

AN ECONOMETRIC ANALYSIS OF FINANCIAL MARKETS IN
EASTERN EUROPE: THE CASE OF POLAND

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by

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To my parents

AN ECONOMETRIC ANALYSIS OF FINANCIAL MARKETS IN EASTERN EUROPE: THE CASE OF POLAND

by Kalvinder K. Shields

ABSTRACT

In recent years, the economies of Eastern Europe have experienced a complete breakdown of their political and economic structures in the transition process. These changes have led to the emergence of a financial sector, the infrastructure of which has had to be established practically from scratch. In Poland, the most important non-bank financial sector, the Warsaw Stock Exchange (WSE), has played an essential role in the privatisation process and in providing an alternative source of finance and investment amongst firms and households. In this thesis, we provide an econometric analysis of asset returns on the WSE.

On the WSE, there exists a one-period censoring of asset returns moving beyond a pre-specified range introduced to limit speculative behaviour and volatility on the market. Our principal aim has been to incorporate such a feature into any analyses undertaken. Considering predictability, in an explicit intertemporal model of an investor's effective demand for a single asset facing a binding quantity constraint, we show that the market may *not* be predictable and return predictability on such constrained markets is non-trivial. Proposing an approach to model the predictability of returns, we find evidence of predictability of six main returns series on the WSE.

Considering the volatility of asset returns, we investigate whether the finding for developed stock markets that negative shocks entering the market lead to a larger return volatility than positive shocks of a similar magnitude also applies to two emerging Eastern European markets. Concentrating on the WSE and the Budapest Stock Exchange, we therefore also examine whether the findings differ depending on the exchanges' institutional microstructures. We propose an approach to model the conditional volatility of returns on a quantity constrained market such as the WSE and find no evidence of an asymmetric impact of news on the volatility of returns on either exchange.

Outline of Contents

Acknowledgements

1.	Introduction	6
2.	The Emergence of Financial Markets in Eastern Europe: The Case of Poland	13
3.	The Behaviour and Modelling of Returns on Emerging Financial Markets	54
4.	The Economics of Markets in Disequilibrium	85
5.	Predictability of Returns on the Warsaw Stock Exchange	135
6.	The Predictability of Conditional Second Moments of Returns on the Warsaw Stock Exchange	185
7.	Conclusion	218
	Bibliography	226

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Detailed Contents

Acknowledgements

1.	Introduction	6
1.1	Introduction	7
1.2	Main Contributions	9
1.3	Outline of Chapters	11
2.	The Emergence of Financial Markets in Eastern Europe: The Case of Poland	13
2.1	Introduction	14
2.2	The Emergence of Market-Based Economies	15
	2.2.1 <i>Failures of the Central Planning System</i>	16
	2.2.2 <i>Poland's Deepening Economic Crisis, 1970-1989</i>	18
	2.2.3 <i>Communist-led Reform Attempts and Failures</i>	20
	2.2.4 <i>Reforms of the Post-Communist Era; The Case of Poland</i>	25
2.3	The Emergence of Financial Markets in Eastern Europe: The Case of Poland	32
	2.3.1 <i>The Banking and Financial Sector, Pre-1989</i>	32
	2.3.2 <i>The Collapse of Central Banking and 1989 Financial Sector Reforms</i>	35
	2.3.3 <i>Performance and Importance of Stock Markets in Eastern Europe: The Case of Poland.</i>	39
2.4	Rules and Regulations on Two Eastern European Stock Markets	43
	2.4.1 <i>The Warsaw Stock Exchange</i>	44
	2.4.2 <i>The Budapest Stock Exchange</i>	50
2.5	Concluding comments	51

3.	The Behaviour and Modelling of Returns on Emerging Financial Markets	54
3.1	Introduction	55
3.2	Potential Role of Stock Markets	56
3.3	Characterising Emerging Markets	57
	3.3.1 <i>The CAPM applied to Emerging Markets</i>	58
	3.3.2 <i>Identification of Barriers to Integration</i>	63
	3.3.3 <i>Predictability of Stock Returns</i>	69
	3.3.4 <i>Volatility of Stock Returns</i>	81
3.4	Concluding Comments	83
 4.	 The Economics of Markets in Disequilibrium	 85
4.1	Introduction	86
4.2	Worked Illustrations of Price Setting on a Market with Quantity Constraints	87
4.3	The Concept of Equilibrium and Disequilibrium in Economics	91
	4.3.1 <i>An Equilibrium Approach to Explain Market Disequilibrium</i>	94
4.4	Effective Demand Determination in a Disequilibrium Market	96
	4.4.1 <i>Disequilibrium Trading on a Single Market</i>	98
	4.4.2 <i>Effective Demand Determination with Spillover Effects</i>	107
4.5	Investor Behaviour in a Market with Quantity Constraints and Spillover Effects	116
4.6	Predictability in a Market with Quantity Constraints	121
	4.6.1 <i>Definitions of Market Efficiency and Non-Predictability</i>	121
	4.6.2 <i>A Model of a Disequilibrium Trading System</i>	125
4.7	Concluding Comments	130

5.	Predictability of Returns on the Warsaw Stock Exchange	135
5.1	Introduction	136
5.2	Data and Sample Characteristics	136
	5.2.1 <i>Description of the Data</i>	137
	5.2.2 <i>Summary Statistics and the Distribution of Returns</i>	142
	5.2.3 <i>An Empirical and Simulation Analysis of Autocorrelation</i>	150
	5.2.4 <i>Calendar Effects</i>	161
5.3	Critical Value Generation and Stationarity Tests for Price Series on the Warsaw Stock Exchange	162
5.4	Predictability of Returns on the Warsaw Stock Exchange	168
	5.4.1 <i>Three Simple Predictability Tests</i>	169
	5.4.2 <i>Investigation in the Size and Power of the Predictability Tests: A Simulation Analysis</i>	171
	5.4.3 <i>Non-Parametric Corrected Tests of Predictability</i>	175
	5.4.4 <i>Testing predictability of the Warsaw Stock Exchange</i>	179
5.5	Concluding Comments	181
6.	The Predictability of Conditional Second Moments of Returns on the Warsaw Stock Exchange	185
6.1	Introduction	186
6.2	Model Specification and Estimation	188
	6.2.1 <i>Models of Predictable Volatility</i>	189
	6.2.2 <i>Model Estimation</i>	194
	6.2.3 <i>Misspecification Tests</i>	195
6.3	Modified Models of Predictable Volatility	196
	6.3.1 <i>Misspecification Tests</i>	198
6.4	Estimation and Hypothesis Testing	202
6.5	A Modified Partially Non-Parametric Conditional Volatility Model	208
6.6	Volatility Models for a Developed Exchange with Quantity Constraints	210
6.6	Concluding Comments	212
7.	Conclusions	218
	Bibliography	226

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CHAPTER 1

INTRODUCTION

Summary

In this chapter the background and motivation for the work undertaken in this thesis are discussed. The principal contributions made by this study are then highlighted. The final section of this chapter concludes by outlining the remaining chapters in this thesis.

1.1 Introduction

The countries of Eastern Europe are currently in the process of transforming their centrally planned economies into modern market systems with the aim of achieving the capitalism of the sort already existing in the market-based economies of Western Europe. Having adopted Soviet-type central planning systems in the late 1940s, by the late 1980s, economic and political 'reform' had become the universal objective of almost all Eastern European leaderships. Poland and Hungary, in particular, have recently led the way undertaking price and trade liberalisations, as well as macroeconomic and financial stabilisation of unprecedented magnitudes, in order to eliminate the command imposed system. Although many of the crucial economic reforms have been or are in the process of being implemented, the economies of Eastern Europe still face a unique set of policy problems which will determine the rate of growth and the pace of integration with Western Europe.

One crucial requirement has been the need to ensure that financial systems efficiently direct household savings to their most efficient uses. It is well known, however, that commercial banks in the Eastern European countries in transition have been financially weak, state-owned institutions, whose growths are stunted due to the legacy of bad loans inherited from discredited political regimes. Therefore, the challenge has been to find the appropriate policies to transform these economies and place them on the path to a good equilibrium consisting of a healthy financial sector linked with a strong, vibrant, stimulated real sector. This has meant that, in economies still dominated by the central planning legacy, the appropriate infrastructure underlying a modern financial system and efficient financial intermediation has needed to be constructed virtually from scratch. Given the impediments to the development of the banking sector in these countries, there still remain some serious and substantial problems - especially regarding banks in playing a major role in providing finance to firms for investment purposes. However, at the same time, there has been a simultaneous need to create financial instruments and institutions to meet the demand for risk capital in the reform process. Consequently, it becomes important to take a closer look at the non-bank financial sector, i.e. capital markets in their role of mobilising and channelling long-term capital to firms.

In this thesis we examine the case of the stock market in Poland. This is because, in terms of the period of adoption of the central planning system, geographical location and economic and political structures and histories, Poland can be considered to be representative of an

Eastern European economy. Furthermore, since Poland was one of the first economies to lead the way in fully embracing the transition to a market economy in 1989, valuable lessons from its experiences can be learned. Poland has not essentially differed from other Eastern European transition economies in terms of macroeconomic shocks to industrial output, price increases and interest rates encountered and has shared experiences in the histories and development of the financial systems and practices.¹ Therefore, since the Warsaw Stock Exchange (WSE) in Poland was one of the first stock exchanges to (re-)open after 1989, it can be seen as characteristic of an Eastern Europe emerging stock market and hence its lessons would be extremely useful for other transition economies as well as infant markets. At various points in the thesis, we also make comparisons and draw from experiences with Hungary since, although Poland and Hungary have much to differentiate them, for instance, Hungary undertook a gradual approach to transition, they also share a number of central characteristics.

As in more developed economies, the stock markets of emerging economies play vital roles in setting prices for capital, constituting markets for new share issues and providing secondary markets which facilitate the transfer of assets. Emerging stock markets also fill critical niches by providing mechanisms for the sale of state-owned enterprises and by linking domestic capital markets to broader international capital markets. In fact, one of the key elements in Poland's transition towards a market economy has been the success of its privatisation programme where stock markets are seen to have a significant role by determining market values of privatised companies on a continual basis. This procedure therefore facilitates the valuation of newly privatised companies and consequently, the stock market and the accompanying capital market infrastructure become indispensable to the success of the programme stimulating further interest in the capital market. In the case of Poland, despite the fact that the stock market is emerging, it has still played a vital role in the transition to a market economy and has matured to an extent that it can be considered to serve as an alternative source of finance. Not only is the stock market essential to the privatisation process, it has proved particularly important amongst households facing a lack of attractive alternative investment opportunities after prices were liberalised. Further, the stock market has been vital for firms seeking a source of finance in an economy in an increasingly competitive business environment and an undeveloped banking sector.

Finally, apart from the stock exchanges in Poland and Hungary being significant non-bank financial sectors in each of these countries, these Eastern European stock markets have also become important emerging markets on the world scale. Both have shown tremendous growth

¹ See Hussain and Nivorozhkin (1997), Pescetto (1992), Thorne (1993), Wihlborg (1995) and Hussain (1997).

since their establishment in the early 1990s and hence become attractive to foreign as well as domestic investors. Despite their significance and performance, withstanding a few studies, the stock markets of Eastern Europe have been relatively unresearched areas compared to the yet small but growing area of research on emerging financial markets.

A typical feature of emerging markets is their narrowness thus making them susceptible to large changes in asset prices. A feature introduced on the Warsaw Stock Exchange in order to decrease such volatility are constraints on the movement of returns of a share and therefore quantity constraints on the amount of share traded.² Hence, if the price of an asset moves beyond a pre-specified percentage change (10% on the WSE), the price is censored to 10% above or below the previous price depending on its direction of movement. Consequently, these limits have implications for the economic theory applying to such a quantity constrained system, as well as any econometric techniques applied which assume an underlying Normal or Gaussian distribution of returns. This thesis, in particular, attempts to take account of this institutional feature on the WSE in the theoretical and econometric analyses undertaken of asset returns on the exchange.

1.2 Main Contributions

There are a number of main contributions of this thesis, and underlying all of them is the special theoretical and econometric consideration of the particular institutional micro-structure on the WSE causing the distinct non-normality of asset returns. In early empirical work relating to price limits, the limits have been either ignored or the limit observations deleted (see Hodrick and Srivastava (1987) and McCurdy and Morgan (1987)).³ However, if there is a significant number of price limit moves, then the results of these actions, not only breaks down the dynamic structure of prices, but will significantly distort the underlying distribution of asset returns.

In this thesis, we apply a framework of disequilibrium economics to characterise in general the quantity constraints existing on a stock exchange with a 'disequilibrium' trading system such as that operating on the WSE.

Working within this framework, we analyse the predictability of a hypothetical market, with freely negotiated prices, on which there exists limits of one period returns which are in

² Similar constraints have been imposed on other stock exchanges such as on the Taiwan Stock Exchange in China, the exchange in Saudi Arabia, the French Stock Exchange, and the exchange in Lithuania, for instance.

excess of a pre-specified level. We show that the expected value of the return on an asset, conditional on information from the last period concerning a truncation, can be zero - and hence non-predictable in mean - if there is no intertemporal spillover effect on the market for that share. A simple simulation model is then proposed which applies the analysis of spillover effects resulting from quantity constraints. This analysis therefore has implications for quantity constrained trading systems.

In an empirical analysis of predictability of time series of returns on the WSE, we propose statistical predictability tests which take account of the limits on the exchange. Previous research testing efficiency on the WSE by Bolt and Milobedzki (1994) and Gordon and Rittenberg (1995) have not taken these institutionally imposed constraints into account in their analyses.

An attempt is also made to model the conditional volatility of stock returns on the WSE. Again, accounting for the imposed limits, we propose a model of conditional volatility which incorporates the censoring of returns in the data generating process. We present the corresponding log-likelihood function for estimation purposes, where although similar likelihood functions have been proposed (see Rosett and Nelson (1975) and Nakamura and Nakamura (1983)), in these studies, the context is non-dynamic where there is a constant unconditional variance (to capture volatility).

A second issue on modelling volatility is also the first study, as far as the author is aware, to compare the finding against Eastern European markets, that for developed stock markets, negative shocks entering the market lead to a larger return volatility than positive shocks of a similar magnitude. The WSE and the Budapest Stock Exchange (BSE) are considered where the first point of investigation is whether an analogous asymmetric characteristic is reflected in these emerging markets. The second point of investigation is whether the findings differ depending on the institutional microstructure of the exchange being examined given that the Warsaw Stock Exchange operates a quantity constrained system. Modified econometric techniques applied to the WSE and standard techniques applied to the BSE reveal that no asymmetry exists on either emerging market. However, further investigation implies that it does exist for a stock return series on a developed market also operating a quantity constrained system.

³ Ignoring price limits means that the observed market price is taken as if it was the equilibrium price in the event of a limit move whereas deleting price limits means that the limited prices are dropped from the sample.

1.3 Outline of Chapters

Chapter 2 provides a background to the establishment and development of the current stock exchange in Poland. The chapter is divided into three sections. Firstly, the emergence of market-based economies in Eastern Europe is described, highlighting the economic and political problems which led to the collapse of the central planning system operating in these countries. The particular focus is on Poland although experiences of Hungary are also considered in places to provide a point of comparison. Secondly, we consider the emergence of the financial sector in Poland where the emerging patterns of savings and investment are described before and after the 1989 reforms in Poland. Finally, we provide an overview of the development, regulations and operations of the Warsaw Stock Exchange and the Budapest Stock Exchange.

In chapter 3, given the area of interest is emerging financial markets, we provide a review of studies investigating the behaviour of stock returns on emerging stock markets.

Chapter 4 considers two main issues in a theoretical framework. In the first part, we show that the traditional ‘economics of equilibrium’ needs to be abandoned essentially because of the strong underlying assumption of market equilibrium no longer holds and we apply the disequilibrium framework introduced by Benassy (1982) to the market under consideration. We extend the single market setting to that of a multi-market, incorporating cross and intertemporal spillover effects, and note the appropriateness of such a framework to a market mechanism such as that existing on the WSE. Relying on ideas proposed by Benassy (1982) and Dreze (1975), we propose a more explicit model of traders’ behaviour on a market experiencing quantity constraints from which we are able to make inferences about asset predictability in such a market. In the second part, we propose a model of a disequilibrium trading system such as that existing on the WSE and analyse the predictability on the hypothetical market.

In chapter 5, the analysis is split into two main sections. In the first, we undertake a time series analysis of return series on the WSE paying particular attention to the limits censoring the movement of returns. In the second section, we propose an approach to model the predictability of returns for stock markets with disequilibrium trading. We present empirical test statistics based on the corrected Student- t statistic of a regression of returns of some information concerning the previous truncation. Finally, we apply the proposed predictability tests to six main time series of returns on the Warsaw Stock Exchange.

Chapter 6 investigates the whether the finding for developed stock markets that negative shocks entering the market lead to a larger return volatility than positive shocks of a similar magnitude also applies to two emerging Eastern European markets. The Warsaw Stock Exchange and the Budapest Stock Exchange are considered, where the first point of investigation is whether an analogous asymmetric characteristic is reflected in emerging markets. The second point of investigation is whether the findings differ depending on the institutional microstructure of the exchange being examined given that the Warsaw Stock Exchange operates a quantity constrained system. Hence, econometric techniques are modified accordingly and a 'Double-Censored Tobit GARCH' model is developed.

Finally, chapter 7 summarises the work contained in the thesis. Our main findings are then reviewed and some suggestions for future research are made.

CHAPTER 2

THE EMERGENCE OF FINANCIAL MARKETS IN EASTERN EUROPE: THE CASE OF POLAND

Summary

This chapter provides a background to the introduction and establishment of the current stock exchange in Poland, namely, the Warsaw Stock Exchange (WSE). The chapter is divided into three sections. Firstly, we describe the emergence of market-based economies in Eastern Europe, with particular focus on Poland. In doing so we briefly highlight the economic and political problems which led to the collapse of the central planning system operating in these countries. We also consider the experiences of Hungary in order to provide a point of comparison to those in Poland. Secondly, we consider the emergence of the financial sector in Poland. The emerging patterns of savings and investment are described before and after the 1989 reforms in Poland, and subsequently, the origins and role of the stock market. Finally, we provide an overview of the development, regulations and operations of the Warsaw Stock Exchange and the Budapest Stock Exchange.

