents for Ethereum and 8 cents for Litecoin during the pandemic. On other hand, the results of the hedging effectiveness estimated and presented in Table 10.4. It should be known that a higher value of HE indicates higher hedging performance (Basher and Sadorsky 2016). The results show that the hedging performance increase during the pandemic compared to pre-COVID-10 period. We find that the Ethereum is the most desirable hedge for S&P500 index than Bitcoin, Litecoin and Tether, which present the high hedging effectiveness. Notice that hedging effectiveness value of Tether is negative during the pre-COVID-19 period which indicates hedged portfolios are worse than unhedged portfolios. While during the pandemic, the hedging effectiveness of Tether rise to positive value which reveal than can work as a hedge instrument to S&P500, but their performance is very weak compared to the remains virtual currencies. These findings indicate that the cryptocurrencies are desirable to hedge the U.S equity market, especially during the COVID-19 pandemic crisis. The Ethereum is the better hedge asset when it is combined with the S&P500 stock index during the sample period cover the pre-COVID-19 pandemic and the COVID-19 pandemic crisis periods.

The findings of our study have important implications for investors and portfolio managers seeking higher returns on the S&P500 equity index while hedging their exposure to the risk market in their portfolio construction. The time varying conditional correlations show that the risk spillover during the COVID-19 period has reached the highest level compared to pre-COVID period, this implies that COVID-19 pandemic support the risk spillover between U.S stock markets and cryptocurrency markets. Our analyzes of dynamic conditional correlations show some negative connectedness between the U.S stock market and cryptocurrency pairs, as well as between the each cryptocurrency couple variables. The inverse relationship produced from DCC-GARCH model, suggesting significant diversification benefits of the portfolio, but the COVID-19 acts as a systematic risk that cannot be diversified.

Moreover, we find that the average of optimal hedge ratios and the hedging performance between US stock market and cryptocurrencies increase between pre-COVID-19 and COVID-19 pandemic period, and we document that Ethereum exhibit the high hedging effectiveness for the S&P500 than Bitcoin, Litecoin and Tether during the sample period. More specifically, the Ethereum remain the best hedge asset either in normal or crisis periods followed by the Bitcoin. In fact, the investments in the S&P500 stock index, the cryptocurrencies can serve as a hedge asset against extreme market conditions.

10.5 Conclusion

This paper proposed an original empirical investigation to understand and forecast the correlation and hedge ratio between cryptocurrency and stock markets before and during the COVID-19 outbreaks. The paper carried out a deep analysis of investors behaviors in both markets. The forecasting exercise was performed thanks to the dynamic conditional correlation GARCH method (DCC-GARCH). However, the dynamic correlation and the hedging analysis is done by a rolling window analysis to calculate the out-of-sample hedge ratios. We compare hedging ability of the cryptocurrencies for the S&P500 index by considering their hedge performance. The comparison represents a very common instrument of portfolio risks assessment. Two this end, we calculate the hedge ratios summary statistics and hedging effectiveness between S&P500 index and the potential hedge assets. We decompose our analysis into two panel; i) during the pre-COVID-19 pandemic period; and ii) during the COVID-19 pandemic period.

We find that the dynamic conditional correlation within market pairs is positive, which supports the volatility spillover. Whereas, in some periods, though short, the conditional correlation is low or negative for some pairs, indicating that portfolio managers and investors must earn more gain from a portfolio diversification strategy. Overall, the correlation between most pairs is time-varying and highly volatile, suggesting that portfolio managers should change the structure of their portfolios over time. For the hedging analysis, we find that the Ethereum is the most desirable hedge for S&P500 index than Bitcoin, Litecoin and Tether, which present the high hedging effectiveness. The hedging effectiveness value of Tether is negative during the pre-COVID-19 period which indicates hedged portfolios are worse than unhedged portfolios. While during the pandemic, the HE of Tether rise to positive value which reveal than can work as a hedge instrument to S&P500, but their performance is very weak compared to the remains virtual currencies. These findings indicate that the cryptocurrencies are desirable to hedge the U.S equity market, especially during the COVID-19 pandemic crisis.

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Chapter 11
Management and Resolution Methods of Non-performing Loans: A Review of the Literature

Dimitris ANASTASIOU

11.1 Introduction

Before mentioning the NPL management methods, I deem it appropriate to define which loans are called non-performing. As non-performing loans are characterized, these specific loans are past due over 90 days. To be more specific, if a borrower has a loan and has not fulfilled his loan obligations to the bank for more than 90 days, his loan is considered non-performing. Exploring the management techniques of ex-post credit risk[1] is a matter of essential importance for regulatory authorities, banks, and governments concerned with financial stability. NPLs can arise in a bank's balance sheet because of poor credit risk management.

NPL management has not to do only with finding ways to handle NPLs when they have incurred, but also with the development and the implementation of policies and strategies concerning credit management before the problem arises. That is why there must be a clear separation of the managerial tools that have to be used (i.e. ex-ante and ex-post management) to deal with the problem of NPLs.

The objective of the management of NPLs is different for each bank. Nevertheless, banks desire to have the lowest possible level of NPLs in their balance sheets. The reason is simple. If a bank has low levels of NPLs, this directly implies that it will have low levels of risk. Consequently, the banks will have the least possible losses.

[1] *"The ex-post credit risk takes the form of non-performing loans (NPLs)",* Louzis et al. (2010)

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Moreover, banks build their foundations on consumers' confidence. If a bank appears to be "weak" or "fragile," then customers might choose to withdraw their deposits and put them elsewhere. This unpleasant event may happen when high levels of NPLs appear in a bank's balance sheet; since the existence of a high amount of NPLs indicates "weak" credit management.

During the last decade, great literature on management of banking crises and restructuring has been written (Turner and Hawkins 1999; Latter 1997; Huang and Bonin 2001; Lee 2002; Hoggarth et al. 2004) and particularly on the management of NPLs (Woo 2000; Shih 2004; Xu 2005; Matoušek and Sergi 2005). Also, a plethora of literature exists on the determinants of NPLs such as Berger and DeYoung 1997; Espinoza and Prasad 2010; Louzis et al., 2010; Nkusu 2011; Anastasiou 2017; Anastasiou et al. 2016, 2019a, b etc. Nevertheless, there is still scarcity regarding the research that explains the differences of each resolution method and management technique of NPLs.

This study aims to describe, as analytically as possible, the methods and approaches that have already been mentioned from other conducted research on how to deal with the problem of NPLs and, therefore, to avoid banking crises. As far as I know, this is the first study that collects all possible NPL management and resolution methods in the literature in only one paper.

11.2 The Impact of NPLs on Banks' Growth

Non-performing loans are considered to be a drag on the economic activity of each bank. A study from the IMF (2015) supported that in countries where their banks have high levels of NPLs, credit growth remains slow. More specifically, firms that are more dependent on bank finance are likely to be affected more than other firms by banks' reduced lending capacity. Moreover, according to the IMF (2015), banks with high levels of NPLs on their balance sheets also have a lower ability to lend to the real economy. This happens through three major channels: Lower profitability: The existence of a high NPL level implies less net operating income for a bank. Also, increased levels of NPLs significantly reduce profits due to the greater effort that must be exercised from the human resources to manage and monitor the large stock of NPLs. Higher capital requirements: NPLs constitute risky assets. This means that they attract greater risk weights, and as a result, higher capital requirements will be needed. Higher funding cost: Banks that hold large amounts of risky assets, such as NPLs, make other banks and investors less willing to lend them or lend with higher funding costs. All the above can be easily seen in Fig. 11.1.

In particular, increasing levels of NPLs constitute a substantial drag on the banking performance in the sense that banks with high levels of NPLs will have:

- net interest income cuts,

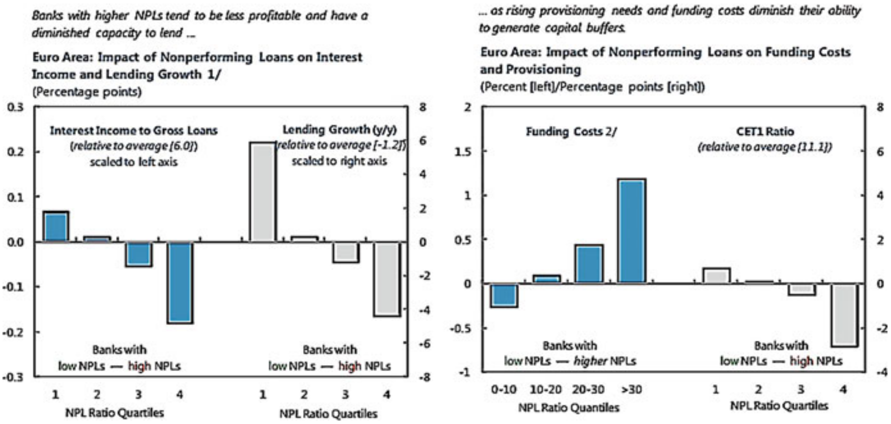

Fig. 11.1 The impact of NPLs on the banking activities. (Source: IMF 2015)

- rise of impairments costs,
- extra capital requirement for risky weighted assets,
- potential lenders with lower risk appetite (i.e., less risk-lover borrowers)

11.3 Management of Non-performing Loans

11.3.1 Ex-ante NPL Management

The Financial Stability Institute firmly believes that addressing the non-performing loans' problem is a non-stopping challenge.

According to Campbell (2007), during the last 20 years, the most common method for coping with non-performing loans is creating an institution by public authorities, which will be responsible for dealing with NPLs. Of course, apart from this method, other methods can help banks deal with NPLs.

Campbell (2007) stated that it is vital to consider three distinct factors to address the problem. The first factor has to do with how banks can prevent NPLs or keep them into controllable levels. Secondly, the specific banks in which NPLs can be found is another important matter. Lastly, another factor that should be considered is how insolvent banks should be treated. Thus, Campbell (2007) argues that the first stage for the NPL management is prevention and control. Having adequate legal powers is of high importance for the banking supervisors to undertake their tasks and be effective. More specifically, this kind of powers should include an appropriate licensing system, and as for the supervisor, he ought to have a variety of tools for corrective action, such as the ability to close banks by withdrawing the banking license.

Moreover, as I previously mentioned, the supervision and prudential regulation system is not adequate in the case of banks with liquidity problems. This is the reason why an emergency liquidity financing mechanism is needed. A mechanism as such could be provided only by central banks, but in order for an increase in moral hazard in the financial system to be prevented, the mechanism's usage must be discretionary.

Concerning the second stage, banks should manage their impaired assets. Impaired asset management is a complicated and important aspect of the recovery process of insolvent banks.

After the prevention-control and the management of the impaired assets at the third stage comes the treatment of insolvent banks. The banking system's good condition is essential for each country's economy, and more specifically for the payment system. Furthermore, it is an undeniable fact that one bank's financial problems may cause problems to others, or/and if there is a systemic banking crisis, the depositors will take their money away from the banks; a problem that will spread to all banks.

During the past 25 years, many systemic banking crises occurred, a significant factor of which is the speed with which the banks develop and spread. Another interesting question that Campbell (2007) is occupied with is how the crises spread. This has to do with the nature of the banking business. Based on what has been mentioned so far, even if a well-managed bank has a powerful balance sheet, it may be subjected to liquidity problems. Consequently, a liquidity funding mechanism is used in the most developed banking systems by central banks to help the operations of the banks in their interbank market. A bank supervisor must be alerted by a liquidity problem, which sometimes may cover dire problems. Before the supervisor decides on his actions, he should consider the case of the potential doubtful quality of the whole or a part of the bank's loan portfolio.

Ugoani (2016) also suggested some ideas for ex-ante management of NPLs in Nigerian banks, some of which can be generally adopted by other governments and/or banks. Firstly, he proposed that bank regulatory authorities have to improve the micro and macro-prudential guidelines for banks. Another measure that could be possibly implemented is not to allow banks to grant loans to their subsidiaries. Moreover, external auditors of banks should have a maximum of 2 years of tenure. That is because a tenure of long duration provides ground for the emergence of corruption. Finally, each bank's central management should not be composed of "self-professed gurus" of banking because history has proven that some of them have criminal intent.

Furthermore, bank managers should be disciplined men with excellent knowledge in banking, finance and risk management. Also, the credit managers' decisions must be unbiased and not be influenced by political corruption and personal interest, as happened during the banking crisis in Pakistan. (Masood et al. 2010).

11.3.1.1 Regulatory Forbearance and Bank Resolution

According to Pagano (2014), bank resolution issues are closely associated with issues of supervision. As far as the banks and regulators' excessive forbearance is concerned, the concerns of the European policymakers have been heightened by the euro debt crisis. An additional "preoccupation" of the European policymakers is the potential forbearance which might be generated by the cross-border externalities and the absence of a resolution mechanism, which is integrated, for problematic banks with an expansion of cross-border operations. Under Pagano (2014), the European Commission and Parliament attempted to encounter these problems by drastically reinspecting the banks' prudential supervision system and the banks' resolution particularly for these banks that are considered to be systemically important. Moreover, in 2013 -and more specifically in November- the "Single Supervisory Mechanism (i.e., SSM) regulation", by which the ECB has bestowed bank supervisory powers, started functioning. Thus, the SSM generated a new system of financial supervision, which consists of the national authorities. The reduction of the risk in regulatory forbearance, which should emanate from the bank's supervision centralization, can be accomplished by placing homogeneous standards. The Bank Recovery and Resolution Directive (BRRD hereafter) was incorporated by the EU Parliament in April of 2014. Thus, bank resolution and supervision possess at least a borderline set of tools and powers to intervene if required. Thus, the national resolution authorities are entitled to resolve banks' branches based in other countries under certain circumstances and are provided with a framework that consists of enhanced collaboration and synchronization between the resolution authorities and national supervision.

In addition, one of the immediate objectives of BRRD is to allow authorities to rescue a bank, which needs resolution, using internal resources, and thus to bail in some of its liabilities. The main benefit of this act is that the government subsidy which is granted to banks in the European Union will be reduced. Moreover, it will help banks reduce their motivation to indulge in ex-ante excess "tolerance" (i.e., forbearance). Pagano (2014) also pointed out another established mechanism that the European Parliament has also approved. This mechanism is the Single Resolution Mechanism (SRM hereafter). This resolution mechanism has three serious weaknesses. Its first major weakness is that it entrusts the decision for the closure of a bank to many authorities, such as the ECB (which is the prudential regulator), the board of the SRM, and the European Union Commission, but it allows for the resolution's implementation to be carried out by national authorities. A second disadvantage is that different financial institutions, whose bankruptcy may set off a financial crisis, also known as a systemically important financial institution (SIFI hereafter), cannot be supported by the Single Resolution Fund. The last downside of this mechanism is that the resolution mechanism of the EU is not supplemented by a centralized deposit insurance mechanism which is going to be used as a safety net to deposits and therefore, bank runs might arise in countries where banks seem to be distressed. A centralized deposit insurance mechanism can be found at the Federal Deposit Insurance Corporation (FDIC hereafter) in the US.

11.3.2 Ex-post NPL Management

Campbell (2007) highlighted that during the past decades, there were many systemic bank crises that occurred due to a lot of impaired assets (mostly NPLs) and the reason behind this is the liquidators' inability to accurately cope with them. During the last 20 years, the most appropriate ex-post method to cope with the non-performing loans problem is the creation of one or more institutions by public authorities, which will be responsible for coping with NPLs of the insolvent banks in general. The previously mentioned institutions are widely known as asset management companies (AMCs hereafter). In most cases, an AMC will probably be an organization administered by the government, which will face the need to have legal powers essential for managing NPLs. Also, regarding AMCs, it has to be mentioned that the most widespread and accepted method in many countries is that the individual banks sell their NPLs to an AMC. The main benefits for choosing this method are the following (Woo 2000):

- Enhancement of credit discipline: if there is a clear separation of bad loans from the financial institutions this might lead to a more effective and objective management of NPLs
- Division of labor: separating NPLs from a distressed bank permits to the bank managers to be more concentrated on banking restructuring and new lending, since AMCs managers have to be focused on the recovery of NPLs.

However, the separation of NPLs and good assets has some drawbacks, such as (Woo 2000):

- Pricing of bad assets: It is a very difficult process to correct the transferred bad assets, especially during economic crises.
- Political intervention: The vast majority of AMCs are state-owned. So, it is not easy to exclude governmental management and avoid potential political interference.

Turner and Hawkins (1999) supported that the possibility of segregating the management of the bad debts from the originating bank is required to be one option in a debt consolidation program. That being said, the fact that a bank is preoccupied with dealing with bad debts is likely to increase its risk-aversion. Another eventuality is considered to be the purchasing of the non-performing loans from the bank itself by a government agency to move a little further. However, the bank should have the onus to continue administering the NPLs. Nevertheless, such kinds of arrangements are quite difficult to contrive in such a manner to provide the selling bank with a strong inducement to assiduously pursue the borrowers. However, the main drawback is that the worst NPLs can be sold by the banks to the AMC at a higher price while the NPLs with better prospects will be retained, due to the fact that the assets are mispriced. "Purchasing" problematic assets with bonds that are guaranteed by the government, is another widespread method for the AMC. When the bonds have matured enough the AMC hopes to sell off the assets.

If the AMC has bought the assets at a market price, the government guarantees should not be necessary. Such bonds can be zero-coupon (Malaysia and Mexico) or interest-bearing (Korea) (Turner and Hawkins 1999; Inoguchi 2012).

Finally, an alternative mechanism for the government could be to take over the problematic banks for a while. Such banks are known as State-owned banks (SOBs hereafter).

The difficulty of this method is that banks must continue working on "commercial lines" and trying to collect the impaired loans during this period. This mechanism can prove risky if banks continue to be public for many years. This happens either because the government does not find the buyers or the terms of purchase acceptable or because this temporary state is favored by both borrowers and employees.

During and after the Asian financial crisis, Malaysia and Thailand also established AMCs in their efforts to cope with the large amounts of non-performing loans they had. In particular in 1998, a public AMC was created by the Malaysian authorities with the name Danaharta. This state-owned AMC bought non-performing assets at market value. Apart from the Danaharta, Malaysian authorities also used a plethora of other policies and measures in order to expunge NPLs, such as banking consolidation and bank closure.

According to Thailand's case, in 2001, the authorities of Thai created its own AMC named TAMC. The Financial Institutions Development Fund (FIDF) funded the establishment of TAMC. Prior to the establishment of TAMC each bank has set up its own AMC. Nonetheless, these AMCs were not able to sufficiently eliminate the amount of NPLs. It has to be mentioned that according to Inoguchi (2012), although TAMC established after the Danaharta, it bought with a steady pace huge amounts of NPLs each year (between 680 and 780 billion baht[2]).

Stijepovic (2014) stated that in order to have a proper bad debt (i.e. NPL) restructuring process, three types of restructuring measures must co-exist:

- Financial restructuring measures: The first thing that has to be done is the creation of a restructuring plan for each type of loan separately. This restructuring plan must be well-designed and it should contain collateral valuation, adequate legal documentation, and financial information about the borrower's business activities. Other financial restructuring measures could be the debt relief, interest rate cuts and a payment extension of the interest.
- Corporate restructuring: This type of restructuring implies changes on some elements of the capital structure of each firm. Such changes could be in firm's capital, organization, assets and management. Changes in management structure include the removal of the already existing manager. Regarding the changes in assets, a company can sell its assets to retrieve cash and, therefore, ensure its payment obligations.

[2] Baht is the official currency of Thailand.

- Business restructuring measures: Some key business restructuring measures could be the option of a merger or acquisition and the realization of "disinvestment transactions".

11.3.3 Ex-ante and Ex-post NPL Measures: The Euro Area Case

Banks in the Euro area are striving with the high NPL levels. For the whole EU, the ratio of NPLs reached over 11% of GDP at the end of 2015. In the Euro area, NPLs are especially increased in some of the Euro area periphery countries, such as Greece, Portugal, Spain and Cyprus (Figs. 11.2 and 11.3).

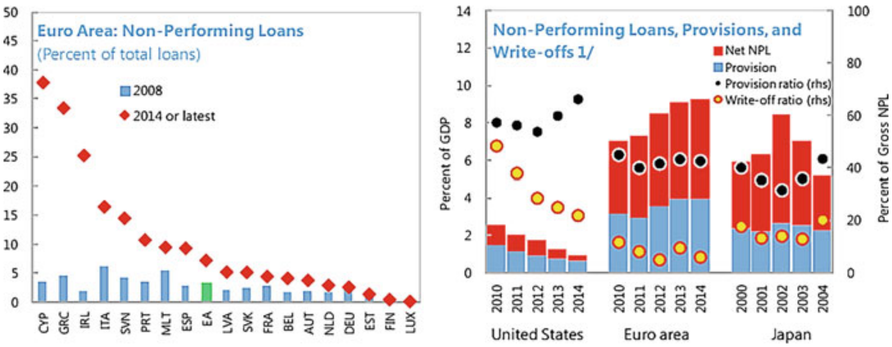

Fig. 11.2 Non-performing loans in the Euro Area. (Source: IMF 2015)

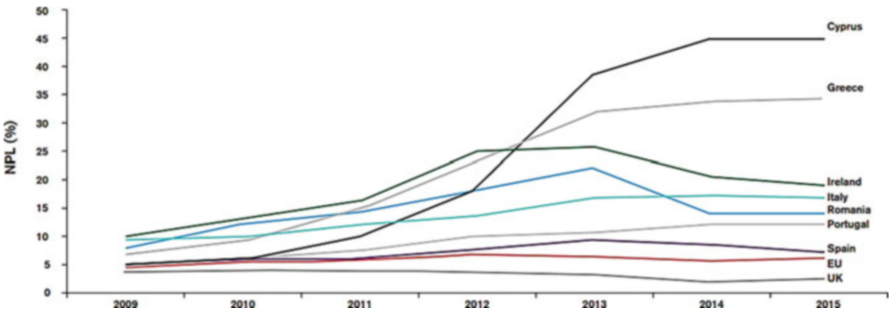

Fig. 11.3 Gross NPLs % Total Loans for the Eurozone's Periphery countries. (Source: World Bank, European Banking Authority and International Monetary Fund)

The main ex-ante measures that can effectively help banks to overcome the NPL problem are the following:

- Tightening of bank supervision and strengthen of capital requirements.

If there were more collateral valuation and more conservative provisioning, then banks would be more encouraged to deal with NPLs quickly. Moreover, bank supervisors must require banks to set aside even more capital for non-performing loans that remain on their books for an extended period. Also, bank supervisors should require banks to achieve the loan restructuring goals within a logical time period.

- Structural reforms

Structural reforms are also needed in order to make debt collection a much easier task. The court procedures are very time-consuming and hence they should be shortened. The out-of-court arrangements (Garrido 2012) constitute an alternative approach, which is highly encouraged. Such reforms would make it easier for banks to write off bad loans.

- Developing internal NPL management skills

Banks have to be fostered to develop an inclusive management plan for NPLs. This NPL management plan should specify the rules and practices for the resolution of NPLs. These rules and policies could be (1) the removal of the bad loans from typical loans and adoption of concrete tools for early arrears, and (2) conducting risk scoring more often.

Ex-ante NPL management methods are maybe more important than the ex-post measures since prevention is the best cure. These ex-ante measures can be characterized as pillars of reform and they have to be implemented simultaneously in order to have better results.

Below I tried to make a brief list of all kinds of ex-post NPL measures implemented in the Euro-Zone since the beginning of the 2007–2008 financial crisis (IMF 2015).

I. Bad banks

The creation of a bad bank is maybe the most classical approach that can be used in order to manage banks' NPLs. When banks are in an emergency situation because of high NPL levels and there is no private solution, public bad banks have to be set up. Bad banks' role is simple; their role is to take over the impaired assets/loans and relieve private banks. The first bad bank was created by Mellon bank in 1989. Ten years later,[3] in 1998, we have another example of bad bank, IMBRA in Indonesia which was established during the Asian financial crisis. Other

[3] The bad bank of Indonesia in 1998 was not the second bad bank in the history. Between 1988 and 1998 other bad banks were also created.

typical examples could be KA Finanz of Austria and Erste Abwickelungsanstalt and FMS Wertmanagement in Germany.

II. System-wide Bad banks

Banks with problematic loans which are under restructuring transfer their non-performing assets to these bad banks. Prominent examples of system-wide bad banks are BAMC of Slovenia, SAREB in Spain and NAMA in Ireland. While BAMC is full publicly owned, SAREB and NAMA are both privately owned. Such banks may create economies of scale in the illiquid assets management. It has to be mentioned that a publicly owned bad bank's capital structure plays an important impact on public finances, because bad banks' NPLs are considered as public debt.

III. System-wide aid free mechanisms

Some member states of the Euro-area decided to develop new mechanisms in which state aid is not involved. Specifically, on February 2016 an asset protection scheme was approved by the Commission for the Italian banks. As a result, the Commission came to the conclusion that the transfer of NPLs has to be done at market prices without the state aid inclusion.