2.1 Introduction

Having adopted Soviet-type central planning systems in the late 1940s, the countries of Eastern Europe are currently in the process of transforming their centrally planned economies into modern market systems. The aim has been to achieve the capitalism of the sort already existing in the market based economies of Western Europe. By the late 1980s, 'reform' had become the universal objective of almost all Eastern European leaderships. Poland, in order to accomplish this objective, undertook a rapid procedure whereby the transformation was initiated with price and exchange rate liberalisation followed by a sharp deflationary macroeconomic policy and swift privatisation. Changing the behaviour of production enterprises in goods and labour markets is one requirement of the transition process. However, equally crucial, is the need to ensure that financial systems efficiently direct household savings to their most efficient uses. In economies still dominated by the central planning legacy, the transition process has meant that infrastructure underlying a modern financial system and efficient financial intermediation has needed to be constructed practically from scratch. Therefore, in the transition economies of Eastern Europe (for example, Poland, Hungary and the Czech Republic), the impediments to the development of banks as lenders has led to the consideration of non-bank sources of finance, for instance, financial markets. In this chapter, we provide a background to the establishment of the current stock exchange in Poland, namely, the Warsaw Stock Exchange (WSE) in the following three sections.

Firstly, in section 2.2, we describe the emergence of market-based economies in Eastern Europe, briefly highlighting the problems causing the eventual collapse of the central planning system operating in these countries with particular focus on Poland. This coverage starting with the background is vital, especially given that the experiences of these economies, although being gradually transformed to market economies, are very much different to those of the familiar market-type economics. Furthermore, it is useful to appreciate the legacy of the central planning system in order to acknowledge, (i) the reasoning behind the reform procedures adopted, (ii) the scale and scope of the difficulties faced, and (iii) the accomplishments achieved with regard to the transformation from a centrally planned economy to a market economy. The focus throughout the thesis is on Poland, since in terms of the period of adoption of the central planning system, geographical location and economic and political structures and histories, it can be considered in some ways to be a representative Eastern European economy. Furthermore, since Poland was one of the first economies to lead

the way in fully embracing the transition to a market economy in 1989, valuable lessons from its experiences can be learned. However, at various points in the thesis, we also make comparisons and draw from experiences with Hungary since, although they have much to differentiate them as will be discussed, they also share a number of central characteristics. For instance, culturally, both were part of the Austrian Empire until World War I. Politically, both attempted to break free from Soviet domination and the central planning system of operation, and both are committed to democratic principles (at least more so than their eastern and southern neighbours). Moreover, as in other middle income countries such as Brazil, Mexico or Israel, having benefited from long periods of growth and relative stability in the past, they both experienced severe structural crisis in the 1970s and 1980s and undertook modest attempts at reform.

In section 2.3, we consider the emergence of the financial sector in Poland. Although, the main concern of this thesis is the Warsaw Stock Exchange, the emergence of the financial sector is described from a general viewpoint first where the emerging patterns of savings and investment are considered and hence the origins and role of the stock market. Consequently, any proceeding investigations and possible policy implications can be placed in the context of the rapidly changing underlying political, economic and financial culture.

Section 2.4 finally provides an overview of the development, regulations and operations of the Warsaw Stock Exchange and also very briefly, the Budapest Stock Exchange in Hungary (for comparison purposes in later analyses).

2.2 The Emergence of Market-Based Economies

The following section 2.2.1 commences by outlining the reasons causing the breakdown of the central planning system. The resulting economic situation, namely, the increasingly disappointing economic performance and creeping stagnation of the years in Poland up to 1989 is described in section 2.2.2. Subsequently, the various reform attempts, albeit unsuccessful ones, which were carried out in Poland in the 1980s in an effort to improve economic performance are summarised in section 2.2.3. It becomes evident that the socialist framework, i.e. the overwhelming predominance of state ownership and a commitment to stability and security for the population, increasingly appeared as the most fundamental barrier to an improvement in performance. By 1989, the only reason for ideas for changing the economic system within the framework of reform to socialism was that nothing more radical

was likely to find acceptance from the political authorities. After the overthrow of Communist power in 1989, a completely new framework could be adopted, and thus the 1989 reform measures for the transformation of the centrally planned economy to a market economy and the ensuing economic situation in Poland (and Hungary) are considered in section 2.2.4.

2.2.1 Failures of the Central Planning System

The failures of the central planning system were substantial enough to be abandoned completely in Eastern European countries such as Poland and Hungary. To its credit, however, the complex and highly centralised system did have some achievements. For instance, before the 1980s, full employment was maintained and prices were almost completely stable, resources were mobilised and savings and investment rates increased. Hungary and Poland underwent rapid industrialisation achieving high growth rates of production, especially in the industrial sectors, which were accompanied by slower, although still quite significant, improvements in the general living standards. Hence, it was possible for outside observers to perhaps be impressed by the performance of central planning. However, there were problems inherent in such a system, and to such an extent that they have led to efforts towards the complete relinquishment of the system in the majority of the countries in (Central as well as) Eastern Europe. In this section, we consider the systematic problems which were faced by the centrally planned economies in general (not only in Poland) and their consequences with the main focus being on Poland and to a lesser extent, Hungary, both countries having committed themselves to transformation at approximately similar times.

The problems intrinsic to the central planning system include those relating to objectives, organisation, co-ordination, efficiency and incentive. For instance, objectives are set by the state rather than by consumers resulting in tendencies to favour industrialisation and military expenditure over private consumption. Hence, the inconsistency between state and consumer preferences could be congenial to social unrest. In addition, the system requires a cumbersome bureaucratic organisation in order to convey information from the central agency to the individual production units. However, this framework clearly encourages corruption, misinformation and inefficiencies - at the least because so many resources get tied up in unproductive rent-seeking activity. Co-ordination problems arise because of the requirement to ensure that the plans for individual sectors or industries are consistent. Therefore, when there are inconsistencies between sectoral demand and supply occur, adjustments are made through variations in planned output rather than in prices, but the quick resolution to

imbalances is hampered by the inept bureaucratic organisational structure. This method of adjustment, however, also caused interference with investment plans which were curtailed or disrupted by the demands of short-terms balance with scarce resources being allocated to specific shortages as they arose. Moreover, the failure to use the price mechanism to indicate relative scarcities has additional implications for economic efficiency.¹ Economic efficiency was further hindered when, in the achievement of these social objectives, it would seem that priority was to be given to objectives that unfortunately conflicted and consequently disrupted the longer term plans.

As a result of these characteristics, a number of severe economic problems arose which eventually have led to the overthrow of communism. These can be grouped into the following categories (most of which apply to the whole region of Eastern Europe):

- (i) poor investment decisions, slow productivity growth;
- (ii) persistent shortage, poor quality of output;
- (iii) unfavourable international comparisons, for instance, the increasing awareness of Western living standards;
- (iv) failure of partial reforms and other 'conservative' (or communist-led) strategies to improve performance.

With regard to the first category, although Eastern Europe experienced favourable growth in the 1950s and 1960s, much of this was due to huge increases in the main factor inputs. For instance, the supply of capital grew extremely quickly during this time as a result of the very large imposed increases in the savings rate in the early 1950s, and even when the savings rate fell somewhat, capital continued to expand rapidly. The effective labour supply, in particular in the industrial sectors, also rose sharply due to a massive increase in female employment. Consequently, although rates of growth output were impressive during this time - yet not surprising – measurements of total factor productivity showed very little increase. Hence, sooner or later a slowdown in growth was expected once the inputs became exhausted and both Poland and Hungary had begun to experience slower growth by the 1970s. In addition, the co-ordination and increasing evidence suggested that under the central planning system the investment process itself was highly inefficient. These inefficiencies arose mainly because of two reasons. Firstly, because of attempts to sustain excessive rates of investment by central

¹ For instance, the minimal adjustment by many Eastern European economies to the rising price of world oil in the 1970s subsequently led to the inadequate energy conservation that followed.

planners, capacities in many manufacturing sectors became overstrained and the resulting investment costs were too high. Secondly, as well as improving too many projects, there was a tendency for the central planners in Hungary and Poland to approve projects which were inappropriate for their economies. For example, projects in Hungary and Poland, for example, were approved based on the Soviet model of development where investment in heavy manufacturing was favoured above other sectors despite being small trade-dependent economies. Consequently, trade for these countries became even more essential.

Persistent excess demands both in markets for intermediate and consumer goods also became widespread at the same time leading to conditions of shortage. One consequence of this was that firms had no problems in selling their output and thus there was no need to make any efforts in marketing. This took away any incentives to improve product quality and as a result, firms were able to sell poor quality output. Another aspect of the shortage problem was that firms, in dealing with the problem of securing inputs, invested in behaviour to protect themselves such as in-house production of components and informal trades between firms. Neither of these problems could be solved through competitive entry of new firms since even the entry and exit of small firms was under strict control.

Gradually, by the 1970s, the performance of the Eastern European countries looked increasingly weak against international comparisons, and in the early 1980s, the countries were affected negatively by foreign economic trends, (see Davis and Charemza (1989)). For instance, the hard-currency debt accumulated in the 1970s became increasingly difficult to service because of increasing real interest rates, uncompetitive products and the recession in the OECD region led to poor performance in the export market, and there was a credit squeeze by Western institutions reflecting both the world debt crisis and a re-evaluation of country risk in the socialist bloc (see Vanous (1985), Balassa and Tyson (1985)). These problems, some having been recognised at least since the 1960s prompted somewhat hesitant policy responses in these countries in the late 1970s from modest efforts to improve central planning and to more decentralised approaches. We consider Poland's deepening economic crisis and the corresponding reform attempts and failures during 1970-89 in what follows.

2.2.2 Poland's Deepening Economic Crisis, 1970-1989²

² For a comprehensive account of Poland in the twentieth century, see Korbonski, (1992), Lipton and Sachs (1990), Sachs (1993) and Rostowski (1989).

Even though there was a steady growth in the agricultural and production sectors in the 1950s and 1960s in Poland, by the 1970s, these limited sources of growth were clearly being exhausted.³ In response to this situation, the government undertook a modernisation strategy which, in the main, involved the importation of new capital equipment and technology - hence firmly operating within the socialist framework. In order to achieve this aim, Poland undertook a huge amount of borrowing, between 1970 and 1977, from Western governments and banks of approximately the amount \$20 billion. Hungary, having seen the failure of their relatively more radical reform attempts, also sought to buy its way out of trouble by accepting very large hard currency loans from the West. The objective of both countries was to engineer an investment boom which would eventually translate into hard currency exports and therefore repay the loans. However, somewhat surprisingly, very little increase in exports was actually achieved, consequently, the heavy borrowing could not be repaid and Poland and Hungary succumbed to a severe debt scenario.⁴ A deep balance of payment crisis ensued, with the current account peaking at almost 10 percent of GDP in 1975, and external debt reaching 40 percent of GDP by the end of the 1970s. The situation was exacerbated by the simultaneous decline in East Europe's terms-of-trade with the USSR due to the lagged impact of the 1979-80 rise in the world price of oil (on intra-CMEA transferable rouble prices). In response, there were uniform attempts to promote exports and reduce domestic demand. Moreover, imports from the West (and therefore imported raw materials and consumer goods) were also cut back sharply due to the draining of foreign capital, resulting in the volume of imports falling by more than 50 percent between 1979 and 1982. However, as a result of the external disturbances and domestic policies stimulating significant disequilibrium in the East European markets, there were increased shortages in the retail sector and a decline in the standard of living as well as economic performance indicators. Hence, as Poland's economy plunged into a deeper recession, its debt to the Western economies grew, from about \$28 billion in 1978 to approximately \$45 billion in 1991.⁵

Between these crisis years, which also saw the birth of Solidarity, it was clearly evident that sustained growth would not be attainable, and it became impossible to maintain the standard of living that had been supported by borrowing.⁶

³The growth of production in these sectors was based upon large-scale investment in heavy industry and the absorption of labour from the rural sector.

⁴ Essentially, the poor choice of projects and the world recession around 1980 following the second oil price shock caused the failure of the scheme.

⁵ See Fallenbuch (1986), Kazmer (1986) and Beksiak (1987) for a more detailed exposition of the debt crisis in Poland and Eastern European economies.

⁶ The birth of Solidarity in 1980, although had substantial political success in 1980 and 1981, it was however demolished by martial law at the end of 1981.

2.2.3 Communist-led Reform Attempts and Failures in the 1980s

Throughout the 1980s, the Polish communist regime made several attempts to undertake modest economic reforms.⁷ The main objective of these reforms was to decentralise economic activity, mainly through enterprise reform, the intention being to give a greater degree of freedom to state enterprises to set wages, inputs and outputs. In an attempt to alleviate the balance of payments crisis, the Polish government endeavoured to decentralise certain aspects of economic decision-making in two stages of partial reform; the first in 1981-82 and the second in 1987-88. However, the harsh reform measures imposed in 1982, under the cover of martial law, further caused real wages and per capita consumption to fall sharply to approximately 15 percent below the 1978 levels, and consumption and production levels were not restored until 1988, according to the official statistics.⁸

In comparison, Hungary had begun to discuss economic reform in the mid-1960s resulting in a program called the 'New Economic Mechanism' (NEM) announced in 1969, also attempting to decentralise decision-making in the Hungarian command economy.⁹ However, it soon became apparent that the NEM would not be implemented as originally intended and in fact, state control of the economy actually increased. For instance, taxes and subsidies were introduced to protect the Hungarian economy from world market forces, which was contrary to the original design of the NEM. Hence, the net result was an economy facing typical problems in the 1980s, such as worsening economic performance and a growing debt. Despite attempts to overcome these problems through the introduction of a stabilisation program¹⁰ and membership of the International Monetary Fund in the 1980s, the persistence of Soviet-type controls still left the economy with a wide range of unresolved economic problems at the end of the 1980s.

Tables 2.1a – b present statistics illustrating the economic difficulties experienced in the Polish and Hungarian economies during the 1980s.

⁷ For an in depth account of Poland's economic experience in the 1980s, see Fallenbuchl (1989) and Kaminski (1989).

⁸ From his analysis of official statistics, Fallenbuchl (1985, 1989, p.125) reports that actual performance was far worse than actually reported.

⁹ The program basically sought to combine traditional state control of the major sectors of economic activity with increasing reliance on market forces to aid decision-making. The proposed changes included a reduction in the number of compulsory targets, profits as a source of financing, direct negotiation in foreign trade by firms and even some price flexibility to allow changes in foreign prices to influence domestic Hungarian prices.

¹⁰ For instance, controls to limit imports and expand exports, wage limits to constrain the growth of consumption etc.

Table 2.1a: The Polish Economy: The 1980s

	Average Annual Rate of Growth							
	1971-80	1981-85	1987	1988	1989	1990	1991	1992
Real GDP	3.6	0.6	-1.5	2.3	-1.06	-9.6	-7.6	-1.5
Real GDP*	2.6	-0.3	-2.0	2.0	-2.0	-9.8	-8.1	-1.7
CPI**	-	-	575	938	3325	-	-	-

Notes: '*' refers to Real Gross Domestic Product per Capita; '**' denotes the Consumer Price Index, (1980=100).

Sources: Directorate of Intelligence, *Handbook of International Statistics 1992* (Washington, D.C: CIA, 1992), Table 13; *Handbook of International Statistics 1993*, Tables 8 and 9.

Table 2.1b: The Hungarian Economy: The 1980s

	Average Annual Rate of Growth							
	1971-80	1981-85	1987	1988	1989	1990	1991	1992
Real GDP	2.7	0.3	1.5	1.5	-2.3	-6.8	-6.8	-7.8
Real GDP*	2.1	0.9	1.8	3.5	-2.1	-6.8	-5.9	-7.8
CPI**	-	-	164	184	240	-	-	-

Notes: '*' refers to Real Gross Domestic Product per Capita; '**' denotes the Consumer Price Index, (1980=100).

Sources: Directorate of Intelligence, *Handbook of International Statistics 1992* (Washington, D.C: CIA, 1992), Table 13; *Handbook of International Statistics 1993*, Tables 8 and 9.

Table 2.1a shows the growth in output in Poland experiencing serious fluctuations after secular declines in earlier years. During these years, the volume of industrial employment fell by approximately 20%, inflation was an extremely serious problem and the Polish hard-currency debt roughly doubled during the decade. In comparison, Hungary also shows a worsening economic situation in the 1980s in Table 2.1b. Again, inflationary pressures (although not as serious as those in Poland) and internal microeconomic imbalances troubled the economy coupled with a growing external hard-currency debt. Despite the debt being half the size of that in Poland, it nevertheless doubled in the 1980s. Therefore the economic difficulties in both countries paved the way for transition to market economies.

The reform measures in the 1980s did serve, however, to ease the eventual process of transformation to market economies. Nevertheless, they failed in their task of stimulating the economies, and only managed to achieve moderate success in the areas of investment decisions, wage setting, firm finance, and international trade. Despite measures to move towards a more decentralised decision making process, the main explanation as to why the reforms failed was basically because they failed to lead to the creation of real markets with real competition, and decentralisation in both countries was proved to be a poor substitute.

The reform procedures towards decentralisation undertaken in Poland and why they failed in the 1980s can be essentially summarised as follows.

Firstly, in 1982 many enterprises were released from compulsory participation in sectoral associations which had acted like cartels in their particular industries. However, subsequent to this, many enterprises in fact formed voluntary associations instead in order to retain informal linkages that guaranteed their market power. Additionally, enterprises were finally granted autonomy in 1987, but which again led to many unintended and undesirable consequences involving the abuse of state assets, where the state were forced into a position of obliging the practices due to the fear of unemployment.

Secondly, enterprises were gradually granted a greater amount of autonomy concerning their productive decisions and the moderate reduction of centrally planned investment meant that individual enterprises had more authority over their production and investment planning decisions as well as their execution. However, special practices also introduced in 1982, namely, operational programs and government contracts, which provided new alternative forms of central co-ordination of productive activity and the allocation of inputs implied that the government was still involved in approximately 80 percent of the sales of producer goods (see Balcerowicz (1989, p.44)). This continued involvement of the government in enterprise decisions reflected the scepticism and the lack of credibility on the behalf of the reformers themselves in the competitive market concept, the consequence of which was that decentralisation did not lead to functioning markets.¹¹

Thirdly, the privatisation of state enterprises was even not considered as one of the possible reform procedures, therefore not acknowledging the inefficiencies met due to the state ownership, - the simplest being that managers could quite easily distort enterprise behaviour

¹¹ For instance, free entry by firms was still discouraged, there were still restrictions on international trade, hence domestic producers faced a lack of real competition, and scarce resources and excess demand made it extremely difficult or even impossible for firms to operate or survive. Furthermore, the government was reluctant to shut down state enterprises in order to avoid the risk of lay-offs, given their lack of confidence in private sector activity.

to serve their own purposes, rather than represent the interest of capital, as would occur in a market economy system.

Fourthly, there was a relaxation of administrative controls over producer prices, although many prices were alternatively regulated on the basis of costs and subjected to government monitoring. Throughout the 1980s, in fact, the pricing system, instead of becoming more flexible, became increasingly subject to government interference and bureaucratic negotiation, and thus little advancement was made in the attempt to eliminate shortages in the economy.