IV. Asset protection schemes

Instead of the classic case of physical transfer of NPLs, an alternative measure was the provision of guarantees in order to cover the losses that have to do with a specific asset portfolio. Schemes like these can, through an insurance mechanism, cover the losses until we have favorable market conditions again. Countries which constitute featured examples of this measure are Spain, Austria and Germany.

11.4 NPL Resolution Methods

According to Fig. 11.4, if a bank wishes to achieve a desirable outcome concerning NPL resolution, several factors must coexist and work in harmony. For instance, legal and regulatory infrastructure should enact laws and rules in order to facilitate the resolution of NPLs. Alongside the legal and regulatory infrastructure, prudential regulatory authorities have to give stronger inducements to banks to accelerate the collection of NPLs. Apart from the above, bank shareholders have to finance the planning objectives of the bank.

Following Xu (2005), I present the most popular NPL resolution methods:

- Debt-for-Equity-Swap

Debt-for-Equity-Swaps are one way of dealing with subprime mortgages-NPLs (Xu 2005; Stijepovic 2014).

These types of Swaps are generally created to help a struggling company and hence to help the company to continue to operate. Typically, what a lender might

Fig. 11.4 The NPL Resolution "System". (Source: Johnson 2013, "NPL resolution: A market overview")

claim is a rise in the margin, the restructuring fee payment, further deleveraging and the provision of further security (i.e., further guarantees). On the other hand, the borrower has to look for a standstill agreement, when the D/E swap terms are in a negotiation stage.

This resolution method has many benefits as it helps companies to grow, protects the employment and expands the firm's lifeline.

Regarding companies, this solution is highly beneficial as it enables them to continue trading and competing by temporary relieving them of their debt burden. Moreover, a debt-for-equity swap can achieve a longer value appreciation for all stakeholders, since the insolvency measures create only partial value for specific creditors. Nevertheless, debt-for-equity-swaps have some disadvantages. Maybe the most important disadvantage of this method could be the fact that D/E swap can be time-consuming and expensive. Also, in practice, D/E swap might not be able to combine fulfillment of both secured creditor and company's aims. Xu (2005)

- Direct Sales to Investors

Xu (2005) supports the argument that this NPL resolution method takes two forms: "sales of individual assets and bulk sales, including negotiated sales and auctions". The most common kind of transaction is sales of debt rights, which is followed more by settled assets and less by equity rights. Investors benefit from the existing difference between their "ultimate recovery price" and "the purchase price". According to Xu (2005), some investors "manage to foreclose on assets backing the loans", despite the existing difficulty coming from legal and bureaucratic limitations.

In some countries there is a scarcity of repossession and foreclosure laws. Due to this fact, foreign investors make the decision to bid on deals acceptable to the borrower and to settle NPLs at a reasonable price. Correspondingly, foreign investors hardly take part in restructuring programs of indebted companies and this is because of weak bankruptcy legislations.

- Securitization

In the case of non-performing loan securitization, the receivables securitized are the awaited stream of cash flows resulting from the NPLs.

The asset securitization process's major advantage is that it can repackage cash flows, created by a diversified loan portfolio, into marketable securities and thus can aim at a wider investor base with varied risk characteristics. Due to the large number of the European Union's NPLs and the sluggish pace of recovery until now, securitization appears to be an excellent solution because it permits the collection of a significant number of assets. As a result, there is an instant cash recovery for the seller. Additionally, as Xu (2005) mentioned, securitization allows for the design of securities with different security levels (i.e. various returns and maturity dates). Each tranche has diverse classes of loss protection and therefore could appeal to investors ready to take on a wide range of risks. Finally, it has to be mentioned that the most notable challenge for securitization is the deficiency of the respective legislation.

11.5 Structural Barriers to NPL Resolution in European Union

NPLs have been meaningfully increased for all the EE countries since 2008, mostly because of aggressive lending, poor governance and supervision, lax credit controls, aggressive acquisition strategies and loosen of the credit underwriting policies.

This *status quo* gets even worse with the protracted economic recession forcing even more the highly leveraged borrowers (i.e. borrowers with already high levels of debt) into financial difficulties and resulted to the existence of a significant number of defaults.

Finally, another decisive factor which contributed to have these elevated levels of non-performing loans throughout Europe is the amplified regulatory requirements for NPL management.

As we can see from Fig. 11.5, the absence of distressed debt markets and a proper legal system are considered the greatest challenges for creating a well-designed NPL resolution mechanism instead of other obstacles (structural or institutional).

More specifically, some of the structural barriers to NPL Resolution in the European Union are:

- Poor equipment of available tools and sources: Some banks fail to undertake an internal resolution of NPLs because of the scarcity of resources, experience and restructuring tools. In countries that face serious problems with their banks'

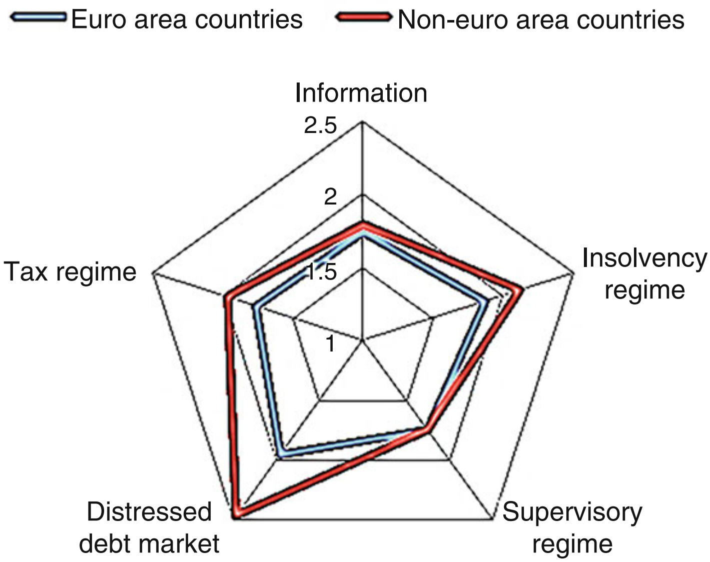

Fig. 11.5 Scores on NPL resolution obstacles, based on an IMF survey. (Source: IMF 2015) Notes: The figure presents the average obstacle scores based on the survey responses of Euro-area and non-Euro-area countries with high levels of NPLs. For each country, the final obstacle in each area is a maximum of two scores, based on the responses of the authorities and banks operating in these countries. The range of the values of these scores is from 1–3, where1 means no concern, 2 stands for medium degree concern and 3 implies high degree of concern

NPLs (such as Greece, Ireland and Cyprus) the supervisory authorities employed independent specialists in order to examine the NPL managerial ability of banks. Their findings were really disappointing.

- Tax regimes: Banks' incentives for resolving their NPLs may be reduced due to specific tax regimes. For example, until recently, the Italian banking authorities gave penalties to banks that wrote off NPLs aggressively. This Italian tax treatment has permitted tax reliefs only for write-offs in insolvent conditions. Another example is Spain, where taxes on D/E swaps were recently eliminated in order to encourage banks to acknowledge their losses from bad assets.
- Accounting standards: Accounting standards do not provide adequate motivation for the resolution of NPLs. For example, although the International Financial Reporting Standards (IFRS) explicitly allow loan amortization of impairment losses, they do not give any information for writing off modalities, which are remained with the supervisors. Moreover, under IFRS, insufficient provisions may be incurred due to the *incurred-loss approach to provisioning for loan losses, giving an essential space for judg*ment.
- The capital buffers' size: Banks' capability to increase provisions will be constrained if there are low capital buffers and low profitability. So, a bank

with NPL superfluity and with less loss-absorbing capability could worsen the situation.

- Small, distressed debt market: The European distressed debt market is tiny compared to the corresponding market in the U.S.A. Banks' collection burden is reduced when there exists a disposal market for NPLs. Also, a large market for distressed debt can boost loan recovery values. However, the European distressed debt market is not yet fully-developed and its focus is mainly on commercial loans and commercial real estate.

11.6 Conclusions and Policy Implications

The issue of non-performing loans is a continuous and unstoppable challenge for Europe and around the world. In this paper, I tried to summarize the existing literature on the management and the resolution methods of the theme of NPLs. I also tried to make a clear separation of ex-ante and ex-post measures to address the theme of NPLs.

Countries that face a big problem of NPLs must explore the methods above and examine them from a new angle. I am convinced that if each country's governments establish the following rules-actions, then much of their non-performing loans will be eliminated. To begin with, AMCs have to be established, and governments have to foster banks to accelerate the NPL transmission procedure. Also, SOBs have to be allowed to sell non-performing loans below of their book value to other investors. Concerning the resolution techniques of NPLs, the debt-for-equity swap method, while it appears to have some effectiveness, ultimately only helps transient the firm's capital structure. Finally, legislations for foreclosure must be created or be improved, and law for NPL securitization has to be enacted, thus allowing the formation of SPVs.

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Chapter 12
How Accurate Are Risk Models During COVID-19 Pandemic Period?

Foued HAMOUDA, Rabeb RIAHI, and Jamel E. HENCHIRI

12.1 Introduction

Managing risk has always been an important part of financial institutions such as banks, insurance industries and investment funds. Recently, "risk management" has become a popular buzzword – the phrase appeared more than 450,000 times in web of science search engine in 2021. For many years risk managers have long been searching for a "good" risk measure. The growing complexity of financial products, particularly derivatives, has made assessing and measuring the risks faced by financial institutions more challenging. Value at Risk (*VaR*) emerged as the favored method for measuring risk. It has become a very popular risk management method for many multinational companies in the last two decades. The *VaR* measures how much the value of a portfolio could decline over a certain time horizon because of changes in market prices. In this sense, it summarizes the risk of the entire portfolio in a single number that non-specialists can understand quickly and easily.

The *VaR* concept has been applied since 1994, when J.P. Morgan provided the first set of standardized assumptions called RiskMetrics (RM). The most used *VaR* models assume that the probability distribution of the daily financial asset return is normal. However, many of firm's returns show significant levels of skewness and kurtosis. In this context, most empirical studies focused on market risk and estimates *VaR* for stocks index.

This *VaR* estimation seems to be a difficult task during periods of financial turmoil. In fact, the main concern in the estimation of market risk with the *VaR*

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method is the choice of the appropriate model. As a result, many studies have used several methods that allow to better assess the market risk. For example, Bao, Lee, and Saltoglu (2006) compared different *VaR* models and support the dominance of filtered models over unfiltered and Riskmetrics models. Dimitrakopoulos et (2010), using historical simulation and extreme value theory, assesses the precision and effectiveness of different *VaR* approaches in 16 emerging and 4 developed stock markets. Echaust and Just (2020) compared the accuracy of *VaR* forecasts between conditional and unconditional models. They found that the choice between the two models depend on the period of the analysis and the type of risk measure. Abad et al. (2014), In a review paper, found that the best methods for forecasting are approaches based on Extreme Value Theory and Filtered Historical Simulation. In a more recent paper, Ghorbel and Trabelsi (2014), studied the performance of *VaR* estimates from three energy commodity markets. They find that GARCH-t, conditional EVT and FIGARCH extreme value copula methods produce acceptable estimates of risk both for standard and more extreme *VaR* quantiles. In the same line, Aloui and Mabrouk (2010), computed the *VaR* for three ARCH/GARCH-type models including FIGARCH, FIAPARCH and HYGARCH. They conclude that asymmetry, fat-tails and long-range memory are common facts on energy markets volatility. Hence studies provide different results based on the data used and the period studied.

The right way of assessing risk has become the de facto industry standard. Overreliance on value at risk, however, might give risk managers a feeling of security or mislead them into complacency. While *VaR* has become a standard risk management tool, the methods for calculating it have improved significantly since 1994. For practitioners and regulators, generating precise *VaR* estimates for specific applications has become a challenging task. Therefore, multiple methods of *VaR* are necessary to be investigated.

In this chapter we evaluate the performance of several common *VaR* estimation in the context of the recent COVID-19 financial crisis. We analyze many methodologies developed to estimate *VaR*, ranging from standard models to recently proposed ones. We used models that best matching with our economic question (how risks are best managed by models?). Besides, COVID-19 has become an important area of investigation, as suggested by Goodell (2020). This coronavirus disease 2019 (COVID-19) which first occurred in Wuhai, China in December 2019 has spread rapidly to other countries. From both theoretical and practical viewpoints, we will expose the relative significance of these methodologies in Tunisia until March 2020. Tunisia was chosen because, it has a high daily death rate, hence placing its health-care system under severe stress and depleting oxygen supplies. Second, it received one of the highest financial assistances (600 million) from European union. Moreover, in developed and emerging markets, financial assets behave differently and are subject to frequent and substantial shocks. The volatility distributions are fat-tailed and difficult to model analytically. As a result, *VaR* estimation in emerging markets is a difficult task.