Fifthly, efforts were also made to decentralise the wage-setting process so as to encourage efficiency in labour usage. However, somewhat predictably, this strategy backfired and the result was accelerating inflation where, in the interests of keeping peace amongst the work force, managers conceded to demands for increased wages.¹²

Finally, more power was given to individual enterprises to conduct international trade instead of exclusively relying on the few state enterprises that dominated international trade. In addition, the government pursued a policy, in 1985, of reducing the overvaluation of the zloty by depreciating the official exchange rate at a pace much quicker than the rate of inflation. But, as mentioned, this policy again failed to produce a fundamental improvement in export performance.¹³

In the case of Hungary, familiar problems were also met with the NEM. For instance, there were still political constraints and traditional political rigidities which imposed real limits on how much central power could be delegated to lower levels. Secondly, the problem of implementing economic reform within an existing economic structure, which was not often suited to a market environment, remained. And thirdly, political leaders often found unacceptable the goals and outcomes accompanying the implementation of the reform measures. For instance, mobility and unemployment would be likely if labour markets were to function, and inflation, if prices were freed. But these outcomes were considered to be unacceptable to the leaders of the planned economy.

In summary, the decentralisation reform efforts during the 1980s reflected governments' endeavours to deal with the problem of the soft budget constraint of enterprises, by making enterprises self-financing, thus infusing financial discipline.¹⁴ If the policies had been successful, then the ideal scenario would have seen profitability as the key performance

¹² Moreover, since in many cases managers were elected by directly by workers councils, the managers themselves had little incentive to oppose pressures for wage increases.

¹³ For a general discussion of enterprises in socialist economies and exports see Winiecki (1986a).

indicator for enterprises, and consequently, there would have been an improvement in the efficiency of management as well as product quality. Moreover, in the allocation of funds, the financial sector would now judge each enterprise according to its performance, and in the event of the enterprise not being viable, then it would face bankruptcy. However, in practice, very little of what was desired was actually achieved, and instead of decentralisation easing bureaucratic control, the outcome was actually an increase in bureaucratic bargaining, where direct control was now replaced by numerous policy instruments, - and even their method of usage was arbitrary and constantly fluctuating.¹⁵ Therefore, although the several attempts at reform in the preceding years had been made in an attempt to address the apparent inadequacies of the centrally planned regime, on the whole, these reform attempts merely served to exacerbate the difficulties that the economies were already experiencing.¹⁶

Nevertheless, one certain outcome was that there was evidence that decentralisation was a meagre proxy for real markets, and that there had to be a new approach to reform. Decentralisation had failed to instil discipline on enterprises analogous to that of market forces. The lack of provisions for free entry and exit, the hesitant confidence of the government in real competition, the absence of the restraint posed by capital markets on investment decisions and wage setting, and the lack of subjection to competition pressures from abroad, all contributed to the failure to stimulate the economy.¹⁷ The challenge facing reformers involved encountering difficulties seen to be typical of East European economies such as: severe shortages and a general weakness on the supply side of the economy; a 'soft budget constraint' both at the individual enterprise and the economy level; repressed inflation resulting in other forms of excess aggregate demand; hidden unemployment; and unproductive rent-seeking activity.

¹⁴ Soft budget constraints refer to the cheap credit, subsidies, tax breaks etc., that serve the purpose of cushioning enterprises from real competition, and also have led to imprudent investment, see Grosfeld (1987), Kornai (1980, 1989), and Winiecki (1986b).

¹⁵ For instance, the bankruptcy law introduced in 1983 in Poland only led to the liquidation of 11 state enterprises, and whereas in 1988, 140 enterprises were deemed to be non-viable, only 33 of the cases saw liquidation.

¹⁶ Further details on the nature of earlier reform attempts and the events leading to the economic crisis in the late 1980s can be found in Lane (1991) and Wolf (1991).

¹⁷ For a more thorough account of the conflict between the Marxist-Leninist ideological legitimacy and economic performance, see Dembinski (1991), where he concludes that the collapse of the central planned economy was an inevitable event, with previous reform attempts serving merely to delay the ultimate collapse of the system.

2.2.4 Reforms of the Post-Communist Era; The Case of Poland

On September 12th, 1989, the Solidarity-led government came into power, with its principal economic aim being to move to a market economy. At the time, money wage increases were out of control, there was a significant budget deficit rampant hyperinflation. The 1st of January 1990, signified the introduction and implementation of this radical reform program constructed under the authority of Deputy Prime Minister Leszek Balcerowicz, with the objective to end Poland's hyperinflation and create the legal, institutional and economic setting for a market economy.¹⁸

However, the path of reform to a market economy in Eastern Europe was certainly not a simplistic one. Since the ability to conduct successful reforms is constrained by the initial environment in which the economy is embedded, changes had to be made in the sub-systems that make up an economy. These included the decision-making structure of a system (i.e. who decides what); the information structure (i.e. what information is collected, by and to whom it is transmitted); and the motivation structure (i.e. how the economy's gains and losses are shared among its participants and how the prospects of these gains and losses affect their decisions). The approach undertaken in Poland was sudden and termed 'shock therapy' as opposed to the more 'gradualist approach' used by countries such as Hungary.¹⁹ The strategy chosen consisted of four main components: fiscal control and the elimination of the budget deficit, control of domestic credit expansion, limits to the growth of wages and the convertibility of the zloty. In addition, the program entailed a number of legislative and executive measures designed to remove any remnants of the previous economic system and build a legal and institutional foundation appropriate for a market economy. These measures included,

- (i) privatisation, to start the transformation of the ownership structure to eventually ensure a more efficient use of resources and maintain financial discipline beyond the short run;
- (ii) a competition policy, aimed to allow free entry and break and prevent monopoly power, and implement suitable bankruptcy procedures;

¹⁸ For more detailed discussions on the post-1989 reforms, see, for instance, Berg and Blanchard (1994), Bonin (1993), Sachs and Lipton (1990), Estrin and Richet (1993) and Gomulka (1992) to name but a few.

¹⁹ A 'shock therapy' refers to the rapid implementation of a set of specific set of transition policies. See van Brabant (1993) and Funke (1993) for a survey perspective on both approaches.

- (iii) modernisation of the banking system, which embodied an increase in the number of and range of financial institutions, and an improvement of the regulatory, accounting, and prudential environment; and
- (iv) tax reforms.

In contrast, transition in Hungary not only differed from Poland in that it was gradual, it also has not been based on a 'grand design', and it began earlier and under different circumstances compared to Poland.²⁰ The beginning of the transition in Hungary has been dated back to 1985 and since then a series of ongoing systematic policy changes have been taking place on a sequential and continually changing basis. Again, as in Poland, the changes have been in areas such as privatisation, macroeconomic and microeconomic policies. However, unlike in the Polish case, inflation in Hungary did not require immediate stabilisation measures and issues relating to foreign trade were of particular importance mainly because of the size of Hungary's hard-currency external debt.

However, there are huge obstacles that are encountered in the creation of any market economy. For instance, in the case of Poland, not only were there difficulties faced in carrying out fundamental social, political and economic changes, these changes at the time of their implementation were during a period of a deep and worsening economic crisis. Furthermore, the Eastern European economies are still overcoming pressures of the communist power structure throughout society, and additional problems such as the inexperience of managing a market economy, fragile political institutions, the re-emergence of historical enmities and in some cases, severely deep-rooted ethnic fissures.

One of the main problems facing many of the socialist countries, which has implications for the monetary and financial sector of the economy, was the problem of the so-called 'monetary overhang' (see Portes (1989)). A monetary overhang is defined as an excess stock of cash or savings deposits because the population has been 'forced' to save. There are basically two reasons why this occurs more so in socialist economies. The first reason is the excess demand and goods rationing which may prompt consumers as well as Eastern European firms to hold both a large volume of goods as well as cash (in order to be able to seize the chance to buy goods). The second reason is 'forced saving' reflecting the fact that consumers are not able to spend their disposable income on what they want. However, forced savings in these countries were considered to be only a temporary phenomena due to the

operation of thriving black markets, operating at market-clearing prices, for a range of products. Hence, households could always find goods on which to spend 'excess savings'. However, at the macroeconomic level, the underlying cause of the monetary overhang is a mismatch between wages and the amount of goods available at the state-controlled price level. In many socialist economies, the sum of all wages exceeded the available supply of goods at the price level fixed by the government. Therefore, trade between households does not affect the aggregate equilibrium since the only way cash can go back to the government is through state-owned stores or savings accounts. Thus, at the aggregate level, households are 'forced' to save.²¹ The reason as to why this was seen as a serious obstacle was that, it was argued, after price liberalisation, consumers would spend all their accumulated excess cash balances and this would lead to a jump in the price level and then most likely inflation.²² Although it is difficult to assess the size of the monetary overhang in various Eastern European countries, it was the case that as growth stagnated in the 1980s, households were forced to keep their savings only because the queues got longer. Moreover, widespread rationing, the long queues and the large price differential between the official prices and black markets were certain indicators of a monetary overhang, although it was still extremely difficult to estimate the jump in the price level required to eliminate it. The disequilibrium particularly posed a serious problem at the point when price liberalisation was imminent since prices were expected to increase and consumers expected to queue until the marginal cost of standing in the queue was equal to the difference between the current price and expected future price. However, in the case of Poland, the sign of effective market-clearing prices was the end of the shortages which disappeared almost immediately after January 1990. In Hungary also, the supply of the market improved significantly.

Another problem which also exacerbated the reform process concerns the Eastern European data, which, for a number of reasons was, under the communist regime, extremely misleading, actively falsified, or simply just collected on an inadequate base, hence making it

²⁰ For further more detailed discussion comparing the experiences of Hungary and Poland, see Davis and Condon (1994), Newbery (1990), Hare (1991) and Kornai (1990), for example.

²¹ Note that they only do so if prices and expectations are that each household does so voluntarily. For instance, if households expect that the supply of goods will increase, then they will put part of their money into savings accounts for the goods. But if they expect shortages to increase, they will bid up prices on the black market to the point where they are indifferent, at the margin, between consuming black market goods or saving the money.

²² Although inflationary pressures did persist in most of the countries, they were not only due to price liberalisation and monetary overhang. In most Eastern European economies, they were due to lax financial policies, a lack of control over state-owned enterprises and an inefficient fiscal system.

difficult for policy makers to evaluate the exact state and nature of the existing economy.²³ For instance, Sachs (p.103, 1990), expresses the observation that with reference to Eastern European countries central planning appeared to be a good system for the economy as a whole in the 1950s and 1960s - but this was partly due to the upwardly biased growth statistics. For instance, whereas in a market economy, a fall in the real wage usually implies a drop in the living standards, by contrast, in a shortage economy, a similar scenario could simply imply the elimination of queues and thereby a rise in living standards.²⁴ Fischer, Sahay and Véhy (1996a) also note the problems of serious biases in the data of countries in transition and provide a discussion of sources and limitations of the data available. The authors argue that the prices before transition were not in line with both costs and world prices and often, goods were not available at those prices. Hence, the changing relative prices during the transition process and the movement of resources towards sectors whose prices have risen, causes output decline in base prices to be overstated relative to declines measured at world or new prices. Essentially, the measurement problems mainly arise from the fact that as state sector output falls and private sector output rises, an increasing share of output tends not to be recorded as a result of many still rudimentary statistical services. Data problems therefore not only pose a serious barrier to economic analysis, but also, in the course of stabilisation, policy-makers can face pressures to undertake apparently justified courses of action, that could undermine the stabilisation program itself. However, for further discussion of data inadequacies, see Fallenbuchl (1989, 1985), Alton (1989) and Fink and Havlik (1989).

Nevertheless, since the watershed year of 1989, the leading reformers of Eastern Europe have made substantial progress on the road to a market economy.²⁵ The output decline has stopped in the countries that have stabilised and growth has been resuming in most of them. Hence, fears of political hindrance, as in the past, to the reform process unless progress was rapid have been unfounded in most of the countries.²⁶ Tables 2.2 and 2.3 show annual output and

²³ As Fallenbuchl (1989) notes, double counting of inputs, inadequate depreciation allowances, inclusion of wasted materials etc. led to the over-estimation of the rate of growth.

²⁴ Janos Kornai has undertaken a thorough investigation of the role of shortages in the socialist economies and the implications of shortages for the transition strategy, whereby the shortage economy basically constituted the initial point for the transition to a market economy. For an unmitigated explanation and discussion, see Kornai (1980, 1982, 1986, 1989 and 1990b).

²⁵ There are numerous readings on the outcomes of the continuing reform program in Poland; see Myant (1993) for an excellent and detailed account and discussion of the pre and post-1989 reforms in Poland and other Eastern European countries and for transition progress in Central and Eastern Europe, see Fischer, Sahay and Véhy (1996a, 1998). Also, for a comparative discussion of the state of reforms up to 1988 in the various countries, see Vacic (1989) in addition to the readings already mentioned.

²⁶ See Aslund, Boone and Johnson (1996) who present a convincing case that reformers have done well in the polls.

inflation data, respectively, for three Eastern European countries, namely the Czech Republic, Hungary and Poland, which have much in common as a result of geographical location, level of socio-economic development and recent political history.²⁷

Table 2.2: Annual Output Growth in the Czech Republic, Hungary and Poland, 1989-1995

Country	1989	1990	1991	1992	1993	1994	1995
Czech Republic	1.4	-1.2	-14.2	-6.4	-0.9	2.6	4.8
Hungary	0.7	-3.5	-11.9	-3.0	-0.8	2.9	1.7
Poland	0.2	-11.6	-7.0	2.6	3.8	6.0	6.5

Notes: see notes to Table 2.4.

Table 2.3: Stabilisation Programs in the Czech Republic, Hungary and Poland, 1989-95

Country	Stabilisation Program Date	Exchange Regime Adopted	Pre-Program Inflation (12- month)
Czech Republic	January 1991	Fixed	45.5
Hungary	March 1990	Fixed	26.0
Poland	January 1990	Fixed	1096.1

Notes: Sources: National Authorities; International Monetary Fund; The World Bank; De Melo, Denizer and Gelb (1995).

Inflation is in the twelve months previous to the month of the stabilisation program.

See Fischer, Sahay, Végh (1996a, 1998) for further figures for countries in transition.

²⁷ In contrast to Poland and Hungary who made persistent (unsuccessful) attempts at economic reform pre-1989, in Czechoslovakia, the Husak regime (installed in the wake of the 1968 Warsaw Pact invasion of the country) remained militantly committed to the beliefs of the Marxist-Leninist ideology and to the bureaucratic-centralist model of economic management based on the Soviet system under Brezhnev.

Table 2.4: Annual Inflation in the Czech Republic, Hungary and Poland, 1989-95
(Period average)

Country	1989	1990	1991	1992	1993	1994	1995
Czech Republic	1.4	9.5	56.7	11.1	20.8	10.0	9.1
Hungary	16.9	29.2	34.2	23.0	22.5	18.8	28.2
Poland	251.1	600.0	76.4	43.0	35.3	32.2	27.8

Notes: Sources: National Authorities; International Monetary Fund; The World Bank; See Fischer, Sahay, Végh (1996a, 1998) for further figures for countries in transition and details on data definitions, sources and limitations.

Table 2.5: Inflation and Output Performance in the Czech Republic, Hungary and Poland, 1989-95

Country	Year in which Inflation was Highest	Max. Annual Inflation	Year in which Inflation fell below 50%	Annual Inflation in 1995	Year in which Output was Lowest	Cumulative Output Decline 1989=100	Cumulative Output Growth since Lowest Level
	(1)	(1)	(1) (2)	(1)	(3)	(3)	(4)
Czech Republic	1991	52.1	1992	7.5	1993	21.4	7.5
Hungary	1990	34.6	n.a.	28.5	1993	18.2	4.7
Poland	1989	639.6	1992	24.2	1991	17.8	20.2

Notes: Sources: National Authorities; International Monetary Fund; The World Bank;

(1) Inflation calculated from December to December.

(2) In Hungary's case, this criterion is not applicable because inflation was below 50% even before 1989.

(3) Output decline from 1989 to the year in which output was lowest. GDP is measured on an annual average basis.

(4) Lowest level refers to the lowest output level reached during 1989-95.

See Fischer, Sahay, Végh (1996a, 1998) for further figures for countries in transition.

The figures in Table 2.2 show that output declines during the transition process have been very large. Although the above figures are only the *reported* ones bearing in mind problems with measurement and reliability of the data causing probable exaggeration of the data, the output declines are still dramatic in the early 1990's. However, by 1995, it seems that the worst is over and Fischer, Sahay and Végh (1998) show that fourteen of the twenty-six economies in their sample of Central and Eastern Europe economies had begun to grow by 1995. In fact, output growth in most of these economies had begun as early as 1993-94, the average level of output in Eastern Europe having reached a minimum in 1993. Table 2.3 shows annual rates of inflation prior to the stabilisation program where it reached extremely high figures in the case of Poland. Inflation in Hungary, on the other hand, was by far the lowest amongst all Eastern Europe economies before transition, and even during the transition process, it only ever reached a high of 34.6 in 1990 (Table 2.5), being one of the few countries not to reach triple figures. Although inflation was initially high - for Poland in particular - as seen from Table 2.4 and 2.5, this was mainly at the early stages of transition where there was an initial jump in inflation associated with price liberalisation and devaluation.²⁸ However, in recent years inflation stabilisation has been succeeding with annual inflation down to approximately an average of 20% in Eastern Europe countries in 1995 (measured from December to December; see Table 3, p.8 in Fischer, Sahay, Végh (1998)).

In summary, Poland, being one of the most advanced Eastern European economies into the transition process, faces, as do the other economies, a unique set of policy problems which determine the rate of growth and durability of stabilisation. The previous complete breakdown of the political and economic structures of these economies, and currently the interplay across different sectors of structural and economic problems, makes the formulation of policies particularly daunting and the eventual outcomes a very slow process in most cases. At the same time, these countries become pioneers in facing the challenges of systematic transformation to the market and therefore from which valuable lessons can be learnt.

The following section goes on to review the emergence of the financial sector in Poland, which relative to developed market economies, is still fairly poorly articulated. One important subset of the emergence of the capital market has been the Warsaw Stock Exchange in Poland, which provides the main focus of analysis of this thesis. This is documented in third section.

²⁸ This can therefore be primarily thought of as a price level change.

2.3 The Emergence of Financial Markets in Eastern Europe; The Case of Poland

Since transactions play an extremely significant role in capital markets, coupled with the fact that capital markets are highly dependent on information, commercial banks lie at the heart of capital markets. However, it is well known that commercial banks in the Central Eastern European countries in transition have been financially weak, state-owned institutions, whose growths are stunted due to the legacy of bad loans inherited from discredited political regimes. Consequently, they do not function like banks in the Western economies so that these countries find themselves trapped in a bad equilibrium with a distressed financial sector coupled with a weak real sector. Hence, the problem or challenge has been to find the appropriate policies to transform these economies and place them on the path to a good equilibrium consisting of a healthy financial sector linked with a strong, vibrant, stimulated real sector.

The plan of this section is as follows. Section 2.3.1 begins by outlining the state of the banking sector and the investment opportunities open to household and firms before the transition to the market economy began. The effects of some pre-1989 attempts at reform in the Polish financial sector are also considered. Section 2.3.2 goes on to describe the major developments and accomplishments within and related to the emerging financial sector following 1989. This procedure is an incredibly time-consuming one where, as noted by Abel and Bonin (p.109, 1994), the transition ‘involves replacing one set of institutions and ‘economic culture’ with another’. Section 2.3.3 finally considers one niche in the financial sector, namely the stock market, where the relative importance and performance of emerging stock markets - concentrating on Poland’s stock market in particular - compared to stock markets of more developed countries are reviewed.²⁹

2.3.1 The Banking and Financial Sector, Pre-1989

In the traditional central planning system, pre-1989, the type of banking system existing in Poland was of the type of a ‘monobank system’. This monobank system involved the National

²⁹Emerging markets can be defined in several different ways. For instance, in one sense, ‘emerging’ implies that a market has begun a process of change, growing in size and sophistication in contrast to markets that are small and give little appearance of change. In another sense, ‘emerging’ can refer to any market in a developing economy,

Bank of Poland fulfilling both the roles of a central bank and a commercial bank responsible for providing the finance for state owned industry. Consequently, the financial authorities had little or no independent decision-making authority and the allocation and distribution of financial resources was the responsibility of the appropriate central planning agency and the National Bank. Investment decisions were undertaken directly by the state formalised in development plans and financed through the issue of state directives to the Bank's commercial departments. So, basically, financial institutions and instruments were used mainly to record transactions and monitor compliance with plan directives, as well as maintaining monetary balance at the macroeconomic level. By contrast, however, the role of financial institutions in the allocation of resources in the market economy, is vital; commercial banks play crucial roles in the payments settlement between companies and individuals, the provision of liquidity for the financing business activity (e.g. trade credit and working capital), and in the intermediation between savings and investment plans. Nevertheless, the monobank system served to meet the needs of both households and state enterprises by firstly, providing a forum for household savings - on which the government drew; secondly, by the specialised banks - being also de-facto branches of the national banks - serving as channels for budget grants to finance investment by state-owned enterprises and foreign trade; and thirdly, by specialised banks providing short-term credit to state-owned enterprises in order to finance their inventories, keep the firm liquid between customer payments and to meet their seasonal or other precautionary requirements. The respective investment choices facing households and firms are each considered in following sub-sections.

Investment Choices for Households, Pre-1989

Households faced a limited number of options when making their saving and investment decisions. Other than spending their incomes in consumer goods and services, they could keep some cash in hand in the national currency in which they were paid. Alternatively, they could save a part of their income in a savings bank - which would be a branch of the unique bank which monopolised the banking business of the country. However, in the 1980s, all Eastern European nations suffered, to some degree, from open inflation causing the real interest rate to be negative, although all such household deposits in the savings bank were guaranteed in nominal terms by the government.

with the implication that all have the potential for development. Here, according with the International Finance Corporation definition, the former definition is referred to.

Households were additionally faced with the option of buying and holding foreign convertible currencies, but this was only partially successful in preserving the purchasing value of the money saved by households, given the depreciation of Western currencies. This form of saving was a zero interest form of saving, although Poland did, uniquely, offer an opportunity to open interest bearing accounts denominated in a foreign convertible currency. This, in fact, proved to be very popular among the private savers. Furthermore, life insurance could be purchased, although the payment of premiums did not differ greatly from depositing money in a savings account, since state-owned insurance companies, themselves, could only deposit their receipts in a savings bank.

A final choice facing households was to buy goods or other physical assets in the hope that the value of these assets would increase at least in line with inflation. However, purchases of these consumer durables from government sources were subject to strict rationing, even when the demand for non-durable goods prevailed. Moreover, the Treasury did not issue any bonds for either household investment, local government organisations or even private firms, and additionally, at the time (pre-1990s), neither was there a stock market from which households may have bought shares from private firms or state-owned firms.

Therefore, there was a relatively significant lack of choice facing potential customers compared to Western countries in the years pre-1989.

Investment and Financing Choices for State Enterprises, Pre-1989

The assets of the bank consisted of short-term loans and limited amounts of currency and their liabilities comprised, in the main, of deposits of state-owned enterprises and of government and non-government organisations. Hence, as long as a state-owned enterprise was able to submit the necessary documents to the banks justifying the request for credit,³⁰ then, in the majority of the cases, it was granted. If, however, the application was rejected, for some particular reason, by the branch of the national bank to which the state-owned enterprise was assigned, then the firm faced no other source of finance (see Wyczanski, 1993, p.12). Moreover, in principle, neither did liquidity constrained state-owned enterprises have the option of seeking relief from the debts owed to their suppliers by obtaining trade credits from them. Nevertheless, although inter-firm credits were formally prohibited, (see Balcerowicz, 1992, p.8), they were often extended, especially during periods of credit or budget restraint. In

fact, in Poland, through the 1970s and 1980s, links of subordination in the economic hierarchy, particularly in the financial sector weakened.³¹ Consequently, inexpensive credits were ‘incredibly difficult to resist’ (see Wyczanski, p.13, 1993), and exerting pressure from firms to local branches of the national bank, local branches on regional branches, and regional branches on central bodies, was relatively easy.

Capital markets did not exist to allocate credit in the central planning system, where investment spending was typically negotiated between firms, the relevant government ministries, and the central planning commission. If the investment was approved, they were subsequently financed by the various reserve funds set aside by an enterprise, and from centrally allocated investment funds from the national budget, and loans from the central bank. Moreover, in the setting up of an enterprise, rather than the entry and exit procedures that exist in the market-based economy, the socialist economy lacked adequate procedures for this; government ministries or local authorities, which simultaneously arranged for the funding to commence operations, typically established enterprises. On the exit side, bankruptcy and liquidation of the state enterprise activity was extremely rare and the absence of markets and meaningful relative prices in the economy implied that it became almost impossible to distinguish between enterprises that were viable and those that were not.

Thus, the number of different sources regarding enterprise financing - unless the purpose to which it was going to be put was approved by the state - was fairly restricted. However, during a time of political fragility, although funds were quite easily obtainable, clearly, the additional lack of real competition only served to increase the inefficiency of the firms.

2.3.2 The Collapse of Central Banking and 1989 Financial Sector Reforms

As can be appreciated from the above discussion, financial intermediation had been kept at a primitive level in the pre-1989 systems and as J. M. Montias quotes, (1994, p.20), ‘Reforms were sorely needed in this domain if a fully-fledged market economy, primarily based on private enterprise was to be created.’ In the 1980s, although attempts at decentralisation had brought about some changes in the economy, the financial sector, however, had been left almost untouched. Things started to change in 1987, and 1988 saw a new bill on bonds being passed, however, it was in 1989 that revolutionary foundations were laid for financial markets. In January 1989, a new banking law and a law on the National Bank of Poland led to

³⁰ Where the credit was for the purposes of financing inventories in accordance with the state-owned enterprises plans, or for other sanctioned uses.

significant changes in the institutional structure of the banking system whereby a two-tier banking system was established; this type of set-up involves a system where the central bank is independent from its commercial banking sector.³² As a result, the situation in which the banking sector served solely as the controller for the state was no longer the case. There was then the emergence for an alternative market-oriented means of intermediating between households with excess liquidity and the enterprises demanding liquidity for investment purposes.

This evidently was not a straightforward, simple reform of the existing financial system. On the contrary, 'the creation of an entirely new institutional structure and the introduction of financial markets was required', (D. M. Kemme, p.41, 1994). The main financial reforms that took place post-1989 can be summarised as follows:

- (i) the creation of new institutions, inter-alia, a functional central bank and commercial banks, mainly state-owned;
- (ii) new financial instruments for intermediation and monetary control and the development of monetary policy to implement the newly-created instruments for macroeconomic management;
- (iii) a regulatory policy permitting state-owned commercial banks to continue lending to state-owned enterprises which are most unlikely to be credit-worthy; and
- (iv) the creation of a stock market.

Each of the above vital developments are described below, although the first three financial reforms are only briefly mentioned since, although they are not the major focal point of this analysis, they are of related importance.

This type of reform in the banking sector and in the capital market was a fresh concept in Poland, whereby the reform process was initiated in the financial sector, in the main, by the establishment in February 1989, of nine commercial regional banks from the national bank. As a result, private citizens, private firms and government-owned enterprises had a choice as to which bank they wanted to be affiliated with. Also, besides the previously existing

³¹ This was a time when repeated strikes and social upheavals shook the foundations of Communist rule.

³² Poland, however, was not one of the first Eastern European countries to reform its banking sector. Hungary started to reform its banking sector in 1986, followed by Bulgaria in 1989, the Czech and Slovak Republics and Romania in 1990, all similarly adopting the two-tier banking system. Laws on the central and commercial banks in these countries were subsequently brought into operation in the early 1990s. However, see Kemme (1992), Calvo and Kumar (1993), Borensztein and Masson (1993), Dittus (1994) and Hussain and Nivorozhkin (1997) for a more thorough review and discussion of the reforms undertaken in the financial sector in Central and Eastern European countries.

specialist banks, which, analogous to commercial banks, were allowed to accept deposits and grant loans to all suitable applicants, the creation of private banks was encouraged by the government.³³ Additional to these private banks and government-owned banks, there also existed a third sector of small quasi-banks that specialised in the lending of capital for risky ventures. Their existence was justified by the lack of institutions specialising in the servicing of the risk capital sector. Table 2.6 illustrates the remarkable growth of the number of banks from 1988 through to 1992. It shows the categorisation of the new commercial banks; some of them state-owned, formed on the basis of operations previously conducted by the National Bank of Poland, some of them brand new, established as joint stock companies with private or mixed capital.

Table 2.6: The Number of Banks in Poland.

(End of year)	1988	1989	1990	1991	1992
Number of Banks (a)	5	17	43	89	94
of which					
state banks	2	11	12	3	3
banks with state as a major shareholder	3	3	3	12	12
private domestic banks (b)	-	3	27	67	77
private foreign banks (c)	-	-	1	7	11

Notes: a) without co-operative banks - their number was relatively stable, on average around 1600; b) banks with shareholders from both private and public sector; c) legally Polish companies with a major share of foreign capital; the figure for 1992 includes one branch of a foreign bank.

Source: National Bank of Poland.

Further notable reforms in the banking sector included the transformation of the government-owned commercial banks (which had been founded in 1989), into joint stock corporations with government-held shares, with a view to subsequent privatisation, and the development of inter-bank transactions.³⁴ These inter-bank deposits formed the first segment

³³ For instance, the minimum capital, in Poland, to found a private bank in 1990 was set at only USD 2 million (or USD 6 million if it was founded in part or in whole by foreign capital). Consequently, by the end of 1990, there were 75 country wide private banks, of which 30 had a majority of foreign capital.

³⁴ As an example, in June 1993, the majority of shares of one of these banks - Wielkopolski Bank Kredytowy - was successfully offered to investors on the Warsaw Stock Exchange. This was followed by the privatisation of Bank Przemyslowo-Handlowy (January 1995), Polski Bank Rowoju (March 1995), Bank Gdanski (December 1996) and more recently by Powszechny Bank Kredytowy (1996) amongst others. The case for the banks receiving shares had its advantages; banks were the one existing financial institution in Poland that were, at the time, capable of holding and managing corporate equities, in addition, there is an increasing number of financial

of the money market, and they rapidly started to play an important role in adjusting the structure of banks supply of loanable funds to that of their customers demand.³⁵

The other consequence of the two-tier banking system was that the National Bank of Poland was given independence to formulate and conduct monetary policy without parliamentary approval of detailed credit plans. As an illustration of its independence, the Central Bank issued its own bills, mid-1990, with a 30 day maturity, at a time when the Government's lack of credibility prevented it from issuing its own. The bills were mainly used to control the liquidity of the banking system and in 1990, approximately 86 percent of them circulated within the banking system. Other money market instruments were also implemented in 1991 and 1992 by the Central Bank, although their existence was not as important as those of Treasury Bills. For a more detailed discussion on the path of monetary policy in Poland, see Chopra (1994) and Kokoszczyński (1994) and Lorinc (1995).

With regard to firm financing, whereas in the central planning regime, state enterprises had their investment decisions and plans made by the state, and the respective financing provided by the commercial departments of the National Bank, post-1989, the structure of financing changed. In the transition plans, private firms, state-owned enterprises and 'corporatised' government firms³⁶ were to be made financially responsible for the consequences of all their decisions and therefore liability for risky decisions transferred from the key players in the economy to the decision-makers themselves. Additionally, firms - whatever the nature of their ownership - that were not viable on the market, would be reorganised, forced into bankruptcy or liquidated, and a new regulatory policy permitted commercial banks to independently finance those firms which they considered to be viable.

It goes without saying that the success of the transformation programs in previously centrally planned economies has and still depends crucially on the development of efficient financial intermediaries and of credit and capital markets. Therefore, there are close linkages between financial sector reforms, the conduct of monetary policy, and macroeconomic and financial stabilisation. The mammoth resurrection of the productive sectors needed for a sustained improvement in productivity and growth requires developing efficient financial markets to mobilise savings and channel them efficiently. In the particular case of Poland, as

studies that suggest that banks are excellent candidates for share ownership in that this activity tends to cultivate a healthy long-term relationship between the banks and the industrial enterprises, which contributes particularly to the long-term plans of the industrial firms. For further discussion, see Cable(1985) and Hoshi, Kashyap, and Scharfstein(1990a, 1990b).

³⁵ In March 1989, the first inter-bank deposit of the amount zł 10 billion, took place between commercial banks and by the end of December 1989, the volume had increased up to zł 1775 billion.

has been outlined above, there have been substantial developments in the area of monetary policy and financial sector reform, especially since 1991.

However, there are many areas in which there needs to be many developments, and much remains to be done, for example:

- (i) the effectiveness of monetary policy continues to be hampered by structural problems and institutional rigidities;
- (ii) the level of monetisation in Poland is still relatively low;
- (iii) firm credit is scarce and mainly short term, with investment, in the main, financed by internal funds;
- (iv) although Poland has a relatively well developed interbank market and an advanced money market, there are inefficiencies in financial intermediation;
- (v) the bank supervisory capacity needs to be strengthened;
- (vi) a narrowly based stock market has previously shown signs of volatility that could have adverse implications for the long term development of equity markets;
- (vii) inflation, although reduced, it is nevertheless still high;

Although many of the above problems warrant research and investigation, the focus of this analysis is Poland's major non-bank financial institution, namely, its stock market. This non-bank financial market was of particular importance in Poland in particular regarding its role in attracting the 'forced' savings of households when growth in Polish economy stagnated in the 1980s - especially since other investment opportunities were much less attractive. We consider its performance and development in the following section.

2.3.3 Performance and Importance of Stock Markets in Eastern Europe; The Case of Poland

Analogous to the more developed economies, the stock markets of emerging economies play vital roles in setting prices for capital,³⁷ constituting markets for new share issues and providing secondary markets which facilitate the transfer of assets. Emerging stock markets

³⁶ i.e. joint stock corporations with limited liability, with majority government ownership.

³⁷ Hence the privatisation process is greatly facilitated since the stock market allows some form of consistent valuation of assets. For a discussion on the privatisation policy adopted in the reform process in Poland, see Sachs (1994), Myant (1994). Gruszecki (1990) provides an account of the privatisation regulations in Poland, and Berg (1992) gives a detailed account of the logistics of privatisation in the first two years of reform in Poland.

also fill critical niches by providing mechanisms for the sale of state-owned enterprises and by linking domestic capital markets to broader international capital markets. In addition, as already referred to above these markets have contributed a significant amount of risk capital to local businesses that have needed to modernise and expand in an increasingly competitive business environment. As has been evident in Eastern European economies, there has been a simultaneous need to create financial instruments and institutions to meet the demand for risk capital in the reform process. One important aspect of the non-bank financial sector to meet this need in countries such as Poland, Hungary and the Czech Republic, has also been the establishment and development of a stock market. In the case of Poland, despite the fact that the stock market is emerging, it has still played a vital role in the transition to a market economy and has matured to an extent that it can be considered to serve as an alternative source of finance. Poland has not essentially differed from other Eastern European transition economies in terms of macroeconomic shocks to industrial output, price increases and interest rates encountered (see Hussain and Nivorozhkin (1997) and has shared experiences in the histories and development of the financial systems and practices (see Pescetto (1992), Thorne (1993), Wihlborg (1995) and Hussain (1997). Therefore, since the Warsaw Stock Exchange (WSE) in Poland was one of the first stock exchanges to (re-)open after 1989, it can be seen as characteristic of an Eastern Europe emerging stock markets and hence its lessons would be valuable for other transition economies. At the outset, we therefore consider its relative performance and importance in the context of world stock markets.

The WSE differed from other stock exchanges in the early years due to its amazing growth. This growth partly reflected the excess demand that was brought about by low interest rates, the lack of alternative investment possibilities and high expectations. In contrast to the Czech and Hungarian markets where the majority of shares are held by foreign investors, the percentage of Polish shares owned by foreigners on the WSE in mid-1995 was less than 20% and accounted for only 10% of the total trade volume. In 1993, the market capitalisation of emerging stock markets topped the \$1,000 billion mark for the first time and the value of shares traded almost reached the 1989 record level. In total, emerging stock markets grew to represent almost 12 percent of world stock market capitalisation by the end of 1993, up from 4 percent in 1984. In fact, in the latter part of 1993, price gains in many emerging markets were so steep and the valuation measures so rich that many observers considered the levels to be unsustainable. In some markets, returns on investment for the year were remarkable, for example, the IFC Index for Poland increased by nearly 720 percent in dollar terms, causing it to be the best performing stock market in the world in 1993. Hence, despite the WSE only

commencing operations on 16th April, 1991, it already held a major place in the performance of emerging markets as well as making its mark on the global scale.³⁸ The following tables present some statistics illustrating the growth of the WSE. For comparison purposes, the same statistics are presented for another emerging Eastern European stock exchange in Hungary, i.e. the Budapest Stock Exchange (BSE) which started its operations in June 1990.