We are trying to find the best risk model that might be applied during the period of COVID-19. The goal is to provide the financial risk researchers with models which better capture risk in Tunisia during COVID-19 and therefore bringing them to the limits of this field of knowledge. By giving a more precise understanding of risks, an accurate *VaR* estimation technique would substantially benefit practitioners and regulators.

The paper is structured as follows. The next section provides a brief literature review. In Sect. 12.3, a complete range of methodologies developed to estimate *VaR* from filtered historical simulation to extreme value theory are reviewed. Section 12.4 presents empirical results, and Sect. 12.5 concludes.

12.2 Related Literature

Since the financial crisis of 2008, economists and practitioners have paid more attention to risk measures, which are at the center of risk management practices. In this context, the so-called Value-at-Risk (VaR) is an important new idea in managing risk. The pioneering work on VaR was Morgan (1996), Jorion (2007), Duffiee and Pan (1997). Essentially, VaR introduces the question: "How much money might we lose over the next period of time?". Accordingly, a common measuring unit, a temporal horizon and a probability must be chosen in advance to calculate VaR. This measure is usually employed by risk managers and market regulators to define the maximum loss with a given probability level (α). In the literature, several approaches for calculating VaR have been proposed and can be classified into two categories. The non-parametric methods and the parametric (and semi parametric) models based on an econometric model for volatility dynamics and the extreme value theory approach which models only the tails of the return distribution.

Parametric VaR (also known as the analytical or correlation method) is based on the estimate of the variance-covariance matrix of asset returns, using historical time series of asset returns to calculate their standard deviations and correlations. This means that the variance-covariance matrix completely describes the distribution. However, the main assumption of the parametric VaR is that the distributions of asset returns are normal. This type of VaR is called VaR with historical simulation (HS) or stochastic simulation also known as Monte Carlo (MCS).

Historical Simulation is the most popular procedure to forecast VaR. For instance, According to Pérignon and Smith (2010) nearly three-quarters of banks who disclose their VaR approach use historical simulation. The success of HS can be attributed to its ease of use and smoothness. Inspired by this method and by including Exponential Weighted Moving Average into the VaR forecast, Žiković and Aktan (2011) propose forecasting the VaR using Weighted Historical Simulation (WHS). Also, Vlaar (2000) used the historical simulation (HS) approach and found that the HS-estimates outperformed those produced from Gaussian approaches. Yi-Hou Huang and Tseng (2009) found that the HS is slightly more accurate than the MCS VaR. The HS estimations' increased accuracy can be due to better matching of tail probability. However, the best-known parametric VAR model is J.P. Morgan's RiskMetrics.

Since the introduction of the Risk Metrics method (RM), academics and practitioners have questioned the best method for calculating VaR. From a theoretical point of view, many studies have examined into the effectiveness of HS-VaR model. According to some authors (Daníelsson and de Vries 2000; Angelidis et al. 2004) HS is inaccurate, with high significant standard errors particularly in rare events (in tail). As a consequence, HS estimates are difficult to verify.

Alternatively, several authors propose nonparametric returns distribution estimators that avoid the effects of possible misspecification. These nonparametric methods are more computationally difficult, but they can yield inferential improvements when the parametric models' assumptions are incorrect. For example, extreme Value Theory (EVT), which models the tails of the distribution of returns without making any precise assumptions about the distribution's center, can be used to estimate the quantile of the distribution. This EVT approach was first employed by Koedijk (1990) in which he tried to evaluate how heavy-tailed are bilateral European Monetary System (EMS) foreign exchange rates. Likewise, Neftci (2000) compared the EVT approach to VaR calculation to the standard one based on the normal distribution. He concluded that the statistical theory of extremes and implied tail estimation are indeed effective for VaR calculations. Some other authors like Ben Ameur et al. (2020) used high-frequency energy data and applied different extreme risk measures to capture the intraday dynamic dependence between oil and gas prices. For a detailed and highly useful survey on EVT in finance, see Rocco (2014).

Since the 1996 Market Risk Amendment in the Basle accord, U.S. and international banking authorities adopted VaR models for determining market risk capital requirements for large banks. VaR has become a standard measure of financial market risk and, as a result, it has increasingly been adopted by other non-financial firms.

12.3 Methodologies

12.3.1 Specifying Volatility

Like GARCH model developed by Bollerslev (1986), We used the modified GARCH models (NGARCH) so the weight given at the return will depends on the sign of the return. In fact, assuming that the negative return increases variance by more than a positive return of the same magnitude, we can take into account the leverage effect. This model is expressed as follow:

$$\sigma_{t+1}^2 = w + \alpha(R_t - \theta\sigma_t)^2 + \beta\sigma_t^2 = w + \alpha\sigma_t^2\left(Z_t - \theta^2\right) + \beta\sigma_t^2 \tag{12.1}$$

A positive piece of news, $Z_t > 0$, (rather than raw return R_t) will has less impact on Variance than a negative piece of news, if $\theta > 0$.

12.3.2 VaR with the Filtered Historical Simulation Approach

Since a negative return increases Variance by more than a positive return of the same magnitude the equity value will drop and the company becomes more risky and highly levered (assuming the level of debt stays constant). In this case, we can use NGARCH model as the weight given to the return depends on whether the return is positive or negative. By allowing a dynamic Variance model, we can write this:

$$R_{TUIX,t+1} = \sigma_{TUIX,t+1} z_{t+1} \tag{12.2}$$

where $\sigma_{TUIX,\, t\, +\, 1}$ is the vaiance simulated by the GARCH /NGARCH model. Hence

$$VaR^{p}_{t+1} = -\sigma_{TUIX,t+1}\text{Percentile}\left\{\left\{\hat{z}_{t+1-\tau}\right\}^{m}_{\tau=1}, 100p\right\} \tag{12.3}$$

where

$$\hat{z}_{t+1-\tau} = \frac{R_{TUIX,t+1-\tau}}{\sigma_{TUIX,t+1-\tau}} \text{for } \tau = 1, 2, \ldots, m \tag{12.4}$$

12.3.3 VaR with the Cornish-Fisher Approximation

The Cornish–Fisher is used to determine the percentiles of the distribution that are non-normal. The *VaR* with coverage rate p can then be calculated as:

$$VaR^{p}_{t+1} = -\sigma_{pf,t+1} CF^{-1}_{p} \tag{12.5}$$

where

$$\begin{aligned} CF^{-1}_{p} &= \phi^{-1}_{p} + \tfrac{\xi_1}{6}\left[\left(\phi^{-1}_{p}\right)^2 - 1\right] \\ &+ \tfrac{\xi_2}{24}\left[\left(\phi^{-1}_{p}\right)^3 - 3\phi^{-1}_{p}\right] \\ &- \tfrac{\xi_1^2}{36}\left[2\left(\phi^{-1}_{p}\right)^3 - 5\phi^{-1}_{p}\right] \end{aligned} \tag{12.6}$$

ξ_1 is the skewness and ξ_2 is the excess kurtosis of the standardized returns, z_t, and $Z_{t+1} = \frac{R_{TUIX,t+1}}{\sigma_{TUIX,t+1}} \sim^{iid} D\,(0, 1)$, $D(0, 1)$ represents a distribution with mean equal to 0 and Variance equal to 1.

12.3.4 VaR with the Standardized T-Distribution

The standardized $\tilde{t}(d)$ distribution is defined by:

$$f_{\tilde{t}(d)}(z, d) = c(d)\left(\frac{1+z^2}{(d-2)}\right)^{-(1+d)/2} \quad \text{for } d > 2$$

Where $c(d) = \frac{\Gamma((d+1)/2)}{\Gamma(d|2)\sqrt{\pi(d-2)}}$

$$z = \frac{x - E(x)}{\sqrt{VaR(x)}} = \frac{x}{\sqrt{d/(d-2)}} \quad (12.7)$$

By combining a powerful NGARCH model and a standard distribution t, we can specify the model portfolio return as:

$$R_{TUIX} = r_{TUIX} z_t.\text{With } z_t \overset{iid}{\sim} \tilde{t}(d) \quad (12.8)$$

The parameter d will be estimated using maximum likelihood by selecting d that maximizes:

$$\begin{aligned} \ln L_1 &= \textstyle\sum_{t=1}^{T} \ln\left(f_{\tilde{t}(d)}(z_t; d)\right) \\ &= T\left\{\ln\left(\Gamma\left((d+1)/2\right)\right) - \ln(\Gamma(d|2) - \ln(\pi)/2 - \ln(d-2)/2\right\} \\ &\quad - \tfrac{1}{2}\textstyle\sum_{t=1}^{T}(1+d)\ln\left(1 + \left(R_{pf,t}/\sigma_{pf,t}\right)^2/(d-2)\right) \end{aligned}$$

The VaR is defined by

$$VaR_{t+1}^{p} = -\sigma_{PF,t+1}\sqrt{\frac{d-2}{d}} t_p^{-1}(d) \quad (12.9)$$

12.3.5 VaR with the Extreme Value Theory

Gnedenko (1943) proved the celebrated EVT *theorem*, which specifies the shape of the cumulative distribution function (cdf) for the value of x beyond a cut off point u. The main result of extreme value theory is that when the threshold u increases, the distribution of observations beyond the threshold converges to the generalized Pareto distribution.

$$GPD(y; \xi, \beta) = \begin{cases} 1 - (1 + \xi y|\beta)^{-\frac{1}{\xi}} \ if \ \xi > 0 \\ 1 - \exp(-y|\beta) \ if \ \xi = 0 \end{cases} \quad (12.10)$$

With $\beta > 0$ and $y \geq u$ and the tail index parameter ξ controls the shape of the distribution tail and especially how fast the tail goes to zero when the extreme y goes to infinity.

The tail index can be estimated non-parametrically with the Hill estimator (Hill 1975) and VaR will be estimated by

$$VaR^{\mathrm{p}}_{t+1} = \sigma_{TUIX,t+1} F^{-1}_{1-p}$$

$$VaR^{p}_{t+1} = \sigma_{TUIX,t+1} u \left[\frac{p}{T_u / T} \right]^{-\xi} \tag{12.11}$$

where T_u is the number of observations y larger than u.

12.4 Empirical Results

12.4.1 Descriptive Statistics

We used the return of Tunisia stock index TUNINDEX defined by:

$$R_{TUIX} = Ln\left(\frac{TUIX_t}{TUIX_{t-1}}\right) \tag{12.12}$$

where $\mathrm{TUIX}_t$is the daily closing value of the TUNINDEX on day t

The daily price is shown on panel (a) of Fig. 12.1 and the related volatility of NGARCH is shown on panel (b). We observe a significant high volatility after the first appearance of COVID-19 in 02/03/2020. This increase encourages market professionals to manage risk through conventional methods. The volatility in March is four times (0.004) more important compared to other months (0.00005) on average.

Table 12.1 reports descriptive statistics for the daily returns before and after 01/03/2020. The mean daily return is positive (negative) before (after) March 2020 justifying a downward movement of stock prices after 02/03/2020.

For the two subsamples, the sample skewness is negative, which means that the negative shocks are more common than the positive ones. The estimation of kurtosis is very strong before the first appearance of the Corona, indicating that the return distributions are leptokurtic, with heavier tails than the normal distribution. On the contrary, Jarque-Berra statistics shows that during COVID-19 sub-period the distribution is not normal with a significant level of 1%. This result is confirmed for the full sample.