As a new stock market, Poland has shown remarkable growth and compared to the Budapest Stock Exchange, and at the end of 1996, nearly twice as many companies were listed on the WSE. Both exchanges, however, show that the narrowness and fragility of their markets (a characteristic feature of emerging markets) has made them more susceptible to volatility. For example, from a position of being the best performing stock market in the world in 1993, the Polish Stock Market Index (WIG) dropped 39 percent in zloty terms making Poland one of the worst performing emerging stock markets in the world in the following year. After beginning on an optimistic note, in the second quarter of 1994 there was a dramatic change of events whereby the extremely high price to earnings ratio led to attempts by domestic investors to liquidate their equity positions on the WSE.³⁹ This initiated panic selling amongst domestic investors which induced the decline of the WIG of 28 percent and 24.2 percent respectively in zloty terms in March and April.⁴⁰ Capital finally fed back into the market after the end of the second quarter, induced by good financial earnings as well as a lack of attractive investment alternatives and the WIG, encouraged by investor optimism initiated by a strong economic recovery and promising financial results for listed companies, increased by 37.5 percent in July and August. More recently, the gradual opening of the markets to foreign investors, promising outlooks for the economies and corporate profits have caused both markets to exhibit impressive growth. For instance, the International Finance Corporation (IFC) index gained 71.8% in dollar terms and the WSE index 89.1% in zloty terms in Poland in 1996. Most of the fluctuations during the year were mainly due to oscillating foreign investment although by the end of the year, corporate fundamentals and

³⁸ Poland, in 1993, in terms of stock market growth was followed by Turkey, for which the IFC Index increased by nearly 214 percent and a survey conducted for 73 stock markets by the IFC in early 1994, ranking world stock market performance, reported that emerging markets dominated with eight of the top ten positions. Japan finished 43rd, with an increase of just below 25 percent and US share prices ranked 61st with a 7 percent increase for the year.

³⁹ The initial optimism was mainly due to market optimism, the input of new capital following the announcement made by the government to privatise hundreds of small to medium enterprises and the creation of an over-the-counter market and a new national securities depository

⁴⁰ The WIG Index continued to fall until the end of June despite the new accessibility to foreign investors of 12-month index-linked government bonds. At the time, there was clear preference among investors for quality Initial Public Offerings (IPOs), and these attracted a substantial amount of capital from the secondary market.

Table 2.7: Vital Statistics Illustrating the Performance of the Warsaw Stock Exchange,
1991-1996.

	1991	1992	1993	1994	1995	1996
No. of Listed Companies	9	16	22	44	65	83
Market Capitalisation:						
In Zlotys	158	351	5803	7450	11259	23999
In US Dollars	144	222	2706	3057	4564	8390
Local Index (WIG)	919.1	1040.7	12439	7473.1	7585.9	14342.8
Change in Index (%)	-	13.2	1095.3	-39.9	1.5	89.1

Notes: The base date for the WSE All-Share Performance Index in April 1991=1000.
Source: Emerging Markets Factbook, 1997.

Table 2.8: Vital Statistics Illustrating the Performance of the Budapest Stock Exchange,
1991-1996.

	1991	1992	1993	1994	1995	1996
No. of Listed Companies	21	23	28	40	42	45
Market Capitalisation:						
In Forint	38200	47207	81741	181527	327775	852456
In US Dollars	505	562	812	1604	2399	5273
Local Index (WIG)	837.6	890.9	1264.1	1470.1	1528.9	4134.3
Change in Index (%)	-	6.4	41.9	19.6	4	170.4

Notes: The base date for the BSE BUX Index in January 1992=1000.
Source: Emerging Markets Factbook, 1997.

positive economic prospect dominated investor sentiment. Hungary, on the other hand, was one of the best performing emerging markets in 1996 in dollar terms with the IFC index rising by 99.9%. Again, the core demand for Hungarian stocks came from foreign investors.

In sections 2.2 and 2.3, we have discussed the foundations of Poland's transition from a central planned economy to a market economy, and the resulting and simultaneous emergence of the financial markets. The following section 2.4 goes on to detail the establishment, rules, regulations and operations of the Warsaw Stock Exchange.⁴¹ As explained in the introduction, it is important to understand the circumstances which brought about the growth and development of the Warsaw Stock Exchange, as well as an understanding about the environment in which it operates and an appreciation that this environment is constantly and rapidly changing. Only once this awareness and comprehension has been achieved, can any meaningful policy implications be put forward in particular for emerging Eastern European stock markets, as well as infant (i.e. newly established) equity markets.⁴²

2.4 Rules and Regulations on Two Eastern European Stock Markets

Despite the fact that reforms in the banking sector have been taking place in Poland, there still remain some serious and substantial problems - especially regarding banks in playing a major role in providing finance to firms for investment purposes. It therefore becomes important to take a closer look at capital markets in their role of mobilising and channelling long-term capital to firms. Although there has been much debate concerning the relative merits of bank finance and equity capital in the financing of medium-term and long-term investment⁴³, equity markets are of particular interest for investigation, especially for the school of thought of the opinion that firms would be better to seek finance from equity markets. The reasoning underlying this assertion is that the role that banks can play in a transition economy is seriously limited due to asymmetric information, adverse selection and incentive problems, whilst, on the other hand, stock markets would be virtually free from this adverse selection effect. One of the key elements in Poland's transition towards a market economy is the success of its privatisation programme and stock markets are seen to have a significant role in the privatisation process through the setting of market values of privatised companies on a continual basis. This procedure thereby facilitates the valuation of newly privatised

⁴¹ Although some aspects of the exchange's operations have altered (e.g. continuous trading for some shares since July 1996 recent times), the system described is the original existing pre-mid-1996, for which our analysis takes place.

⁴² See Emerson, Hall and Zalewska-Mitura (1997), in which the term 'infant' markets was introduced and are characterised by being 'small, but steadily growing, with unpredictable movements and a brief history' (p. 75).

⁴³ See, for example, Calvo and Kumar (1993) and Blommenstein and Spencer (1994) for a discussion in this area.

companies.⁴⁴ Subsequently, the stock market and the accompanying capital market infrastructure are indispensable to the success of the programme stimulating further interest in the capital market. Moreover, as already discussed, the efficient mobilisation and channelling of funds and savings is essential for the continued improvement in productivity and growth in the process of reform.

The main focus of this thesis is the Warsaw Stock Exchange described in section 2.4.1, however, to provide a point of comparison in later chapters the operations of the Budapest Stock Exchange are also briefly documented in section 2.4.2.

2.4.1 The Warsaw Stock Exchange

Organisation and Operation

The Warsaw Stock Exchange (WSE) was resurrected after some 52 years when it re-opened for operations on April 16, 1991. Originally, the WSE had been founded in 1817 and prior to 1939, there were also five other stock exchanges in Poland, although of those six exchanges, the WSE was indubitably the most significant as the venue for 90% of all stock trading in the country. Although the creation of the Polish stock market signified an enormous potential for development, the 52-year gap in the functioning of the capital market had created a legal and institutional void. Consequently, coupled with the obvious lack of experience and professional knowledge, the task of constructing the capital market faced immense difficulties.

In the introduction of a mechanism for the securities market, many alternative models of capital market operations were considered with the aim that the model to be adopted should both utilise the most up-to-date methods of legal regulation and organisation, whilst at the same time take into account the particular circumstance of Poland being a country in transition. There are mainly two types organisation; an 'order-driven' market model in which market participants disclose their orders to buy or sell at specific prices; and a 'quote-driven' model in which the participants compete for orders by reporting buy and sell prices. The quote-driven market involves a small group of specialists in the market-making process, the

⁴⁴ The Polish government multi-track privatisation reform plans incorporate the increasing involvement of the Warsaw Stock Exchange; for example, the National Investment Funds Programme (formally the Mass Privatisation Program) implemented in 1995, is a voucher-based privatisation scheme, in which over 600 state-owned enterprises can choose to participate. The scheme, designed to ensure Polish citizens are the main beneficiaries of this privatisation process, involves the issuing of shares to a small number of investment funds for management, and these funds would be open to bids from both domestic and non-domestic managers. Alternatively they may establish joint ventures. The vouchers could be used to purchase shares in the investment funds, which would be freely traded on the Warsaw Stock Exchange.

assumption being that they are more rational and experienced than the typical investor. However, in this system, the main disadvantage is that all orders do not interact, which could give rise to manipulation in narrow markets. In contrast, the order-driven market is relatively more regulated and can be controlled by the authorities, aiming to make the market fairer for the average investor. Consequently, Poland adopted a Continental European model in the form of a French order driven system. This was implemented with the aid of the Societe de Bourses Francaises and SICOVAM - the Central Depository of France. The legal framework of the capital market after much intensive consultations and debate, is according to the Act on Public Trading in Securities and Trust Funds adopted by the Polish Parliament (Sejm) on March 22, 1991. The law established the foundation for the fundamental components of the Polish stock market; brokerage houses, the stock exchange, trust funds and most importantly, the Securities Commission which promotes the stock market and represents a body through which the Government can exercise control.⁴⁵

The next milestone in the creation of the legal infrastructure for the stock market was on April 12, 1991, when the Act re-establishing the WSE was established was signed. In December of 1991, the WSE became a corresponding member of the International Federation of Stock Exchanges (FIBV) and the Federation of European Stock Exchanges (FESE), and on October 10, 1994, the WSE became a full member of the FIBV, thus becoming the first stock exchange in Central and Eastern Europe to be given such a status. The organisational structure of the WSE can be summarised by the following figure.

⁴⁵ According to a Report of the US Agency for International Development by Hogan et al (1993), Poland's legal and regulatory framework for the stock market is fairly highly developed, with clearly defined property rights and extensive disclosure of information.

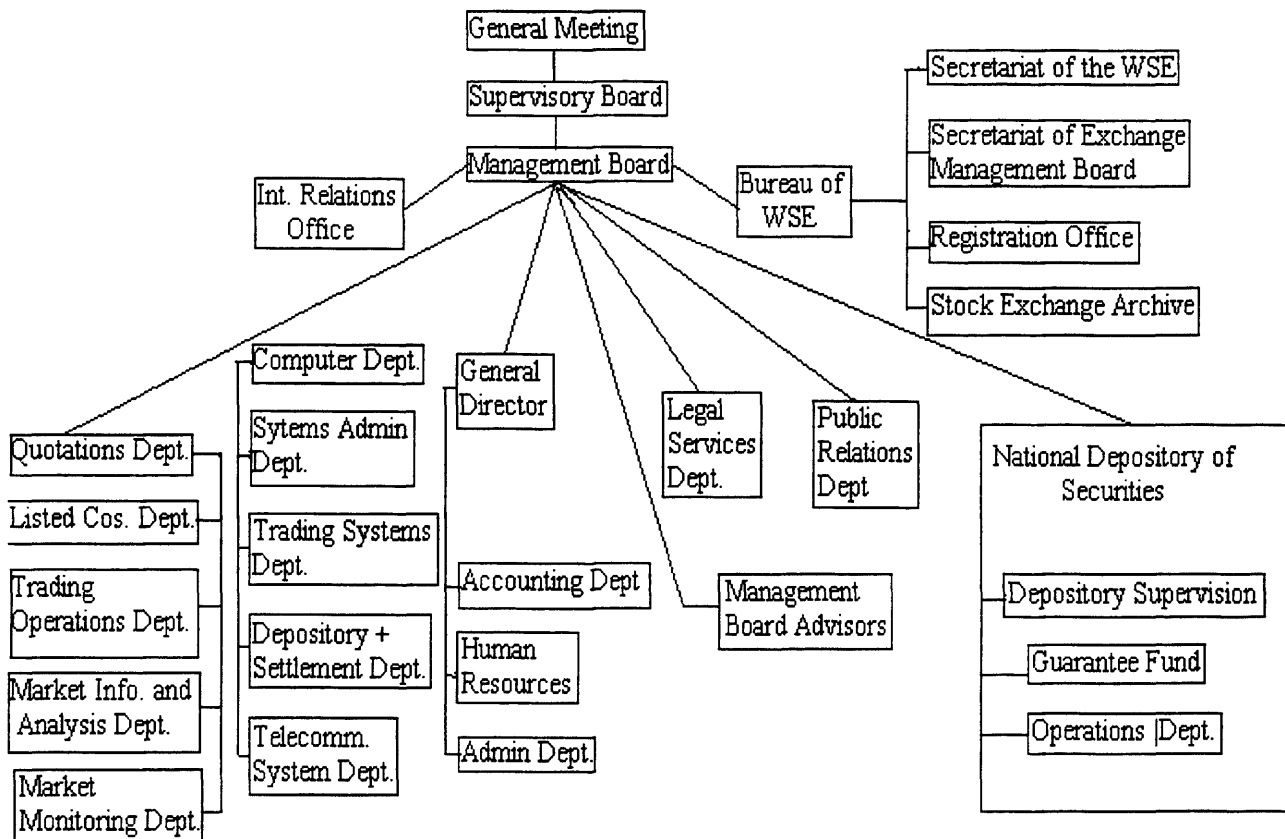


Figure 2.1: Stock Exchange Organisation Structure

The WSE having previously been owned solely as a non-profit joint-stock company by the State Treasury is currently owned by 37 banks and brokerage houses as well as by the State Treasury. The General Meeting is the highest decision-making body of the stock exchange, - its role being to effect changes to the Statute and Rules as well as to elect members of the Supervisory Board. Representatives from the bodies that own the stock exchange make up the General Meeting. Secondary to the General Meeting is the Supervisory Board, which is made up of six representatives of shareholders and six representatives of financial institutions, issuers and the chambers of Commerce. The Board controls the operation of the exchange, admits securities and controls the granting and withdrawal of the membership to the exchange. The day-to-day operation of the exchange is directed through the Management Board and consists of the President and two Vice Presidents. The Management Board also sets the rules for the introduction of securities on to the exchange and oversees the activities of brokers and brokerage houses with respect to market transactions. All these members of the exchange are permitted to trade on the floor of the exchange, whereas other non-member brokerage houses are obliged to process their orders through the member firms.

Trading System of the Warsaw Stock Exchange

The trading system of the Warsaw stock Exchange can basically be characterised by an order driven, centralised market with paperless trading. Essentially, this 'Lyon type' system involves the establishment of a daily price for each stock by comparing buy and sell orders submitted to the stock exchange by brokerage houses before a trading session. The system is a single price auction method (order-driven) rather similar to the French 'par casier' or German 'Einheitspreis' method of quotation. Trading sessions took place once a week until January 1993 when they were extended to three days a week. Since January 1994, trading in the equity market has taken place five days a week from Monday to Friday where one trading session takes place each day at the exchange headquarters from Monday till Friday between 11.00am and 1.00pm.

In this system, an investor intending to undertake a stock exchange transaction, be it in the process of buying or selling securities, needs to perform this through a licensed stock broker, or otherwise termed a 'specialist'. The 'specialist', (or alternatively, a 'specialist broker' if performing its functions through its exchange broker) is defined to be an exchange member who has been authorised to exercise the following functions; (i) primarily to fix the market price; (ii) intervene to balance to balance the market and support trading volume and liquidity; (iii) carry out allocation and reduction; and (iv) issue contract notes.⁴⁶ Therefore, when a firm is floated on the Stock Exchange, each company proposes a specialist firm, or a brokerage house, to the exchange authorities and this broking firm thereafter specialises in that particular stock and operates as its specialist during trading sessions. Each of these specialist firms nominates one or two licensed brokers to act as specialist brokers who are responsible for the realisation of their client's orders. In determining the market price, the specialist broker must take into account the conditions set out below in the following order of priority:

- (i) maximise the volume of turnover;
- (ii) minimise the difference between the volume of securities in sell and buy orders to be executed at the price which has been fixed; and

⁴⁶ A contract note is the proof of execution, on the basis of a broker's order, of an agreement to sell securities as well as a basis for recording and settling market transactions.

(iii) minimise the difference between the current session price and that of the previous session.⁴⁷

In the placement of an order, investors define the quantity and the price limit of desired securities. Hence, buyers will state the maximum price at which he is ready to purchase the security while the seller will propose the minimum price below which he will not be prepared to sell. Almost all orders are valid for the current day's session alone (due to the frequency of large price fluctuation) and can be placed in three ways:

- (i) A limit order - which defines a maximum buying price or a minimum selling price.
- (ii) The order can be placed conditional on the percentage of the offer that can be executed, for instance, all or nothing - WAN, Wszystko Albo Nic.
- (iii) An order can be placed at the market price - PKD, Po Kursie Dnia; in other words, the client will execute the transaction at the price that is defined during the nearest stock exchange trading session.

The orders qualifying for the trading session are then submitted to the appropriate specialist broker after the opening of the trading session and it is then his responsibility to verify the orders and calculate and propose the day's price for a given security taking into account the appropriate considerations.

The distinguishing rule at the WSE is the limitation of price variations in single price quotations. In practice, this implies that the market price cannot vary by more than 10 percent (5 percent with respect to bonds) than the reference price with respect to shares, where the reference price is the price of the previous trading session. Hence, the market price can be 10 percent higher (upper limitation) or 10 percent lower (lower limitation) than the reference price unless the Exchange Management Board decides otherwise.⁴⁸ After the daily price has been fixed and approved by the chairman of the session, all transactions of the given security

⁴⁷ And on fixing the market price, the following conditions *must* be fulfilled: (i) volume of turnover must be maximised; (ii) all 'at the market price' orders, all buy orders with a price limit higher than the market price and all sell orders with a price limit lower than the market price must be fully executed; (iii) orders with a price limit which has become the market price can be fully or partially executed or not executed; (iv) buy orders with a price limit lower than the market price and sell order with a price limit higher than the market price must not be executed.

However, the Exchange Management Board does have the discretion to relax one or more of the above conditions in fixing the market price, if in exceptional cases it is considered that the interests of the market participants requires such a course of action.

are executed at that price. However, a number of situations may arise in the case when there is an excess of either, orders to buy or orders to sell depending on the degree of this excess. The following provides an account of the resulting predicaments which can be categorised under a 'balanced' market and an 'unbalanced' market.

A balanced market ensues if the price of the day is fixed within the permissible limits of +/-10 percent for the upper and lower limit respectively. In this situation, all orders placed at the market price (PKD), all buy orders with a higher price limit and all sell orders with a price limit lower than the day's rate, will be executed. The resulting price of the day is then known as the 'equilibrium price'. The term 'balanced' market is, however, misleading since there may still be excess supply or demand. In the contingency where the excess is small, the specialist may carry out order allocation where he intervenes in the market and buys or sells shares of the stock to equilibrate the market. In the case where the excess is not particularly small, then 'overtime trading' or an extended session is opened. This facility was introduced in July 1993 allowing the specialist to invite offers from other brokers and their clients to balance the market. Overtime trading takes place for approximately one hour from 11.00am, after the daily price has been calculated until about 12.00pm. If, still, overtime trading has not succeeded in clearing the market, then one of the following situations arises: -

- (i) Excess of offers to buy/sell - the specialist may decide to reduce orders placed with limits at the daily price (PKD), thereby enabling only a partial execution of orders.⁴⁹ In this case, the specialist is obliged to ensure that such orders are executed in the same proportion.
- (ii) Reduction of offers to buy/sell - if the above action fails to adequately reduce the excess, then the specialist may decide to reduce all orders (buy or sell, depending on which is the excess), by a percentage which will eliminate it. In other words, buy or sell orders are reduced even if they offer a price higher/lower than the daily price.⁵⁰

In the event that the price that is calculated to maximise turnover and minimise the difference between demand and supply, is outside the 10 percent limit, then the specialist fixes the price 10 percent higher or lower than that of the previous session.⁵¹ The price determined in this way is no longer deemed the equilibrium price and an unbalanced market

⁴⁸ It is possible for the Exchange to remove the barrier if a stock's price rises or falls by the maximum 10 percent in a number of successive sessions, the intention being to restore 'equilibrium'.