The first step is to suit the model that enables the leverage effect. Depending on whether the return is positive or negative we can model volatility by Nonlinear

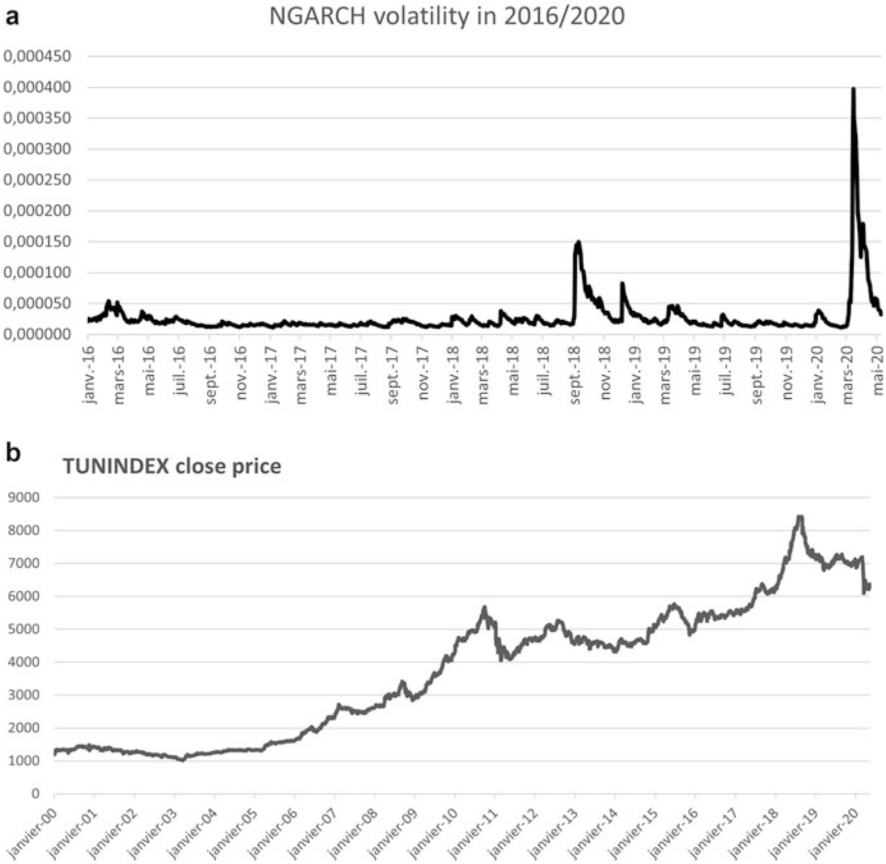

Fig. 12.1 Dynamics of TUNINDEX stock markets**Note:** This figure presents data for TUNINDEX stock index from January 2000 to May 2020; panel (**a**) presents the stock market price of TUNINDEX stock index; panel (**b**) presents stock market volatility of TUNINDEX stock index

GARCH model. In the context of COVID-19, firms become more highly levered and riskier. In panel 2 of Table 12.1, we present descriptive statistics of VaR's for the different models used. On average, The VaR is 1% for the extreme value estimation but higher for other models. The value is likely to increase steadily for the Cornish Fisher approximation. This is also shown in Fig. 12.2. The VaR with extreme values have the lowest value and the VaR with Cornish Fisher have the highest value, for the entire period. It is clear that all these VaR's estimation reach high values by March 2020, the date of the first case of COVID-19 in Tunisia. The comparison of VaR against TUNINDEX return show how well all measures of the risk can detect the abnormal fluctuation of the market. However, in order to demonstrate which model is most effective, we conducted a backtest procedure.

Table 12.1 Descriptive statistics of TUNINDEX and *VaR* at 99% confidence interval

	TUNINDEX		
	Before 01/03/2020	**After 01/03/2020**	**Full sample 04/01/2000 to 15/05/2020**
Panel 1.			
Mean	0,036%	−0,154%	0,033%
Std.dev.	0,00565551	0,01164	0,0057
Min	−0,07	−0,04186	−0,0733
Max	0,07	0,01897	0,0705
Skewness	−0,65	−1593	−0,7776
Kurtosis	24,73	3295	23,9242
JB-test	127,215,02	42,88	120,417,93
	P = 0,00000	P = 0,00000	P = 0,00000
# of observations	4979	49	5028

Panel 2.				
VaR model ($\alpha = 1\ \%$)	Mean	Std.dev.	Min	Max
Filtered historical simulation	0,0116	0,0071	0,0039	0,0710
Cornish-fisher approximation	0,0287	0,0124	0,0187	0,1554
Standardized t distribution	0,0195	0,0085	0,0127	0,1056
Extreme value theory	0,0102	0,0044	0,0066	0,0552

Note: This table presents descriptive statistics of TUNINDEX and VaR models. **Panel 1** presents results before and after the date of the first case of Covid-19. **Panel 2** presents *VaR*'s forecasts using filtered historical simulation, Cornish Fisher, Standardized t-Distribution and Extreme Value Theory

12.4.2 The Performance of the VaR's Models

Every model's performance is measured in terms of the number of violations. if the return on the following day is greater than today's *VaR*, a violation is occurred. This framework (back-testing) consists of three tests method developed by Christoffersen (1998). The unconditional coverage test checks whether the total number of violations is statistically acceptable or not. The independence test aims to check, over time, potential clustering of violations. Conditional coverage test checks in which respect the time series of *VaR* violations does not satisfy the correct conditional coverage. These tests are distributed asymptotically as a chi-squared distribution (Table 12.2).

The back-test study carried out according to the parameter L_{uc}, L_{ind}, L_{cc} shows that all methods are favorable and allow to control the market risk. It shows that because the probability ratio test is always equal to zero, the difference between theoretical and empirical violation ratios is statistically significant. In other words, no negative performance of the TUNINDEX index exceeded the VaR's limit. However, it appeared that Conditional extreme value theory is the only model that can be very close to the TUNINDEX return. Figure 12.3 illustrated this result and indicates that risk in Tunisia can be best controlled by the extreme value theory. All

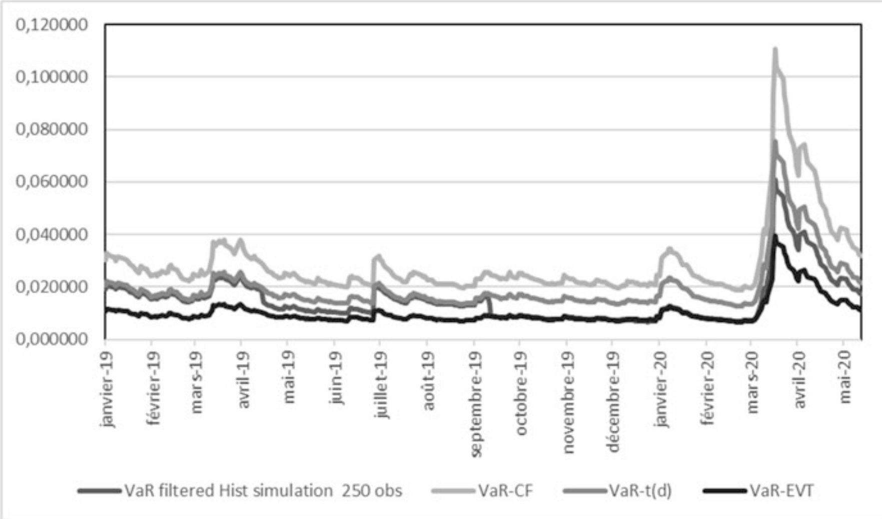

Fig. 12.2 time *Var*ying *VaR* for TUNINDEX index**Note:** This figure presents *VaR*'s forecasts using filtered historical simulation, Cornish Fisher, Standardized t-Distribution and Extreme Value Theory from January 2019 to May 2020

Table 12.2 Backtesting results of COVID-19 period (Test of Unconditional Coverage, Independence and Conditional Coverage)

	L_{uc}		L_{ind}		L_{cc}	
Significance	1%	5%	1%	5%	1%	5%
Filtered historical simulation	***VaR*model rejected**	*VaR* model accepted	***VaR*model rejected**	*VaR* model accepted	***VaR*model rejected**	*VaR* model accepted
Cornish-fisher	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted
Standardized t-distribution	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted
Conditional EVT	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted	*VaR* model accepted

Note: This table presents backtest results from conditional and unconditional tests of Christoffersen (1998)

L_{uc} is the Likelihood ratio of Unconditional coverage test. L_{cc} is the Likelihood ratio of conditional coverage test. L_{ind} is the Likelihood ratio of independence test

models passed all violation tests, but the extreme value Theory is preferable. Filtered historical simulation however rejected the model at 1% level. According to Žiković and Aktan (2011) and Adesi et al. (2014) historical simulation yields significantly lower forecasts than other alternative procedures and contains very little information about future volatility. In the context of exchange rates, Wang et al. (2010) also find that EVT is more appropriate to forecast the VaR of the Yuan in comparison to

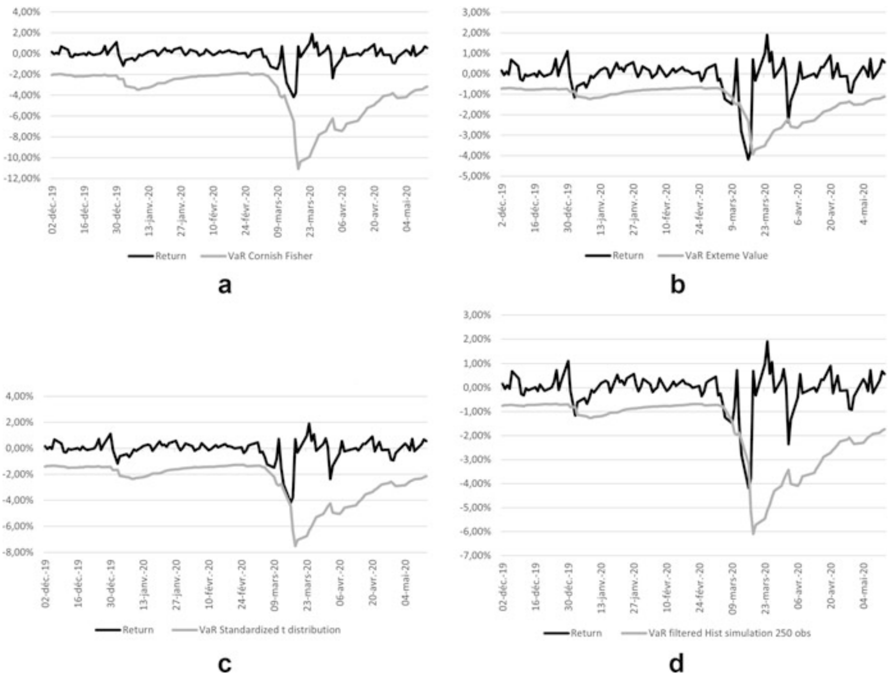

Fig. 12.3 VaR's forecasts superimposed on TUNINDEX return **Note:** This figure presents *VaR*'s forecasts superimposed on TUNINDEX return from January 2019 to May 2020; (**a**) this panel presents *VaR*'s forecasts using Cornish Fisher approximation; (**b**) this panel presents *VaR*'s forecasts using Extreme Value Theory; (**c**) this panel presents *VaR*'s forecasts using Filtered Historical Simulation; (**d**) this panel presents *VaR*'s forecasts using Standardized t Distribution

Historical Simulation and other methods. Out of 4781 cases, the filtered historical simulation fails 67 times however no fails were registered in the other method.

Backtest examination and visualizations for the full sample shows that the Conditional EVT, followed by the Filtered Historical Simulation, the standardized t-distribution and finally the Cornish Fisher approximation, is the best performing model. This result is also valid under each model for the same range of quantiles. Dimitrakopoulos et al. (2010) evaluated and compared several models of VaR during normal, crises, and post-crises periods. Overall, they find that the among the most successful VaR models for both emerging and developed markets is the VaR with EVT. Hence, the Conditional EVT model consistently performs the best in estimating and forecasting VaR for the entire period. Even though, it is the best model, the asymptotic properties of EVT are based on the assumption of *iid* returns which is usually not satisfied in practice. Finally, because intradaily Ultra-High Frequency Data (UHFD) is becoming more widely available, a growing literature recommends estimating VaR using daily volatility based on these types of observations.

12.5 Conclusion

In this study, we investigate a comparative predictability of VaR estimates from various estimation techniques in COVID-19 pandemic period. The main emphasis has been to evaluate how well the VaR's estimation models performs efficiently well in modeling market risk during financial turmoil. It has presented the direct evidence on the performance of Value-at-Risk models during Covid-19 period. In order to investigate this, daily TUNINDEX returns has been considered and from an econometric point of view, we employ several approaches to calculate VaR.

The preliminary analysis of the data shows high volatility which occasionally happened after March 2020 when COVID-19 appeared for the first time. To compare the accuracy of each model, we conducted a backtest estimations for each model. The result shows that the conditional EVT is the best performing model, as it gets closer to TUNINDEX returns. Therefore, it is important to take into account the implications of the estimation of VaR model during exogenous crisis, like the recent COVID-19 crisis. These findings might have useful policy implications for investors, regulators, and hedge fund managers in case they are looking to manage market risk. Results offer important implications regarding the recent financial turmoil with respect to the estimation of VaR. It is clear that in our study, we joint past results were VaR models face difficulties in estimating moderate loss quantiles in non-parametric models compared to parametric models. In some countries which experience unstable financial market we should consider similar recommendations.

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Chapter 13
What Does Matter the Climate Change Risk on Agriculture Adaptation: Evidence From Southern Mediterranean Country

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13.1 Introduction

Risks from climate change now appear to be a recognized and widely accepted phenomenon, and it has been found to be linked, at least in part, to emissions from human activities that contribute to the greenhouse effect. The increasingly frequent heat waves, droughts, and forest fires in 2021 all point to the serious consequences of climate change. The last IPCC report (2021) provided a better understanding of the current state of climate change and human contribution toward it, and it also provided exhaustive information about the climatic fate of various regions and the impact on agriculture in particular. The issue of climate change therefore warrants the development of new approaches for accessing resources and sharing risks, as well as the integration of this environmental issue into public policy choices. Climate change is a global phenomenon, but its effects are being seen at the regional level. It prompts us to question how we manage the natural resources of our planet, because it will put our production methods to the test, especially for the agricultural and the tourism sectors. Challinor et al. (2014) proposed that the yields from cereal

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cultivation under different climate scenarios will allow a better assessment of food-security problems. Without any adaptation, they predicted that in temperate regions like the Mediterranean Basin, a temperature increase of 2 °C would result in losses in cereal production and increased debt for farmers.

In Mediterranean countries, most climatologists agree that agriculture in southern Mediterranean countries is increasingly vulnerable to extreme risks due to climate change (Pozo et al. 2019; Schilling et al. 2020). To better understand the effects of climate change on agriculture—as well as the challenge of adapting to, and mitigating, these effects—it is important to position Tunisia within the context of the Mediterranean Basin. Tunisia, which is centrally located in the Mediterranean region, is a place of transit par excellence for its waters. In the functioning of the Mediterranean Sea, the water that evaporates from it is replaced by rain and inflows from rivers, as well as water flowing from the Atlantic through the Strait of Gibraltar. The mass of water off the Tunisian coast is in perpetual motion due to Tunisia's prominent position in the Mediterranean. The northern coasts of Tunisia face a climate with cold inclusions, while those to the east and south are influenced by a hot and salty sea. Water passes from the former to the latter through the Strait of Sicily.

Climate change is inevitably seen as a threat to both developing economies and its financial resources. It affects crop yields through a complex interplay of crop-specific physiological effects and the availability of water resources in the short, medium and long term. It is highly likely that spring and summer in Tunisia will become hotter and drier in future. Nieto et al. (2010) posited that the major problem for farmers will be the frequency and duration of droughts. Such risks present a problem for developing agricultural assets, something that is needed to increase farmers' incomes and reduce rural poverty (Dilley et al. 2005). Agriculture is a very important economic sector in Tunisia, with it generating 10.57% of national GDP and providing 15% of the direct jobs in 2020.

Over time, farmers have mastered cultivation techniques that are well suited to the local climatic conditions, yet climate change implies that these may need to be revised, which in turn indicates a need for the rapid development of innovative economic and social practices. The use of crop insurance may be one such practice. Mitigation and adaptation measures in agriculture could be based on effective instruments like insurance contracts to limit the economic risk of events related to climate change. This means that insurance companies are now on the "frontlines" of climate change, which is turning out to be more of a threat than an opportunity. They could therefore help manage the associated risk with products and services for agricultural activity, so farmers can mitigate the financial cost of harmful climatic events (Kath et al. 2018).

This article highlights the importance of the effects of future climate risks on agricultural activity in Tunisia, which remains one of the key sectors in terms of food security. It contributes to the extension of knowledge in this field by basing itself on the alarmist and average assumptions of the Representative Concentration Pathways. In our study, we carried out unit root panel tests which allowed us to consider a cointegration relationship. Panel data combines cross-sectional data and time series and allows for more powerful statistical inferences.

Research studies suggest that climate change will affect farmers' future incomes due to lower crop yields (Challinor et al. 2014). In the case of regional data, such losses will not be uniform; however, so one way to cope with this situation could be to take out insurance policies developed for the agricultural sector and the regional heterogeneity of climatic risks. Moreover, this work highlights the important implications that future drought episodes will have for Tunisia by 2050/2100. The regional climate models (RCMs) of the EURO-CORDEX project constitute the basis for our analysis, and these are based on the average emissions scenario RCP4.5 and the pessimistic emissions scenario RCP8.5.

Mediterranean agriculture is highly vulnerable to climatic phenomena like drought, excessive or insufficient rainfall, heat waves, and so on, so they threaten the financial stability of agricultural stakeholders. Studies carried out in the major Mediterranean economies have tended to reinforce the importance of developing crop insurance products as a way to safeguard incomes against climatic risks (Liesivaara and Myyrä 2017).

A drought in the Mediterranean rainy season negatively affects water resources by reducing groundwater and the water stored in reservoirs (Lorenzo-Lacruz et al. 2013, 2017; Raymond et al. 2016). In countries that are highly dependent on sufficient rainfall, such as those in North Africa, a lack of water has negative effects on economic activity, biodiversity, and crop yields (Schilling et al. 2020). There is a general consensus these days about the alarming potential scenarios for droughts in the region, both climatic (Hertig and Tramblay 2017) and hydrological (Forzieri et al. 2016). It is therefore essential to identify the implications of such situations for farmers' incomes, so we can develop strategies to adapt to them, such as by using agricultural insurance. In addition, when developing public policies, a more rigorous assessment of the economic effects of future droughts will need to incorporate dynamic modeling based on different climate scenarios (Escriva-Bou et al. 2017; Pulido-Velazquez et al. 2011; Van Loon et al. 2016).

The remainder of this paper is organized as follows: We first present a literature review before the third section describes the data and methodology used in this study. The empirical results are then discussed in section four before concluding remarks are given in the final section.

13.2 Related Literature

Considerable progress has been made in climatology over recent decades, and there is now no doubt that the climate is changing. The creation of the Intergovernmental Panel on Climate Change (IPCC) helped highlight the importance of climate change and its socioeconomic effects. Faced with this reality, human activities are often identified as being primarily responsible for these global atmospheric changes. Following the establishment of the IPCC over three decades ago, research into climate change grew exponentially. The Paris Climate Agreement later set out several stages of implementation for the rapid reduction of greenhouse gas emissions in order to keep global warming below 2 °C by the end of the century. This would in turn restrict the adverse effects of climate change, such as for the agricultural sector.

In recent times, we have seen increasingly frequent extreme weather events in Mediterranean regions, and these have adversely affected crops yields and consequently the incomes of farmers (Ciscar et al. 2018). Heavy rains and droughts have resulted in production losses due to the vulnerability of crops. To mitigate such risks, some farmers have chosen to take out insurance policies to ensure a certain income even during periods of extreme weather (Fusco et al., 2018a, b).

Having insurance companies help to manage the risk of extreme climate-related events will involve encouraging insurers to offer adequate cover against these risks and farmers to take them up on these policies. The insurance market is relatively new in Tunisia, but it includes insurance companies that specialize in agriculture, mainly to insure against crop losses caused by natural events like drought, hailstorms, insect invasion, frost, and so on. The setting of premiums based on the level of risk management is of course a core concern for insurers given the increasingly frequent and severe natural events that have been seen in recent years. For the insurance industry, income from premiums can often lag behind the growth in claims, and with unpredictable but economically harmful events, suitable insurance premiums cannot be set by considering historical data alone.

In the agro-economic literature, climate change has been shown to potentially affect agricultural production, and this relationship has been the subject of several studies (Wheeler and Von Braun 2013; Suryanto et al. 2020). Farmers will most likely see their incomes decline due to climate change, because they will suffer significant financial losses from infrequent but damaging natural events. Research has posited that the best way to adapt to these unpredictable, extreme climatic risks is to seek insurance through government programs.

Jørgensen et al. (2020) analyzed how farmers use insurance as a means to adapt to climate risks, highlighting that decisions for adapting to climate change rely on farm-management practices and the underwriting of crop insurance contracts. Their study suggests that while farmers who work poor-quality, low-yield land tend to take out insurance against the negative effects of natural events on their crops, farmers who work better quality, high-yield land use agricultural-management methods that are more resilient to climate change, so they are less inclined to take out insurance against losses caused by extreme weather events.

Rozaki et al. (2021) argue that Indonesian farmers combine clean adaptation techniques with crop insurance to cope with natural disasters. Management of risk reduction by third parties (insurance companies) is necessary to achieve efficiency. Crop insurance helps reduce economic and financial losses due to climatic risks.

Based on panel data for Italian farmers, Di Falco (2014) demonstrated the importance of insuring against natural disasters for maintaining the well-being of farmers by protecting against income uncertainties. They posited that climatic conditions will likely increase the demand for insurance products to reduce the exposure to risk. In addition, they showed that greater crop diversification could also mitigate the harmful effects of climatic events on crop yields by playing a hedging role.

13.3 Empirical Methodology

We sought to investigate the effects of global warming on crop yields and their variability. Econometric modeling was therefore applied to shed some light on the possible relationship between yield variability and meteorological factors.

A characteristic of panel data is its structure, which depends on common observable and unobservable factors. Indeed, panel models are used to meet a need to account for the modeling of common factors, specifically the influence of meteorological parameters on agricultural crop yields in this case. Panel models also make cointegration analysis more attractive by introducing the individual dimension (i.e., regions in our study) to the time dimension. Furthermore, they make it possible to modify the statistical properties of the non-stationarity and non-cointegrating relationship between variables and therefore avoid a situation of spurious regression (Phillips and Moon 1999).

Villavicencio et al. (2013) found that the temporal behavior of crop yields is not stationary due to its strong dependence on climatic factors, so any estimates based on a level series will inevitably be spurious. Panel stationarity tests were therefore carried out before proceeding with the study to investigate the dynamics between the different variables in the study. This could be estimated using the cointegration technique, which has two underlying advantages: First, it overcomes the difficulty associated with the narrowness of a time series, and second, it is more powerful than traditional time series tests (Banerjee 1999).

13.3.1 Testing for Panel Stationarity and Cointegration

The use of unit root and cointegration tests for econometric panel data offers a genuine advantage for dynamic models. Many research studies have shown that there is a considerable improvement in the power of unit root tests when using panel data.

In recent decades, several researchers—such as Levin et al. (2002) and Im et al. (2003)—have proposed unit root tests for panel data structures, some of which were applied in this study. The tests used are generally based on the following ADF (Augmented Dickey-Fuller) equation:

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{j=1}^{p_i} \theta_{i,j} \Delta y_{i,t-j} + \varepsilon_{i,t} \tag{13.1}$$

Where we assume the absence of a temporal effect and inter-individual dependencies, that is,

$$E\left(\varepsilon_{i,t}, \varepsilon_{j,t}\right) = 0 \quad for\ all \quad i \neq j \tag{13.2}$$

The second category of tests allows the heterogeneity of autoregressive roots under the alternative hypothesis to be established. These tests seem better suited to our regional panel data, because if the existence of a unit root can be rejected, any identification of autoregressive roots between the different regions is unlikely. The test of Im et al. (2003), or the IPS test for short, like the previous tests, is a joint test of the null hypothesis of unit root and the absence of fixed effects, but it works under an alternative hypothesis that allows for heterogeneity in the autoregressive roots of the different regions. Applying the IPS test is extremely simple, because it is based on calculating the individual Dickey-Fuller statistics before deriving a panel test statistic from the mean and variance of individual t-statistics. Moreover, in the case of panel data, cointegration tests can be considered a means for obtaining additional information when attempting to identify possible relationships between meteorological factors and crop losses.

As for unit root tests, the panel cointegration analysis helps mitigate the low effectiveness of time series tests for small samples. The test we present here uses the null hypothesis of the absence of cointegration between several variables, while the alternative hypothesis depends on the degree of heterogeneity retained. Once again, this test assumes the absence of inter-individual dynamics and therefore tests for the existence of intra-individual cointegration relationships. This test is based on the following long-term relationship:

$$\begin{aligned} &y_{i,t} = \theta_i + \beta_{1,i}x_{1,i,t} + \cdots + \beta_{m,i}x_{m,i,t} + \cdots + \beta_{M,i}x_{M,i,t} + \varepsilon_{i,t} \\ &\text{with i} = 1, 2, \ldots, \text{N; t} = 1, 2, \ldots, \text{T and m} = 1, 2, \ldots, \text{M} \end{aligned} \tag{13.3}$$

Based on the same principle as the Engle and Granger tests for a time series, the procedures of Pedroni (e.g., Pedroni 1996, 2000, 2007) test the residual stationarity of the long-term relationship estimated in the previous step, with the null hypothesis representing the absence of cointegration. Pedroni's test allows the slope coefficients in the cointegration vector to vary across individual panel members (i.e., regions in this case). Pedroni used seven residual-based panel cointegration statistics, four of which are based on pooling data within dimensions, while three are based on pooling data between dimensions. The difference between the two types of tests lies in the alternative hypothesis. The panel cointegration statistics require a common coefficient under the alternative hypothesis, while the group means cointegration statistics allow for heterogeneous coefficients under the alternative hypothesis. These statistics are then compared for the appropriate tails of the normal distribution. For this test, Pedroni allowed for heterogeneity in the cointegration vectors and adjustment rates under the alternative hypothesis, and this appears to be particularly relevant to our model given the significant regional differences in observed yield losses.