⁴⁹ If there is a buy excess, this is denoted by the letters 'nk' (nadwyzka), and in a sell excess situation, by 'ns' (nadwyzka sprzedazy) on the list of quotations.

⁵⁰ If buy offers are reduced, this situation is denoted by the letters 'rk' (reduckja kupna), and if sell offers are reduced, by 'rs' (reduckja sprzedazy), on the list of quotations.

now exists. In this situation, overtime trading supervenes. If after the extended trading session, buying and selling orders do not exceed a ratio of 5:1, then the specialist proportionately scales down the predominating orders as above, in the case of the balanced market. In other words, when there is a predomination of buy orders, then the buys order that are subject to reduction are those with a price limit equal to the fixed market price and those with a price limit higher than the fixed market price. Analogously, with the predomination of sell orders, those sell orders that are scaled down are those with a price limit equal to the fixed market price as well as orders with a price limit lower than the fixed market price. If, however, the predominance of demand or supply is greater than 5:1, then transactions are suspended⁵²; so, the price still moves the 10 percent but this is a non-transaction price and no trade takes place.⁵³ Turnover, defined as the total value of shares sold and bought, under this circumstance is hence zero.

Once the stock exchange has confirmed the results of the session, at 1.00pm, the official prices and turnovers etc., are announced and the specialist brokers issue the contract notes.

2.4.2 The Budapest Stock Exchange

The first stock exchange opened in Hungary in 1864 with 21 traded companies. However, the socialist revolution in the early part of the twentieth century forced its brief closure in 1919 for six months, and subsequently operated until communist rule prevailed in 1948. The recent collapse in communism power resulted in the re-birth of the stock exchange starting operations on 21st June 1990 trading shares of just one company (Ibusz) with 19 commercial banks and 23 brokers as members. By 1996, the stock exchange, playing a vital part in the privatisation process as in Poland, boasted approximately 40 listed companies. The trading system, however, differs substantially from the Warsaw Stock Exchange.

⁵¹ The actual rise or fall in price may not be exactly 10 percent due to the occurrence of rounding.

⁵² A convenient way of viewing the suspension situation is from the point of view of order completion or satisfaction. The 'rate of satisfaction' measures the proportion or percentage of trades which are allowed to take place. If in a reduction or scaling down situation, buy or sell orders are reduced by, for example, 20 percent to achieve equilibrium, then the rate of satisfaction is obviously 80 percent. The 5:1 rule can therefore be interpreted to mean that the rate of satisfaction can not fall below 20 percent; i.e. reductions can not exceed 80 percent.

⁵³ When buy orders predominate, the letter 'ok' represents the situation, and 'os', when sell orders predominate.

Trading System of the Budapest Stock Exchange.

In the trading system of the BSE, all transactions are implemented on the Floor of the Exchange by the brokers during the opening hours. Primarily, brokers make bids and offers orally or in writing and respond to bids and offers of other brokers according to the Rules of the Budapest Stock Exchange. Unlike the single price of the day prevailing on the WSE, the 'opening price' on the BSE is the price of the first transaction of the day and the 'closing price' is the last transaction price of a share. In the event of no trade taking place in a share, the closing price is the price of the share when it was last traded.

In order to stabilise prices in times of volatility, the BSE in contrast to the WSE, introduced breaks and suspensions in trading during which no bids or offers can be made for a particular share. For instance, if the change in price of a share is greater than 20% compared to its opening price, when admitted to the Exchange, the speaker may order a temporary suspension usually lasting for about 10 minutes if the change in price is less than 30% and slightly longer if it is larger than 30%. The Chief Executive Officer may also suspend trading for a maximum of three days if the change in share prices is not supported by the information available to the public or if it is felt that continued trading would significantly endanger the well-being of investors or the operation of the Exchange. Moreover, the Stock Exchange Board or Supervision Board can extend the suspension period to an undefined period of time if they suspect that the further trading of a share would not be organised, transparent and fair. Finally, if the overall financial, economic or political situation causes trading on the Exchange not to be again, organised, fair and transparent, the Stock Exchange Board and Supervision Board have the power to suspend trading of individual securities or of the whole exchange for a limited time. If this time exceeds 10 days, then in this case, the approval of the Ministry of Finance is also required.

2.5 Concluding Comments

In this chapter, we have described how the economies of Eastern Europe, in particular Poland and Hungary, in the recent past have eliminated the pre-existing command imposed system with price and trade liberalisations, macroeconomic and financial stabilisation of unprecedented magnitudes. Although many of the crucial economic reforms have been or are in the process of being implemented, Poland, being one of the most advanced Eastern

European economies into the transition process, still faces, as do the other economies, a unique set of policy problems which determine the rate of growth and durability of stabilisation and hence the pace of integration with Western Europe. The previous complete breakdown of the political and economic structures of these economies, and currently the interplay across different sectors of structural and economic problems, makes the formulation of policies particularly daunting and the eventual outcomes a very slow process in most cases. Nevertheless, at the same time, these countries have become pioneers in facing the challenges of systematic transformation to the market from which valuable lessons can be learnt.

It is clear that many of the economic issues in these economies in transition warrant research and investigation. However, the focus of this analysis is Poland's major non-bank financial institution, namely, its stock market. We have discussed the emergence of financial markets in Eastern Europe, and how the infrastructure of the market based financial system has had to be established. Of particular importance in the financial system in Poland has been the stock market. In the main, not only was this essential to the privatisation process, but the stock market proved particularly amongst households facing a lack of attractive alternative investment opportunities and for firms as an alternative source of finance in an economy with an under-developed banking system. As such, the majority of investment in the WSE up until 1995 has been from the domestic economy.

As well as describing the circumstances that have brought about the growth and development of the Warsaw Stock Exchange, we have discussed the environment in which it operates. Just as important is the understanding that this environment is constantly and rapidly changing. An awareness of these aspects aids understanding and provides help towards any meaningful policy implications that can be put forward in particular for emerging Eastern European stock markets as well as infant equity markets.

The focus of this thesis is, in the main, the behaviour of price series on the WSE. Two things relevant to the WSE noted in this chapter are (i) its relatively recent establishment (particularly in the context of the more well-known emerging markets of Latin America and Asia), and (ii) the particular quantity-constrained price-setting system operating on the exchange. In chapter 3, given point (i), we review empirical studies investigating other emerging markets which have been in operation since the late 1970s and early 1980s. Bearing in mind the very different circumstances giving rise to the stock markets in Eastern Europe, nevertheless, emerging markets share essential characteristics (such as thin trading, inefficient financial systems etc.) and hence, examining the development of these markets can provide

valuable insights for newly emerging Eastern European markets. With reference to point (ii), in chapter 4, we present a theoretical framework in the context of the particular price-setting system on the WSE, and assess its appropriateness. This is necessary since the quantity-constrained system, for certain price movements, no longer relies on the principles underlying equilibrium economics when arriving at a final trade. Therefore, there may be important implications for any market operating such a system.

CHAPTER 3

THE BEHAVIOUR AND MODELLING OF RETURNS ON EMERGING FINANCIAL MARKETS

Summary

In this chapter, we provide a review of studies investigating the behaviour of stock returns on emerging stock markets. Summarising the research findings, the empirical evidence has found that emerging markets were not well integrated with the world financial markets until the early 1980s and increasingly they are becoming more integrated. Despite increasing integration, the general policy conclusion has been towards continuing to lower the barriers to foreign equity flows. The stock returns exhibit higher than average sample returns and, in the short run, have been found to be more predictable in emerging markets relative to industrial market although only weak evidence of return reversals has been found over the longer horizon. Finally, although emerging market stock returns exhibit higher volatility relative to volatility on developed markets, the conventional views that equity and portfolio flows into emerging markets cause destabilising effects through the volatility of stock returns have so far been unfounded.

3.1 Introduction

It is well known that there has been greater recent interest into emerging markets evidenced by the sharp increases in the size of equity flows into these markets. For instance, Folkerts-Landau and Ito (1995) report that between 1987 and 1993, the proportion of foreign portfolio investment from industrial countries into emerging markets rose from 0.5 percent to 16 percent, with a magnitude of \$6.2 billion in 1982 compared to \$37.2 billion in 1992 (see Gooptu (1994)). Moreover, with the flow of foreign capital to equity almost doubling from \$7.6 billion in 1991 to \$13.1 billion in 1992, in some cases, the ratio of market capitalisation to GDP has been greater for emerging markets than developed or mature markets (see Claessens and Gooptu (1994)).¹ Despite this, published research concerning the price determination in these emerging markets and how it compares to developed markets in industrial economies is still comparably little relative to the extremely widely and thoroughly studied industrial economy markets (see Fama (1970, 1991) for comprehensive surveys on developed stock markets). Furthermore, given that the focus of this research is an emerging market (i.e. the WSE), in this chapter, we discuss the characteristics unique to emerging markets and consider the research which has been carried out on the behaviour of stock returns on these markets and how they compare to developed stock markets.

The thesis in the context of this review on emerging markets is important for two main reasons. Firstly, given that this thesis concerns emerging Eastern European markets, it is important to note that these markets can be termed ‘infant’ markets, being established only in the 1990s, relative to the majority of existing empirical research on emerging markets which have generally been established since the late 1970s/early 1980s. Hence, observation of the behaviour of returns on the relatively more ‘mature’ markets can provide valuable insights contributing to the understanding of the development of the newer emerging markets. Secondly, despite these insights being valuable, given that the majority of emerging markets investigated have been Latin American and Asian emerging markets, independent research in Eastern European emerging markets is also deemed essential due to the very different circumstances and pressures giving rise to these markets and the environment in which they

¹ By using the term ‘developed’ markets, we are referring to markets in industrialised economies such as the US, the UK, Germany, France, Canada, Japan, etc., where recall, as in Chapter 2, ‘emerging markets’ corresponds to the definition produced by the IFC as being those stock markets in countries or territories with income levels that are classified by the World Bank as low or middle income. Note it is not strictly correct to refer to mature stock markets as those existing in industrial economies, since the Emerging Markets Data Base (the most common source of data for emerging market studies) produced by the IFC also includes Greece and Portugal - although they are typically classified as industrial countries. However, since it is generally the case that the mature or

operate in.

The plan of the chapter is as follows. In section 3.2, we begin by mentioning the main motivations of these studies specific to developing economies hence highlighting the importance of the research into stock market behaviour. This is followed in section 3.3 by a review of the recent empirical literature that has examined the workings of emerging stock markets; this is divided into four sub-sections. The first sub-section 3.3.1 provides an overview of popular empirical studies investigating the fit of asset pricing models in emerging markets and hence the relation between risk and expected return in these markets. The second sub-section 3.3.2 documents studies attempting to explicitly investigate barriers to investment in emerging economies, and 3.3.3 and 3.3.4 consider the predictability and volatility, respectively, of emerging stock market returns. Finally, section 3.4 concludes.

3.2 Potential Role of Stock Markets

Traditionally, improvements in the functioning of financial markets of developing countries, aiming to allocate capital more efficiently, have been through focusing on core financial themes such as improvements in the roles of banks as financial intermediaries, interest liberalisation and government roles in allocating credit.² More recently though, increasing attention has been paid by policy makers to capital markets and in particular the role of stock markets. Before we review the empirical literature investigating emerging stock markets, let us first examine the potential roles that stock markets can play in developing economies.

Firstly, stock markets can be a vehicle for raising capital for firms. There are other forms of financial intermediaries which also perform this role, however, in developing countries enabling an increasing role for the private sector through undertaking privatisation, this potential function holds particular significance for the resulting large demands in equity finance.³

Secondly, stock markets in particular can allow investors to diversify their wealth across assets relatively easily compared to other financial markets and, in doing so, they are able to reduce the risk that they must bear. In turn, capital markets can reduce the risk premium demanded by suppliers of capital and therefore the cost of capital. Hence, not only could this

developed markets belong to industrialised economies, for simplicity sake, we shall ignore the caveats.

² See Demirgüç-Kunt and Levine (1993) for a survey on the role of capital markets and the relation between stock market development and the functioning of financial intermediaries.

³ For instance, the mass privatisation program being undertaken in Poland through the 1990's has been accompanied by an ever-increasing role for the stock market.

result in increased investment levels and enhanced development, the benefits of a lower risk premium would be especially relevant for foreign investment given that foreign investors are more diversified and thus share the risk.

Thirdly, stock markets can perform a screening and monitoring role. For instance, by reacting on information and judgement of numerous participants, stock prices can quickly reflect changes in the underlying values and therefore indicate profitable investment opportunities. In this way, stock markets can provide a screening and selection role. Moreover, they can perform a monitoring role since the public nature of the listed companies places the ultimate decision-making in the hands of the shareholders. Then, if share prices are continuously adjusting to information, shareholders are assisted in monitoring the managers of publicly traded corporations, thus exerting pressure on managers to consider shareholder and social responsibilities. This improved corporate governance should consequently promote economic development. Clearly, as the number of publicly traded companies in developing countries increases, this monitoring role becomes increasingly vital.

Fourthly, although a stock market is only one element of a financial system, it can, however, act as an important complement, rather than substitute, to the various other financial intermediaries from the point of view of the suppliers and demanders of capital. For instance, in the absence of a well-functioning stock market, firms may be limited in their ability to achieve an efficient mix of debt and equity even though the debt market may be well functioning. Hence, given the complementary nature, a stock market that functions well may have positive externalities for the rest of the financial sector.

Finally, stock markets are thought to play a vital role in terms of efficiency in the allocation of capital to its highest-value users, and therefore increase overall economic efficiency, and also an important role in encouraging savings and investment, both being essential to economic development.

3.3 Characterising Emerging Markets

In recent times, as witnessed by the conference on emerging markets organised by the World Bank in 1993 (see Claessens and Gooptu (1993)), serious research on emerging markets has begun which has sought to investigate, in various ways, the above potential benefits of the stock markets their return characteristics. The clear conclusion from all studies is that, despite the increase in financial flows into emerging markets, equities from these markets have still

maintained different characteristics compared to equities from developed markets. The most apparent differences are that emerging markets tend to exhibit higher sample average returns, more predictable returns, higher volatility and a low correlation between emerging and mature markets which has been increasing through time (see Demirguc-Kunt and Levine (1995) for stylised facts of developing stock markets).

The empirical research can basically be summarised as being, in the main, concentrated in four areas, each of which is documented in the next four sub-sections. These areas broadly involve: (i) formal tests of the Capital Asset Pricing Model (CAPM) and related variations, including the International CAPM, single factor and multifactor ICAPM's, using data from emerging equity markets; these studies therefore consider whether the models that apply to developed markets also apply to developing markets, (ii) the explicit consideration of barriers to integration or investment either through the use of other asset pricing models or some other means, (iii) the predictability of stock returns including the testing for any commonality in the factors driving the predictability of returns across countries, and (iv) the investigation of the volatility of returns in emerging markets especially following market liberalisation. All of these studies have a general underlying aim to investigate how and why emerging markets differ from mature stock markets and, in particular for categories (i), (ii) and (iii), the extent to which they are integrated with mature markets.⁴ Let us consider each of these in turn.

3.3.1 The CAPM applied to Emerging Markets

Using data from emerging markets, there are few formal tests of asset pricing models. These are recent studies and are most commonly based on testing variations of the Sharpe-Lintner asset-pricing model (Sharpe (1964) and Lintner (1965)), which assumes that investors divide their wealth between a riskless asset and risky assets or stocks in proportions depending on each investors risk aversion. Formally, the model is known as the Capital Asset Pricing Model (CAPM), and is basically a simple share valuation model, with its foundations arising from portfolio theory, and provides an equilibrium theory of how to price and measure risk.⁵ Numerous studies have tested an extension of the model using international data in which case it, if extended to an international level, allows investors to choose among stocks from

⁴ For a discussion of recent trends and market participants and institutions, see Gooptu (1993), and also El-Elrian and Kumar (1995) and Feldman and Kumar (1995) for a discussion of the benefits of the liberalisation of equity markets.

⁵ The model is based on assuming that investors are risk-averse, price-takers, utility maximisers and have homogenous expectations about asset returns, assets are perfectly divisible, marketable and returns are normally distributed and that markets are perfect.

many countries rather being constrained to choose from a single stock market. This model, known as the International Capital Asset Pricing Model (ICAPM), has had much success in its description of return behaviour in mature markets in industrialised economies (see Harvey (1991) and Dumas and Slonik (1992)), and thus is a popular choice when considering the extent of integration of emerging markets either by analysis at a single market level or at a multi-market level. Given that many of the recent studies considering emerging markets are based on this model (or simple variants of it), explaining it in a little more detail aids in the understanding of the relevant literature testing asset-pricing models as well as the implications when applied to emerging markets.

Formally, the ICAPM states that the expected return on any given risky asset in excess of the 'risk-free' or 'safe' rate is proportional to the expected return on the market in excess of the risk-free rate, i.e.,

$$E(R_{jt}) - R_{ft} = \beta_j [E(R_{wt}) - R_{ft}] = \frac{\text{cov}(R_{wt}, R_{jt})}{\text{var}(R_{wt})} [E(R_{wt}) - R_{ft}], \quad (3.1)$$

where, R_{jt} represents the total return on asset j , R_{ft} denotes the rate of return on the risk-free asset, β_j is the proportionality factor $[\beta_j = \text{cov}(R_{wt}, R_{jt}) / \text{var}(R_{wt})]$, and R_{wt} represents the total return on the world, or market, portfolio. In this model, the only risk that investors with optimising behaviour care about is the covariance with the market portfolio (β_j), where the above relation (3.1) evolves from investors efforts to diversify risk. Therefore, if the returns of a stock or portfolio are consistent with the ICAPM, then it is said to be integrated with the defined market. Hence, according to the ICAPM, if emerging markets are integrated with the world market, then each market's expected returns should be proportional to that market's covariance with a capitalisation-weighted world portfolio. If, however, returns do not reflect the covariance with the world portfolio i.e. emerging markets are not integrated into the world market, then the implication is that by adding assets from emerging markets into their portfolios, investors not only reduce overall risk, but can also increase their expected returns. More practically, many empirical studies reduce the complexity of the model by creating portfolios of stocks and allowing the investors to divide their assets between the riskless asset and the risky portfolios. Perhaps the most obvious weakness of the model are the assumptions on which it is based (as listed in footnote 5), and the fact that the model assumes independent and identically distributed returns. When considering emerging markets in particular, among

the assumptions, the presence of serial correlation has not only been established as existing in industrial markets (see Cutler, Poterba and Summers (1991)), but emerging markets also display strong serial correlation at short intervals. It is therefore probable that most investors would prefer a more complicated intertemporal strategy compared to the ICAPM. Nevertheless, simple examination of the ICAPM has provided useful insights as documented by the following literature.