13.3.2 Estimation Method: Fully Modified OLS Versus Dynamic OLS

Two popular techniques are often applied to estimate the long-run relationship between cointegrated variables, namely the fully modified ordinary least squares (FMOLS) approach of Phillips and Hansen (1990) and the dynamic ordinary least squares (DOLS) approach developed by Saikkonen (1991). FMOLS is a non-parametric approach for dealing with a serial correlation, and the basic idea behind this procedure is to eliminate endogeneity bias in the regressors and the serial correlation of errors (Pedroni 2001, 2007). Pedroni (2007) suggested two procedures for applying this method to panel cointegration regression: the pooled panel FMOLS estimator (within dimensions) and the group-mean panel FMOLS (between dimensions). We chose to use the group-mean panel FMOLS because it deals with common values and provides interesting results, even with a short time series. DOLS, meanwhile, is an alternative parametric approach in which lags and leads are introduced to cope with problems relating to the order of integration and the existence or absence of cointegration.

To estimate the long-run relationship between crop yield losses and meteorological variables, we implemented the two alternative methods. We estimated the following long-run equation:

$$\begin{aligned} Corp\_Yield\_los_{\mathrm{i,t}} = \beta_0 + \beta_1 Av\_temp_{i,t} + \beta_2\, Min\_temp_{i,t} + \beta_3 Max\_temp_{i,t} \\ +\beta_4\, Cum\_rain_{i,t} + \varepsilon_{\mathrm{i,t}} \end{aligned} \tag{13.4}$$

Where *Corp_Yield_los* is the difference between the expected crop yield per area planted (for time *t* and region *i*) and the mean crop yield (for time *t* and region *i*). *Min_temp*, *Max_temp*, and *Av_temp* correspond to the minimum, maximum, and average temperature respectively. Next, *Cum_rain* represents the cumulative rainfall for each region and year, while $\varepsilon_{i,\ t}$ is the random term.

The phenological development of cereals (i.e., their growth cycle) has been found to be affected by changes in maximum, minimum, and average temperatures. This phenomenon is characterized by an increase in the duration of the vegetative phase delaying the reproductive phase, consequently reducing potential crop yields (Rosenzweig and Tubiello 1996).

13.3.3 Extrapolation of Yield Losses Based on Climate Change Scenarios

Climate projections were used to forecast the relevant meteorological conditions for the various regions in order to determine the likely impacts of climate change on future crop yields. The emission scenarios in the Special Report on Emissions

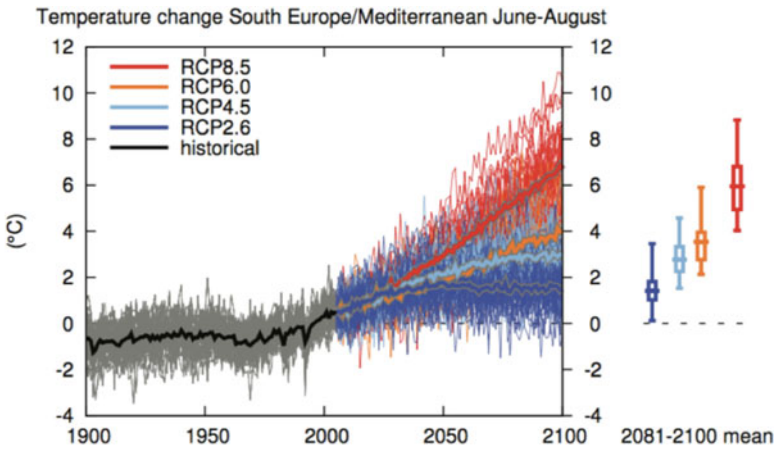


Fig. 13.1 Variations in mean global surface temperature (°C) in relation to the four typical scenarios of the IPCC

Scenarios (SRES)[1] attempt to model how greenhouse gas emissions may evolve over this century.

For our climate projections, we used the scenarios of the EURO-CORDEX Project as the basis for our simulations. These were carried out in relation to two long-term periods of the Coupled Model Inter comparison Project (CMIP), which proposed new climate scenarios as part of an international collaboration. The IPCC, meanwhile, has identified four scenarios for greenhouse gas (GHG) concentration in the atmosphere in the form of its Representative Concentration Pathways (RCPs).

The RCP scenarios describe the level of radiative forcing emissions from 2.6 to 8.5 W m^{-2} (Fig. 13.1). The most optimistic scenario in terms of emissions is RCP2.6, while two median or stabilization scenarios are represented by RCP4.5 and RCP6.0. Finally, RCP8.5 reflects the most pessimistic scenario.

The EURO-CORDEX project uses temperature and precipitation as the basis for simulating 14 regional climate models. The Tunisian National Meteorological Institute, as an associate of the EURO-CORDEX project, conducts climate forecasts for the entire territory. The changes in temperature and cumulative rainfall were calculated for two of the RCP emission scenarios, namely the average scenario RCP 4.5 and the pessimistic scenario RCP 8.5. Explicit policies to limit greenhouse gas emissions or adapt to global climate change are included in these scenarios, so the United Nations Framework Convention on Climate Change is taken into account. RCP8.5 reflects the most credible and severe forecast in terms of increased emissions if no action is taken, while RCP4.5 represents a stabilization of emissions at a relatively low level before the end of the twenty-first century, so this a credible scenario for if human actions successfully abate climate change.

[1] The SRES of the IPCC describes various future scenarios for greenhouse gas emissions.

The Mediterranean region is expected to see an increase in soil temperature of 2–6 °C by 2100, depending on the season. Heat waves and droughts are also expected to become more frequent (Jacob et al. 2014). What is more, most of the Mediterranean basin will experience even hotter summers in the near future, with temperatures being above the current norm for the season.

For this study, we used the two RCP scenarios for both 2050 and 2100. The RCP 4.5 scenario shows increased precipitation until 2050, mainly in the northwest region (Jendouba and Beja), but there is a marked decrease in most regions by 2100. Indeed, the simulations show a clear decrease in cumulative annual precipitation at the 2100 horizon. RCP 8.5, meanwhile, shows decreased precipitation coupled with increased temperatures for the entire country at both horizons. At the end of the century, there is a decrease in rainfall of around 0–14% under the RCP 4.5 scenario and a decrease of around 18 to 27% under the RCP 8.5 scenario for most regions (Fig. 13.2). A spatial climate disparity emerges by 2100, particularly in the south-central part of the country (between Sfax and Gabès), northwest of the country (Jendouba and Kef governorates), and the desert zone of Tunisia (Tataouine governorate).

The temperature simulations were carried out using the INM simulator, and they showed a high degree of variability for the different regions. Both scenarios result in a significant increase in temperature for 2100, namely 3 °C for the RCP 4.5 scenario and over 5 °C for the RCP 8.5 scenario (Fig. 13.3).

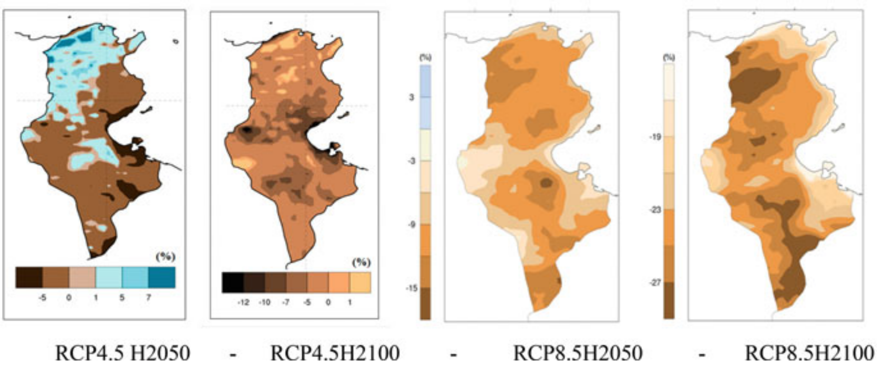
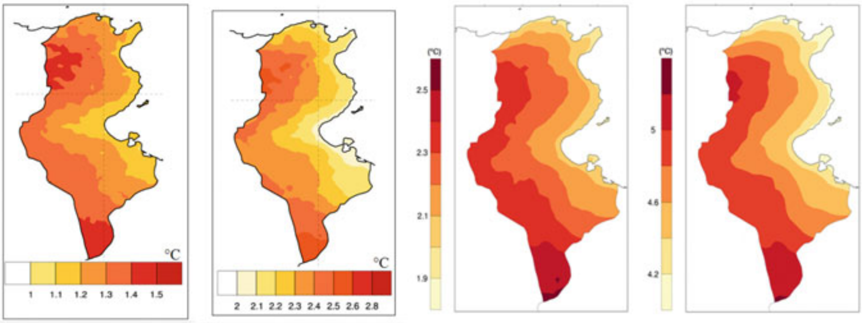


Fig. 13.2 Evolution of total annual rainfall for 2050 and 2100 according to RCP 4.5 and 8.5



RCP4.5 H2050 - RCP4.5H2100 - RCP8.5H2050 - RCP8.5H2100

Fig. 13.3 Evolution annual mean temperature for 2050 and 2100 according to RCP 4.5 and 8.5

13.4 Empirical Results

13.4.1 Data

For this empirical study, we used panel data for the different regions based on annual observations of yield losses and meteorological parameters, namely temperature and precipitation, for the 1980–2018 period. Based on the availability of data, we selected ten governorates that were representative of the entire Tunisian territory, because they covered the main agricultural regions of Tunisia over different climatic zones. These were the northern region (Jendouba, Beja, Bizerte, and Grand-Tunis), the central region (Kasserine, Monastir, and Sfax), and the southern region (Gafsa, Gabès, and Mednine). The data came from different sources, including the National Agricultural Observatory (Agricultural Statistics Yearbook, ONAGRI), the Tunisian Ministry of Agriculture, the National Meteorological Institute (INM), and the Food and Agriculture Organization (FAO).

The "*Yield_losses*" variable (*for t time and i region*) was calculated as follows:

$$Yield\_losses_{t,i} = Expected\_crop\_per\_area\_planted_{t,i} - Mean\_crop\_yield_{t,i} \tag{13.5}$$

The annual crop yield was derived from the agricultural statistics yearbook and the Tunisian regional agricultural commission. The expected crop per area planted is the mean value of the annual crop yield. To characterize climate change, we used temperature (minimum and maximum) and precipitation as climate attributes. We also used the cumulative precipitation for September to March, which is the rainy season in the southern Mediterranean region.

13.4.2 Results

The procedure for estimating the relationship between the "*Yield_losses*" variable and the independent variables (temperature and precipitation) comprised four steps: (i) panel unit root tests; (ii) panel cointegration tests to identify long-term equilibrium relationships; (iii) the FMOLS and DOLS estimation methods to estimate this relationship; and finally (iv) the use of these estimates to forecast crop yield losses for 2050/2100.

13.4.2.1 Panel Unit Root Tests

The presence of non-stationarity in a statistical series leads to spurious regressions, but unit root tests can be used to check for possible non-stationarity in such series. To ensure the stationarity of the selected variables, we performed the Levin–Lin–Chu, Im–Pesaran–Shin, Fisher–ADF, and Fisher–PP unit root tests on the series at level and first difference. The results of these tests are presented in Table 13.1. All these tests suggested that the Crop_Yields_los and Av_temp are non-stationary. For the other variables—namely Min_temp, Max_temp, and Cum_rain—we applied the majority rule (i.e., three tests against one) to conclude non-stationarity. The test results therefore confirmed that all the variables were stationary at first difference.

13.4.2.2 Cointegration Test

The Kao (1999) test and the Pedroni (2004) test are widely used in the literature to test for cointegration between variables (Table 13.2). Equation 13.4 expresses the long-term relationship between Corp_Yield_los, Av_temp, Min_temp, Max_temp, and Cum_rain.

As shown in Table 13.2, the Pedroni and Kao tests indicated that the null hypothesis of no cointegration could be rejected for all regressors at a 1% significance level (five against three). This implies that a long-run relationship exists between yield losses and climatic factors.

13.4.2.3 Estimation

Given the existence of a long-term relationship among the variables, we estimated Eq. 13.4 using the FMOLS and DOLS methods. Table 13.3 presents the estimated coefficients for the long-run relationship between yield losses and the climate variables. The cointegration results indicate that maximum temperature has a positive and significant influence on yield losses, with an increase of 1% in the maximum temperature leading to a decrease in crop yields of around 0.32%. In contrast, the minimum temperature has a negative and significant effect on yield

Table 13.1 The results of panel unit root tests

	IPS W-Statistics		Levin, Lin, and Chu (LLC)		PP- Fisher Chi-square		ADF-Fisher Chi-square	
	Level	First difference	Level	First difference	Level	First difference	Level	First difference
Crop_Yields_los	−1.23	−10.78***	−1.21	−9.09***	21.523	112.364***	20.636	101.144***
Av_temp	−1.15	−7.12***	−1.27	−9.47***	21.264	67.012***	21.37	65.676***
Min_temp	−2.41**	−27.34***	−3.45**	−24.55***	9.782	78.521***	9.511	76.607***
Max_temp	−0.98	−21.36***	−1.24	−18.35***	33.536	126.37***	31.124	124.18***
Cum_rain	−2.36**	−12.36***	−1.348	−13.48***	20.24	234.145***	19.314	212.438***

Notes: ** and *** indicate rejection of the respective null hypothesis at the 5% and 1% significance levels, respectively

Table 13.2 Panel cointegration tests: Kao test and Pedroni test

Method		Statistic
Kao residual cointegration test	ADF stat	−5.80***
Pedroni residual cointegration test	Panel v-Statistic	−0.65
	Panel rho-Statistic	−0.82
	Panel PP-Statistic	−5.53***
	Panel ADF-Statistic	−4.92***
	Group rho-Statistic	0.56
	Group PP-Statistic	−5.00***
	Group ADF-Statistic	−5.15***

Notes: 1. Trend assumption: no deterministic trend; Null Hypothesis: no cointegration
2. Newey–West automatic bandwidth selection and Bartlett kernel
** Denotes statistical significance at 1% level ** Denotes statistical significance at 5% level

Table 13.3 Long-run estimates (FMOLS and DOLS)

	FMOLS	DOLS
Crop_Yields_los		
Min_temp	−0.29***	−0.31***
Max_temp	0.32***	0.20***
Cum_ rain	−0.94**	−0.92**

Notes: *, **, and *** represent the 10%, 5% and 1% significance, respectively

losses, with a 1% increase in minimum temperature leading to a 0.29% decrease in yield losses (i.e., an overall increase in crop yields). Precipitation also has a statistically significant effect on yield losses. In the Mediterranean Basin, the cumulative rainfall for a full year often depends mostly on precipitation in the autumn, winter, and early spring period. Indeed, rainfall between September and March in Mediterranean countries has historically played a very important role in crop yields, because the demand for water for cereal crops is high during this period (Pozo et al. 2019).

13.4.2.4 Extrapolations and Forecasts

Global-level climate modeling has allowed researchers in the field of agricultural production to consider multiple scenarios for projecting the effect of climate change on crop yields (Flato et al. 2013), and recent studies have incorporated these future climate scenarios into crop-simulation models at the regional level (Dixit et al. 2018; Zhang et al. 2019). Our empirical work therefore sought to assess the impact of climate change on the productivity of agricultural land, and the results are presented in the following table (Table 13.4):

The crop yields in the different regions are greatly affected by rainfall levels, a general increase in temperature, and a scarcity of water resources. With droughts

Table 13.4 Crop yields losses projection with different scenarios

	Scenario RCP 4.5		Scenario RCP 8.5	
	2050	2100	2050	2100
North region				
Jendouba	−50.12	−7.03	93.36	179.61
Beja	−28.57	4.91	43.10	110.14
Bizerte	−24.37	−5.98	36.78	153.05
Tunis	−12.62	17.05	38.19	84.9
Central region				
Monastir	10.19	13.62	30.50	71.17
Kasserine	−14.35	1.69	26.12	69.58
Sfax	9.98	14.02	14.01	41.96
South region				
Gabes	7.12	9.49	11.05	33.07
Gafsa	−4.58	7.91	6.35	37.55
Medenine	9.84	13.81	9.9	37.45

A loss with a sign (−) and (+) denotes an increase and a decrease in crop yield, respectively

expected to become more frequent by 2050/2100, agricultural activity may well be threatened, especially in the center and south of the country.

The projected results for crop yield losses suggest that climate change will cause a worsening financial situation for farmers, especially in the central and southern regions of Tunisia, due to crop yield losses of more than 7 quintals/hectare. In the northern regions, the projections are less dire because crops there will be less affected by climate change, especially under the RCP 4.5 scenario until 2050. However, the effect of the predicted future climate on crop yields is more severe under the RCP 8.5 scenario for all regions, with even the northern regions being greatly impacted.

The scenarios adopted lead to increasingly high temperatures and a water deficit for the main regions of Tunisia. It result in severe crop yields losses in accordance with the results of previous work for both developed and developing countries (Lesk et al. 2016; Fischer et al. 2014).

In addition, the adaptive capacity of the various regions of Tunisia makes it possible to mitigate the economic and social impacts of climate change. Subscribing to index crop insurance helps offset the risk of financial loss to which farmers in different parts of the country are subject in the future. Insurance is the most effective way to mitigate the damage caused by climate change to the economic system. The public authorities in the regions should implement a policy of interest to the farmers in order to encourage and induce them to take out crop insurance. Our results provide a better understanding of the extent of the climate change phenomenon and its implications in terms of public policies and the development of national mitigation plans.

Taking into account the main challenges facing the food and agriculture sector at the national level, the government should take into account the macroeconomic consequences of climate change. Climate change tends to increase the crop yield losses due to existing practices and by seeing consequences in reducing agricultural production at the national level and increasing prices. In turn, consumers replace increasingly expensive domestic products with imported ones. Through international trade, the risk of a worsening balance of payments increases.

13.4.2.5 Insurance as Way to Adapt to Climate Change

The agricultural sector is relatively sensitive to climate change, so it will almost certainly be greatly affected by it. For Tunisia, one of the greatest dangers of climate change is increased levels of drought, because this will harm food production and consequently affect the incomes of farmers. Concrete and immediate actions to adapt to climate change are therefore a necessary and urgent concern. Farmers should employ a variety of appropriate approaches for mitigating the effects of climate change, starting with modifying their technical practices. They could, for example, switch crop varieties to more hardy ones that are less sensitive to a drop in rainfall. In addition, they could employ risk prevention and management tools, such as crop insurance, which are playing an increasingly important role in adapting to climate change.

The types of insurance policy available are important for encouraging farmers to take out agricultural insurance. Index insurance has huge potential benefits, for example, but it can be very difficult to implement. What is more, smallholders often do not understand the benefits that insurance can bring them, and all too often, it will be unaffordable for them. The cost of premiums, especially when scaling up a program, can be daunting, and such high premiums can make index insurance unaffordable for those who need it the most. Subsidizing index insurance policies may therefore be a suitable option (Gómez-Limón 2020).

A compensation fund created in 2018 aimed to compensate farmers for any agricultural damage resulting from natural events. The fund is based on an index compensation system that considers the insurable area and the nature and severity of the climatic event. It provides compensation for agricultural damage resulting from events such as floods, storms, winds, droughts, snow, and frost. Farmers are compensated at a rate of 60% in return for a membership fee, which is set at 2.5% of the actual or estimated value, depending on their preference, of their crop yields. The premium paid by farmers is therefore calculated by multiplying the premium rate by the expected crop yield for the coming year.

Insurance allows farmers to protect themselves financially from extreme climatic events affecting their crops, so it presents a way to manage the risks brought about by climate change. Through insurance, the burden of restoring lost income due to climatic events is shared with the government and other participants in the compensation fund.[2] Insurance theory of course anticipates that the premium

[2] The Agricultural Damage Compensation Fund began operating on October 28, 2019.

will increase as the risks from climate change increase (Butler 2020; Kaufman and Roston 2020).

The projections made based on the cointegration relationship for yield losses reveal that there will be a significant increase in crop losses. Climatic disasters are infrequent, however, and this makes it hard for insurance companies to accurately determine the level of risk. Higher premiums will therefore be a likely consequence of the increased uncertainty facing insurance companies.

Without government intervention, the potential long-term dangers will result in higher insurance premiums and possibly even the withdrawal of insurance companies from this market. The insurance system will therefore be uncertain in terms of its viability and efficiency, but the introduction of public-sector insurance would make it possible to overcome the shortcomings of the free market in providing cover for extreme climatic risks. In some countries, agricultural insurance is subsidized by governments through national production protection programs. The United States, in particular, is taking targeted action through the Federal Crop Insurance Program. France, meanwhile, has set up the National Fund for Risk Management in Agriculture (FNGRA)[3] in order to promote the financing of mechanisms for managing climatic and environmental hazards in the agricultural sector. In Morocco, the Fund against Catastrophic Events (FSEC)[4] compensates victims of catastrophic events who are not covered, and it also tops up compensation for those who are not indemnified to the same level as the fund provides for. In Italy, on the other hand, the absence of a state-supported insurance system and the limited availability of private insurance makes it fairly inevitable that the state will need to compensate any farmers who affected by natural disasters.

13.5 Conclusion

The cointegration model estimation for the panel data allowed us to identify regional disparities in the effects of climate change on the productivity of agricultural land. These results, when related to climate change scenarios, should help farmers to better adapt and plan for the possible risks, such as by taking out crop insurance. In Tunisia, an increase in temperatures combined with a decrease in rainfall in recent years has led to fires that have affected crops, with knock-on consequences for farmers' incomes, the environment, and biodiversity. In the future, such phenomena could become more frequent, possibly causing some farmers to abandon agricultural production altogether.

The projections, which are based on the RCP 4.5 and RCP 8.5 scenarios, reveal an elevated risk of crop yield losses, especially in some higher risk regions. In the

[3] This fund was established by law no. 64-706 of July 10, 1964 codified in articles L. 361-1 et seq. The rural and maritime fishing code is managed by the Caisse centrale de réassurance (CCR).

[4] The implementation date of this fund corresponds to 2020.

agricultural areas of Tunisia, crop yields could decrease by 2050/2100 if nothing is done, according to the RCP 8.5 scenario. These projections were made by combining the results of the panel data estimates and the simulations of two climate change scenarios (i.e., RCP 4.5 and RCP 8.5). Although the RCP 4.5 and RCP 8.5 climate change scenarios show similar declining trends in yields through to 2100, we found this differed by region. The northeast and northwest regions, which are characterized by high cereal production, will suffer less from the negative effects of climate change under RCP 4.5, but the other regions will be severely affected.

This suggests that the demand for agricultural insurance in Tunisia could increase, because the future seems likely to be characterized by more frequent and severe climatic events. Mitigation and adaptation measures should therefore be taken to cope with the potential yield losses resulting from climate change. Given the risks faced by farmers, crop insurance presents a means for adapting to climate change by protecting against income fluctuations caused by variations in rainfall and temperature. Educating farmers about good practices for using water and raising agricultural productivity is another avenue to explore. While neither of these approaches will prevent episodes of drought, they will shield the agricultural sector from the worst of the resulting difficulties and the associated socioeconomic disruption.

These results are pioneering in terms of how insurance could be used as a means of adapting to climate change in Mediterranean regions, and they could be considered a useful resource for learning about the future effects of climate change on cereal production and how to cope with them. The public authorities should therefore take into account the results of this work when formulating their future plans for economic development. Indeed, these results could be retained as a reference point for evaluating the effectiveness of adaptation policies at the local level.

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Correction to: Has COVID-19 Pandemic Fear Affected Eurozone Stock Markets?

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Correction to:
Chapter 8 in: H. BEN AMEUR et al. (eds.), *Crises and Uncertainty in the Economy*, https://doi.org/10.1007/978-981-19-3296-0_8

The book was inadvertently published with an incorrect spelling of the author's name in Chapter 8 as Carmen GONZÁLEZ-VELASCOA whereas it should be Carmen GONZÁLEZ-VELASCO. The name has been updated throughout the book.

The updated version of the chapter can be found at
https://doi.org/10.1007/978-981-19-3296-0_8

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