Buckberg (1995), assuming that the ICAPM is an accurate description of mature markets, investigates emerging market data for twenty economies during the periods 1985-91 and 1977-91, using data obtained from the Emerging Markets Data Base (EMDB) compiled by the International Finance Corporation (IFC).⁶ The data for the industrial markets is obtained from MCSI.⁷ The principal aim of the study is to determine to what extent emerging markets behave like industrial markets in relation to the world portfolio, and to examine changes in the degree of integration after increases in the inflow of capital from industrial countries in the late 1980s i.e. how the relation between emerging markets and world portfolio has changed over time. The late 1980s are of particular interest since many restrictions to foreign investment in Latin-American and Asian markets were relaxed, and especially the years 1987-88 when booming Southeast Asian markets first attracted capital from industrial economies to emerging markets. In the paper, each economy's market index is representative of a risky portfolio and tests are undertaken to observe whether the market returns in developing economies are consistent with the model's predictions, or in other words, testing the fit of the ICAPM by comparing the price of risk. Following recent work by Harvey (1989, 1991) and Dumas and Solnik (1992), the author implements 'conditional' or 'expectational' asset pricing to test the above single factor ICAPM in which the expected returns are allowed to change over time. 'Conditional' refers to the use of conditioning information (on some information set) to calculate expected moments and to validly test the ICAPM as a relation between expected returns and *ex-ante* risk; many studies use realised or *ex-post* return and covariance data to test the ICAPM and therefore fail to properly address the *ex-ante* relationship described by the theoretical model.⁸ Buckberg finds that for 1977-84, six of the

⁶ This data base is the one most commonly used by studies investigating emerging markets, covering Latin American and Asian countries, with the main advantage being its consistency and comparability across markets; the IFC constructed indices for each market typically include 10 to 20 percent of listed stocks which are chosen on the basis of high trading volume or large capitalisation. Ten of the markets range as far back as 1976, although prior to 1985, fewer stocks were sampled to create the market indices.

⁷ MSCI's indices represent European, Japanese, U.S. and world market portfolios. The data base does not, however, include all the emerging markets in its world index (and neither does any other standard index).

⁸ For OECD market returns, Harvey (1991) finds that the conditional formulation outperforms the unconditional one, where the author finds returns consistent with the ICAPM in fourteen of seventeen industrial economy markets during 1970-89, with the model failing for Japan and two of the smallest OECD markets (Austria and

ten emerging markets reject the ICAPM in the conditional formulation of the Sharpe-Lintner model, although for 1985-91, eighteen out of the twenty markets do not reject the model. The author argues that this therefore provides evidence that the emerging markets considered became increasingly integrated into global financial markets in the late 1980s, where it is likely that the mechanism to integration was provided by the increased flows into these markets at the time. However, Harvey (1995) questions the power of the tests used by Buckberg and Harvey (1994), allowing both expected returns as well as covariance risk (beta) to change over time, finds that this more general model is not rejected.

These findings in Buckberg (1995) are supported by Harvey (1995) also using data, during the period 1976-92, for national market indices and where he tests a simple single-factor ICAPM implicitly assuming purchasing power parity and that markets are integrated. The author obtains betas, reflecting world market risk exposures, which are typically lower than those found in studies using data for industrial markets and the betas are, again, not found to be significant in explaining average cross-country returns unlike in mature market studies. Moreover, in contrast to the implication of the CAPM, the intercept terms are positive for most countries and in some cases suggest very large pricing errors. These results, in addition to the significant correlation found between average returns and the variance of monthly returns in emerging markets, imply that the emerging markets considered were not fully integrated into world capital markets during 1976-92.⁹ This evidence that global risk factors are not powerful in explaining returns in emerging markets (especially compared with explaining returns in industrial countries) is consistent with emerging markets being segmented from industrial countries, although he also finds that the importance of global factors for many emerging markets has increased. This suggests greater, although still imperfect, integration.

Claessens, Dasgupta and Glen (1993, 1995b) also make use of similar asset pricing models. In their 1993 paper, they compare the fit of a single-factor ICAPM and a multifactor model for eighteen emerging markets (using the EMDB from the IFC) ranging from 1988 to 1992. They find that although the additional factors generate a better fit, the improvement, however, is found not to be statistically significant. Furthermore, the multifactor model is also rejected for every economy except for Brazil, although one possible explanation for these findings could be the short sample period. In Claessens, Dasgupta and Glen (1995b), conducting cross-sectional tests of the ICAPM for nineteen emerging markets, they examine

Denmark).

⁹ Bekaert and Harvey (1994), using the world portfolio as a benchmark for measuring risk, find that an

the effect of asset returns of several risk factors in addition to the beta factor. Again the authors find that the model is typically rejected either because of significant regression intercepts or insignificant betas (i.e. national risk exposures). Moreover, although variables such as the size and trading volume of companies are found to be significant in a number of markets, they often are opposite in sign to such effects in industrial country data (namely, for the U.S. and Japanese markets).¹⁰

In general then, the approach using CAPM's to test for and measure market integration assumes that market integration exists and that the particular CAPM holds. We have seen that although the single-factor CAPM with one source of risk is often used in the domestic context, an alternative specification need to be derived if applied to the international stock market. This is because the model can only describe international stock market returns if all investors have identical preferences (see Solnik (1974) and the review by Alder and Dumas (1983)). Often, unless purchasing power parity holds (which is not the case in the short run) exchange rate risk will have to enter the tests. Few studies have incorporated exchange rate risk, with some exceptions being Claessens, Dasgupta and Glen (1995b), Dumas and Solnik (1994) and Ferson and Harvey (1993), although overall the empirical tests have been ambiguous in tests of the ICAPM. However, the main problem in rejections of the specific asset pricing models lies in the risk of misspecification since it is unclear whether the rejections are attributable to the model or to the lack of integration, and it is particularly so that the existence of a well-established international asset pricing model is lacking. The general direction of the empirical literature, as observed, has now been moving towards more complex multifactor models, where the risk (betas of equity returns) is measured with respect to the covariances (i.e. various risk factors). Nevertheless, again there is a risk of misspecification since the risk factors also need to be pre-specified. Moreover, recent research has found time variation in expected returns in emerging markets which suggests the development of a dynamic asset pricing theory since the simple static asset pricing models imply no changes in the predictability of asset returns over time. Although we consider the issue of predictability in section 3.3.4 and the commonality of factors driving the predictability of returns across countries, no consensus has so far emerged on what produces this apparent predictability in emerging markets. This poses further problems for asset pricing models, since without an explicit, dynamic asset pricing theory, it is impossible to distinguish between highly variable risk premiums, 'peso problems', regime switches, knowledge of

unconditional, single factor CAPM is also unable to characterise returns in emerging markets.

¹⁰ Exchange rate risk was also found to be a significant factor in several countries.

policy changes or other inefficiencies.¹¹

All of these results pose important questions for research into emerging markets using asset pricing models. With new independent empirical evidence emerging, at the least, future research would need to address the problem that any theory attempting to explain asset pricing in all markets must explain how factors can be priced differently simply by crossing an international border. The substantial differences may be attributed to market microstructure, or perhaps and regulatory and tax regimes cause differences in investor behaviour (see Glen (1997) for a discussion on market microstructure in seven emerging markets). However, particular attention, as has been already observed from the implications made by studies using asset pricing models, is being paid to whether these results can be attributed to the increasing integration of financial markets. Increasingly, there is further, more in depth, research being carried out on capital market integration in general which, for any future work using asset-pricing models, is an essential requirement. This literature not only investigates how well these emerging markets are integrated with markets of industrial economies but also the extent to which integration is a function of identifiable barriers to investment. By identifying and examining barriers to investment, which are especially relevant in emerging markets, it is also possible to obtain an understanding of the opportunity costs, in terms of higher capital, associated with these barriers and therefore the implications for emerging market economies as these barriers are relaxed. Hence, it is to this second part of the literature that we now turn.

3.3.2 Identification of Barriers to Integration

The sharp increases in magnitude in capital flows into emerging markets in recent years, as already mentioned, have given rise to questions concerning: the expected return and diversification benefits of investing in emerging markets; the degree of integration of these markets with industrial economies; the extent to which integration is a function of identifiable barriers to investment; and the associated opportunity costs. A number of authors have investigated the return properties and the potential diversification benefits from investing in emerging markets. The studies examining the diversification benefits include those

¹¹ 'Peso problems' arise when market participants anticipate a future discrete shift in policy that is not materialised within the sample period examined. They are often introduced by uncertainties concerning policies governing future earnings if investors fear that some low-probability shift will dramatically reduce returns. For instance, these may include a devaluation, closing of the stock market, expropriation, or perhaps the imposition of capital controls preventing the repayment of capital or profits. The potential for these events to occur, by reducing the expected liquidity of holding emerging market stocks, may cause what appear to be excess returns

undertaken by Divecha, Drach and Stefek (1992), Harvey (1993), Speidell and Sappenfield (1992) and Wilcox (1992). However, the possible benefits of foreign capital reducing domestic capital costs and increasing economic welfare through more a more efficient allocation of resources, as well as the potential diversification benefits for foreign investors may not arise if there are significant barriers to investment. In fact the observation, even on the world-wide scale, of the tendency of investors to hold primarily domestic assets suggests the existence of important barriers to capital mobility at the international level. The existence of these barriers are heightened when developing markets are considered and as a result, there has been a small amount of research specifically aimed towards investigating the effects of these barriers in emerging markets which provide useful insights (Demirgüç-Kunt and Huizinga (1995), Chuhan (1992), Bekaert (1995) and Bekaert and Harvey (1997) being some of the few). In the following sub-sections, we first consider the type of barriers to integration that may exist in emerging stock markets and then go on to review some recent evidence investigating the extent to which integration may be a function of these identifiable barriers to investment.

There are basically three categories of barriers facing foreign investors when investing in emerging markets that we can distinguish between (see Bekaert (1995)). These are 'direct' and 'indirect' barriers and barriers due to 'emerging-market-specific-risks' (EMSRs). The direct barriers includes two groups of barriers. In the first group, there are direct restrictions on foreign ownership where, for example, certain sectors may be closed to foreign investment, or limits may be imposed on the direct ownership of equity¹²; the second group involves exchange and capital controls that affect investment in emerging markets and the repatriation of dividends, where, for instance, capital gains and taxes on dividends fall in this group (see Demirgüç-Kunt and Huizinga (1995)). Both of these are therefore legal barriers arising from the different legal status of foreign and domestic investors. Indirect barriers to investment concern differences in the regulatory and accounting environment where, for instance, the flow of relevant information to investors may not be adequate and the accounting standards, settlement systems as well as investor protection may be poor. The third type of barrier can be identified as being due to risks that are specific to emerging markets. For instance, these could involve liquidity risks, political risks, economic policy and macroeconomic policy risks and instabilities, and perhaps currency risks, all of which

in a period in which a bad state fails to materialise.

¹² For instance, economies such as Nigeria and Zimbabwe are still completely closed to foreign investment and only recently in countries such as Poland, Brazil, Columbia, India, Korea and Taiwan (China) have restrictions been gradually relaxed.

discourage foreign investment and lead to market segmentation.

In general, empirical studies on international capital barriers have not identified exactly what capital controls exist and how they should be expected to affect asset returns. As observed in the previous section, one common approach to testing and measuring the degree of market integration is to assume that markets are perfectly integrated and that a particular international asset pricing model holds. A rejection of the model implied by international capital market integration is then taken as evidence of market imperfections. We have discussed problems with this approach, the major drawback of the approach being the lack of a universally accepted international asset-pricing model prompting further research on market segmentation. But even when specific investment barriers have been identified, the empirical testing of these barriers has so far proven difficult since it is difficult to incorporate the cost equivalents of the range of international capital barriers into asset pricing models. For instance, the investment barriers considered by Cho et al. (1986), Bonser-Neal et al. (1990) and Gultekin et al. (1989) do not allow for a straightforward computation of tax or transaction cost equivalents. These studies, instead, examine how changes in investment restrictions differentially affect the international pricing of assets and of risk.

The second popular approach to measuring the degree of market integration is to model the restrictions to integration explicitly and derive their effects on equilibrium returns. However, the same problem of identifying the cost equivalents of these capital controls remains and furthermore this approach is hampered because it restricts the analysis to the effects on one particular barrier whereas in reality there can be a number of different barriers in operation at any one time. Illustrating these problems, in early attempts to model capital controls, Black (1974) and Stulz (1981) represent barriers to international portfolio investment as proportional taxes on foreign asset holdings, where Black assumes the tax rate is positive for long positions and negative for short positions whereas Stulz assumes a positive tax applies equally to all positions. In a study of the Canadian equity market, Booth (1987) further examines how the differential taxation of dividends accruing to domestic and foreign residents affects the international ownership of equity capital. Other empirical studies alternatively model investment barriers as prohibitions on particular cross-ownership of assets (see, for example, Errunza and Losq (1989), Eun and Janakiraman (1986), Cooper and Kaplanis (1986, 1994) and Hietala (1989)). However, it is important to note that emerging markets may still display very different cross-sectional differences in their exposure to risk which may not *only* reflect actual barriers to investment. This is because the various emerging markets may have different industrial structures which might result in different

exposures to 'industry factors' (see Divecha, Drach and Stefek (1992) on emerging markets, and Heston and Rouwenhorst (1994) and Roll (1992) on developed markets).¹³

Demirgüç-Kunt and Huizinga (1995) implement this second approach for eighteen emerging stock markets (from the EMDB of the IFC) and investigate to what extent features of the international tax system and indicators of transaction costs affect the required rates of returns in emerging stock markets. As in the work of Black (1974) and Stulz (1981), they explicitly incorporate tax barriers in an asset-pricing model and then required pre-tax equity returns are related to taxes applied to non-resident holdings. They find, in particular, that the taxation of purely inflationary capital gains levied on foreign portfolio investors can indeed have an independent positive impact on the required rate of return on equity in emerging stock markets.¹⁴ This result implies that since the firm's equity is part of the issuing firm's cost of capital, then capital gains taxes imposed on non-residents will therefore increase the cost of capital for domestic firms which can discourage investment. Hence, this finding about barriers to investment due to taxation systems has important implications for developing economies suggesting that a country should tax capital gains lightly in comparison to repatriated dividends.¹⁵ Another consequence of the study is that stock market development, as measured by a higher ratio of stock market capitalisation to gross domestic product, is found to reduce the required pre-tax rates of return, where the ratio represents an indication of other costs to investors associated with international portfolio investments. However, it cannot be determined from the available data whether this relationship is due to variation in direct transaction costs, or to a high ratio reflecting favourable stock market practices with regard to the availability of information, accounting practices and other rules and regulations. Nevertheless, from a investigation of mature markets, empirical evidence in Chuhan (1992) based on a survey of market participants in Canada, Germany, Japan, the UK and the US, found that limited information was one of the key impediments to investment in emerging markets. Other factors include those related to liquidity problems, country risk such as unstable macroeconomic policies and indicators of political stability (credit ratings, for

¹³ Furthermore, some economies may be dependent on a limited number of natural resources, which might give rise to different 'commodity exposures', for example, Nigeria on oil.

¹⁴ Dividend taxes, on the other hand, are found not to significantly increase pre-tax equity returns. These results are consistent with the generally more generous foreign tax credits for foreign dividend taxes rather than for foreign capital gains taxes available in capital-exporting countries such as the U.S..

¹⁵ This policy is implemented in Greece, Korea, Pakistan, Portugal and Venezuela in the Asian and Latin-American countries of the EMDB, where there is no capital gains tax imposed on non-residents, although, in general, the trend in these countries is towards lower dividend taxes with little change in the average level of capital gains taxation (contrary to what appears optimal from the above results). Note, however, that the policy has assumed that developed countries will not significantly limit the credibility of foreign dividend taxes after these are raised.

example).

Bekaert (1995) moves away from the two common approaches in investigating barriers to investment (hence, away from the related problems) and undertakes a simple exploratory analysis on nineteen emerging equity markets from the IFC Emerging Markets Data Base for Latin American and Asian countries. The author develops a return-based measure of market integration in two stages. He first interprets the fitted values of regressions of excess returns on five predetermined variables to be estimates of expected returns. These five predetermined components include both local factors (the lagged return and the dividend yield) and global factors (the lagged return on the U.S. market, the U.S. dividend yield and the U.S. interest rate). Then the integration measure is the correlation of the regression estimates of the expected returns in the U.S. and the emerging markets. This correlation provides an indication of the common component in expected returns and therefore, indirectly, of market integration (see Campbell and Hamao (1992)).¹⁶ If, for instance, there were only one source of risk and markets were perfectly integrated, expected returns would be perfectly correlated (see Cumby and Huizinga (1992)). Then several barriers to equity flows are identified to recipient countries and rank correlations are computed between the market integration measure and computed measures of various direct and indirect barriers to investment to examine which barriers were effective. The study finds firstly that one of the most important effective barriers to global equity-market integration is macroeconomic instability, namely, poor credit ratings, high and variable inflation and exchange rate controls are barriers that have a high correlation with measures of lack of market integration. Secondly, another important factor is the degree of stock market development involving factors such as the lack of a high-quality regulatory and accounting framework and the limited size of some stock markets. A related point is made by Claessens, Dasgupta and Glen (1995) where, if there is 'insider trading', 'outsiders' (domestic or foreign) are less attracted to investing in the market. Thirdly, the lack of sufficient country funds or cross-listed securities, or in other words, the de facto openness of the stock market, is also associated with lower integration.

Note, however, that the measure used in this study is a simple representation which will only be a perfect measure of market integration in a one-factor world with constant risk exposures. In reality, it is unlikely that one risk factor will explain all of the cross-sectional and time variation in equity returns. For instance, even if the world is perfectly integrated and assets are priced according to a multi-factor model, there still may be dramatic cross-sectional

¹⁶ By using this measure, Bekaert attempts to control for the apparent decline in global predictability observed over time (see section 3.3.3).

differences in emerging markets' risk exposures which may not reflect actual barriers to investment and may be due to 'industry factors' (where there are differing industrial structures of emerging stock markets) and 'commodity factors', as discussed previously (see also discussion in Harvey (1993)). Hence, the measure used needs ideally to correct for different industry exposures and allow for some diversification within indices for emerging markets. Divecha, Drach and Stefek (1992) consider four 'concentration measures' in emerging markets: the proportion of capitalisation in the top ten companies, as asset concentration factor (equally unity if the entire market capitalisation is concentrated in one market), a sector concentration measure, and the average correlation between stocks in the index. The study finds that sector concentration is not important for explaining emerging-market returns. Bekaert (1995) computes rank correlations between the four asset concentration measures and his market integration measure in order to examine whether the industry and sectoral patterns affect the market integration measure. If, for example, all markets were perfectly integrated and the correlation of expected returns only reflected different concentration or industry effects, then we would expect a positive correlation between the market integration measure and the concentration measures. In contrast to the earlier results, Bekaert found that industry factors were significant and should be considered an important part in future analysis.

Another point to be noted in the interpretation of Bekaert's results is that the correlation computed is the unconditional one, hence, no changes in the degree of market integration are allowed for over the sample period (1986-92). Despite this, comparing correlations for the pre-1985 and 1985-92 periods, Bekaert finds evidence of increased integration for most industrial countries and many emerging markets after 1985. However, Harvey (1995) computes a five year rolling regression and also finds that the correlations for the world and emerging markets are increasing over time. In addition, Bekaert and Harvey (1995a) estimate a regime-switching model of expected returns that allows returns to be determined at different times by domestic factors (segmented markets) or by world factors (integrated markets). Their findings suggest that certain emerging markets (for example, Greece, Korea, Malaysia and Taiwan (China) have been fairly well integrated into the world market in recent years whilst others remain much more segmented.¹⁷

Overall, the research so far investigating the effects of particular barriers to investment has provided useful contributions and insights to the debate concerning the benefits of integration. The evidence shows that there is increasing, though yet incomplete, integration

¹⁷ In fact, most of the results from their model are consistent with the observed market regulations.

over time of emerging markets and thus suggests that there still remains unexploited gains from increased foreign investment for both investors and firms in developing economies. Although there is no formal theory on how capital controls affect asset returns (especially since, ultimately, investors' perceptions and attitudes matter too), the general conclusions have therefore been towards the gradual relaxation of many of the barriers which are most likely to effectively segment the local market from the global capital market.¹⁸ Many barriers, however, can not be removed immediately, for example, poor credit ratings, although some headway can be made on other barriers. For instance, we have seen that a common finding from these studies has been the importance to investors of information, accounting standards, reliable investment protection and settlement procedures etc. Since many exchanges rely on self-enforcing regulators (e.g. investment boards), these safeguards may be relatively easy to implement. We have also seen that the harmonisation of capital gains and dividends taxation of emerging markets with industrial economies can also enhance emerging markets' effective returns to foreign investors and lower their cost of capital.

Nevertheless, research on the testing and measuring barriers to integration is still incomplete, where future studies should take into account dynamic interactions between integration and the barriers. They should also investigate approaches which incorporate both global and local risk factors jointly with barriers to investment with the aim of forcing risk exposures to be a function of the degree of market segmentation.

3.3.4 Predictability of Stock Returns

An investigation of the price and return patterns between emerging and developed markets can be extremely useful in distinguishing the most important differences between the markets. In section 3.3.1, we have seen that one way of addressing the issue of predictability was in terms of returns conforming to some equilibrium model (e.g. the CAPM), where if the model was correct then returns would on average conform to the linear relation. However, one disadvantage noted underlying such analysis was the joint null hypothesis which assumes that security markets are efficient and *ex-ante* returns behave according to the pre-specified equilibrium model. An added complication to the use of standard asset pricing models is the significant time-variation in expected returns found in domestic and international markets. As

¹⁸ There are often concerns about the lower diversification benefits that may result on increasing integration between the capital market and the economy, and therefore leading to a decrease in interest in emerging stock markets by the international investment community. However, in general, studies have not detected a significant relation between the risk-return trade-off and market integration.

such, many studies have focused on the issue of whether predictability reflects as a point of difference between the markets through simple time series analysis involving return autocorrelations, seasonal patterns etc.¹⁹ Note, however, that evidence of predictability still does not necessarily imply market inefficiency. This is firstly because even though some forms of predictability is accepted, often, investment decisions made on the basis of evidence are ultimately risky because of the low level of predictability identified. Secondly, since predictability may arise from the basic factors that drive stock returns, again, the fact that models of returns are unable to capture these factors may indicate model failure rather than market inefficiency.²⁰ In this section we examine recent empirical findings on the predictability of equity returns in emerging markets using evidence based on tests for time series return predictability.

Time series return predictability can be discussed in three separate sub-sections, in all of which the validity of a model of stock prices in which returns are constant through time is tested. The first sub-section discusses seasonal patterns in returns with regard to calendar turning points, the second examines evidence on return autocorrelations of total return indices of EMDB stocks measured over the short and long horizons, and the third considers the evidence on predicting returns with *ex-ante* observable variables.²¹

Seasonal Patterns

The investigation into market anomalies is usually motivated by interest in the possibility of institutional features causing return behaviour to deviate from expected behaviour (for instance, a random walk or some martingale process).²² For industrial economies, anomaly tests have focused on seasonal effects which, for instance, involve effects related to calendar year turning points, end of the tax year effects or small firm effects. Hence, this issue is of particular interest to regulatory authorities and policy-makers in the case of emerging markets given that they have a variety of institutional features differentiating them from one another

¹⁹ Note that Fama (1991) also motivates tests for time series predictability rather than for 'weak-form efficiency', which he had previously introduced in Fama (1970).

Also note that although these tests are *implicitly* a test of an asset pricing model (as opposed to explicitly), they do, however, represent attempts to minimise the problem of jointly testing a particular asset pricing model and market efficiency.

²⁰ See Lehman (1991) for an in depth review of current scepticism on the issue of testing for efficiency.

²¹ Returns are commonly calculated as the percentage change in price adjusted for dividends, rights issues and stock splits.

²² Note that market anomalies do not necessarily indicate market inefficiency, but may just be reflecting certain institutional features of markets for which the particular asset pricing model used does not correct.

and also from industrial economy markets.²³

The empirical literature on market anomalies for industrial markets is extremely extensive (see Keim (1987), Fama (1991) for a review of these studies), yet, in contrast, such studies for emerging markets are few. Although there are isolated studies testing for a particular seasonal effect for a particular emerging market, by far the most comprehensive study so far in terms of the number of emerging markets studied and the range of anomalies investigated is that by Claessens, Dasgupta and Glen (1995). The authors investigate the return behaviour for twenty emerging stock markets of the EMDB, from 1976-92, aiming to shed light on the determinants and behaviour of flows into stock markets as well as the risk diversification benefits and the cost of capital. They undertake anomaly and time series tests, distinguishing between them by referring to anomaly tests as focusing on seasonal or cross-sectional patterns in rates of return and time series tests as focusing on the predictability of rates of return over time. For both they use parsimonious models for rates of return behaviour (i.e. that they are independently and identically distributed). In testing for calendar effects, Claessens, Dasgupta and Glen (1995) employ three different seasonality tests to identify extraordinary returns in January and at the turn of the tax year for the twenty emerging markets. The first test employed is a non-parametric test of the hypothesis that the mean return in all months are equal. The second test is an extension of the latter test, and tests whether the mean rate of return for a specific month is significantly greater than the mean rate of return for any other month of the year.²⁴ Finally, the third test, as described in Corhay, Hawawini and Michel (1987), is a parametric test using regressions of returns on dummy variables for each of the months being tested for abnormal behaviour.

For empirical research on seasonality in industrial markets, the general finding is that there is considerable variation in average returns across months of the year and, in particular, average returns in January are always positive and generally significantly higher than during the rest of the year.²⁵ However, there is mixed and far from conclusive evidence as to whether these findings relate to tax-related trading in industrial markets; see Reinganum (1983), Roll (1983), Schultz (1985), Jones, Lee and Apenbrink (1991) and Keim (1989), for example.

²³ See Roll (1993) for evidence that institutional features may play a role in return seasonality.

²⁴ The first test is known as the Kruskal-Wallis test and both are described in detail in Gultekin and Gultekin (1983).

²⁵ For instance, Rozeff and Kinney (1976) found that, over the period 1904-1974, equally weighted indices containing all the stocks listed on the NYSE displayed significantly higher returns in January than in the other eleven months. Also, Gultekin and Gultekin (1983) examined stock returns of seventeen countries and found that all the countries exhibited a large and positive January mean return over the period 1959-79. For thirteen countries, the average returns in January were significantly larger than returns in the other months. See Corhay, Hawawini and Michel (1987) also.

With regard to such findings in emerging markets, Claessens, Dasgupta and Glen (1995) find that the January effect for the total return indices is only significant for three markets - the Republic of Korea, Mexico and Turkey and the significantly different month coincides with the beginning of the tax year for only two markets, namely, Malaysia and Mexico. Although for sixteen of the markets there are significant month of the year effects for the economy indices (e.g. for Chile, Jordan and the Philippines, three of the twelve months are significantly different from the other months) Pakistan is the only country in which the end-of-the-fiscal-year month is significantly different from the other months. Hence, the January effect finding for industrial markets does not clearly carry over for emerging markets, and although the turn-of-the-tax-year effect is inconclusive for industrial markets, it certainly is not found for the majority of the emerging markets studied in the sample.

When the relation between seasonal effects and size-based portfolios are considered (examined in more detail in Claessens, Dasgupta and Glen (1993)), there seems to be no relation between them for the twenty emerging markets. Again, there is also little evidence of a turn-of-the-tax-year effect that varies with the market capitalisation of the stocks.

Note that these findings could also be attributable to a number of reasons; for instance, (i) the short sample size contributing to the weak power of tests, (ii) tax codes in emerging economies may imply different behaviour compared to industrial economies (i.e. the potential selling of stocks at the end of the tax year to generate a loss for tax purposes may not arise), (iii) there may be weak enforcement of tax codes and hence a lack of evidence for the tax-loss-selling hypothesis, and (iv) institutional factors are very different for emerging market economies.

Return Autocorrelations

The majority of studies investigating the efficiency of the stock market have assumed an equilibrium model of stock prices in which expected returns are constant through time (i.e. that prices follow a 'random walk' process). Therefore, according to this model, if the market is efficient, price changes are unpredictable and the past history of prices is not informative about the prediction of future price changes. Hence, following the literature testing return predictability reviewed in Hawawini and Keim (1995) and Fama (1991), researchers basically estimate return autocorrelations coefficients which are then individually and jointly tested for statistical significance.

In summary, Claessens, Dasgupta and Glen (1993, 1995), Harvey (1993, 1995), Buckberg

(1995) and Bekaert (1993, 1995), amongst others, find that emerging market returns taken from the EMDB display a higher autocorrelation relative to industrial market returns thus indicating that lagged prices may contain information about future returns. Nearly all the studies on emerging markets - including those mentioned - consider short horizon returns, the exception being Richards (1996) who conducts tests for long run predictability investigating the presence of strong reversals in asset prices. In brief, he finds that the results of the tests of long run predictability do not provide firm evidence that there are strong reversals that would perhaps be suggested by long swings or bubbles in asset prices.

In more detail, Claessens, Dasgupta and Glen (1995) find significant predictability in rates of return, where monthly first order total return autocorrelations for twenty emerging stock market indices from the EMDB, over the period 1976-92, are significant for nine economies and for a few economies, the second order autocorrelation is also high.²⁶ When contrasted to return autocorrelation for industrial stock market indices over the same period, the finding is that these autocorrelations are much below 0.2, whereas for seven of the twenty emerging markets, they are greater than 0.2. Moreover, the authors also find that the significant predictability of returns found for the emerging markets does not appear to be related to the size of stock or portfolio.²⁷ These findings are consistent with other studies investigating thinly traded markets. For instance, Laurence (1986) finds statistically significant first order autocorrelations in 31% of stocks on the Kuala Lumpur Stock Exchange, and Butler and Malakiah (1992) report significant departures from the random walk for *all* stocks traded on the stock exchange in Saudi Arabia and on the stock exchange in Kuwait, 13 of the 36 stocks exhibit statistically significant first order autocorrelations.

Buckberg (1995) investigates the twenty emerging markets in the EMDB, the MSCI (Morgan Stanley Capital Perspective) European, Japanese, U.S. and world indices over the period 1985-1991. On examining the return autocorrelations, the finding amongst industrial markets is that the world index exhibits the highest one-month autocorrelation (at 0.0713) and only Japan exhibits positive autocorrelation at two month. By stark contrast, fifteen of the twenty emerging markets display one-month autocorrelation exceeding 0.1000, where the predictable components for Indonesia and Chile reach as high as 0.5509 and 0.4999,

²⁶ First order autocorrelations were significant for Chile, Colombia, Greece, Mexico, Pakistan, the Philippines, Portugal, Turkey and Venezuela. Chile and Greece also display high second order autocorrelations.

²⁷ More generally, the study finds that for the twenty emerging markets from the EMDB the mean rates of return and also the standard deviations are higher than those for industrial economies, and the trade-off between the rate of return and the standard deviation for developing economies is higher than the corresponding trade-off for industrialised markets. In addition, although not suprisingly, the normality assumption is rejected for eighteen out of the twenty emerging markets, and in an earlier 1993 paper, they also find that the assumption is also rejected for all sixteen industrial markets reported by the MSCI.

respectively, and for Chile, Columbia, Indonesia and the Philippines the autocorrelations being significant at the 95% level. Buckberg also finds that most emerging markets exhibit mean reversion after two or three months although six of the markets exhibit autocorrelation over 0.1000 at the two month interval.²⁸

Richards (1996) uses an extended EMDB data set up until the end of 1995 for 27 emerging markets, on which he conducts three tests for the predictability of returns for return horizons of up to three years in contrast to the shorter horizon tests of Claessens, Dasgupta and Glen (1995a) and Buckberg (1995) etc. The first test involves tests for stationarity and cointegration of total return indices, since these properties would imply a strong form of long run horizon predictability.²⁹ The second test implements the regression approach of Fama and French (1988) which, in the case of the U.S., reveals a positive autocorrelation at horizons of a few quarters and negative relations at horizons of two or more years. Finally, the third methodology is that introduced by DeBondt and Thaler (1985) of relative return predictability using the winner-loser methodology.³⁰ The pattern of positive autocorrelation at short horizons followed by negative autocorrelation at longer horizons has been found in developed markets for a wide range of assets by Cutler, Poterba and Summers (1991). They refer to these changes as 'speculative dynamics' which may be caused by the existence of fads, investor sentiment or some other type of irrationality (see, for example, Poterba and Summers (1988)). However, as noted in Harvey (1995), other explanations are also possible; positive autocorrelation and return predictability at short horizons may be due to predictability in risk premiums or risk exposures. Moreover, negative autocorrelations at longer horizons could also be consistent with infrequent changes in required rates of return, which will have immediate effects on asset prices in one direction and an offsetting influence in subsequent periods (see Fama and French (1988)).^{31,32}

²⁸ The study also reports fourteen emerging markets having a mean return higher than all of the industrial market indices and only five being below. However, only five emerging markets which opened during the sample period, namely, Chile, Columbia, Pakistan, the Philippines and Zimbabwe, display a higher reward to risk ratio (mean/standard deviation). The industrial markets, on the other hand, almost identically offer very low variances but also lower than average returns.

²⁹ Stationarity would indicate a strong form of predictability based on the recent history of the series, since it would consistently demonstrate reversion to its mean (trend) following a period of higher (lower) than average returns. The property of cointegration implies that indices have a strong tendency to move together in the long run. Hence, following the Granger Representation Theorem, the implication of cointegration between return indices is that there is also strong form of relative predictability. Note, in the context of this literature, however, if cointegration does exist, because of the *contemporaneous* tendency to move together in the long run, the implication of this form of predictability does not necessarily imply that there is inefficiency. This point is merely noted here, serving to point out a potential flaw in the existing literature.

³⁰ For instance, for portfolio of U.S. stocks, the authors show that at horizons of three to five years there is a tendency for U.S. stocks to undergo reversals in their relative performance; winners and losers in a ranking period tend to undergo return reversals in the following test period.

³¹ Also note that even if traders are rational, bubbles can still be an outcome. See Cuthbertson (1996), who

Using the first approach to test for predictability in returns involving time series tests for non-stationarity and cointegration between return indices, Richards finds that for nine emerging markets investigated, all of the indices are apparently non-stationary and integrated of order one.³³ This finding is consistent with standard asset pricing theory that return indices should contain a random walk component and should not demonstrate the extreme form of predictability implied by stationarity (see also Richards (1995)). Cointegration tests between each of these emerging market series and the world portfolio and also provides evidence of no cointegration between the return indices using both Engle and Granger (1987) and Johansen and Juselius (1990) (for between emerging markets) methodologies. This again confirms the expectation that a strong form of predictability should not exist between the indices, despite evidence that Latin American markets are sometimes subject to similar influences (see Calvo, Leiderman and Reinhart (1993)).

The second aspect of long run return predictability investigated by Richards (1996) is the predictability of long horizon returns based on their own history. For instance, Velasco (1993) notes that an important consideration for investors and policy makers (as well as the volatility of short term returns) is the possibility of long swings in asset prices followed by large reversal, which could have a destabilising effect on the market. A related issue is the concern expressed by some authors about the possible existence of speculative bubbles in emerging markets characterised by a positive deviation of the asset price from its fundamental value, and hence above normal positive autocorrelated returns, in the period when the bubbles are building, followed by large negative returns when the bubble bursts. The second methodology tests for a weaker form of return predictability relative to the previous tests. Following Fama and French (1988), simple regressions are carried out regressing the k -month return (log difference) on the lagged k -month return.³⁴ The results for

investigates 'rational bubbles' arising from the Euler equation (in the absence of an arbitrary transversality condition) mathematically yielding a solution for stock prices that equals the fundamental value plus a 'bubble' term following a martingale process.

³²Hence, return predictability does not necessarily imply market inefficiency (unless there is predictability in risk-adjusted returns) causing most studies to move away from testing for market efficiency and characterising the predictability of the return process instead. Likewise, predictability in relative returns (as in winner-loser reversals) again is not necessarily evidence against market efficiency.

³³ The longest markets investigated, ranging from 1975-1995, are Argentina, Brazil, Chile, Greece, India, Korea, Mexico, Thailand, Zimbabwe.

³⁴ Using this methodology, there are a number of interpretations arising from the coefficient on the lagged k -month return denoted by $\beta(k)$; if the index is a pure random walk with no stationary component, the estimated $\beta(k)$ should be equal to zero for all k (after correcting for negative biases on the autocorrelation coefficients); if the index contains a stationary component but no random walk component, the coefficient on the lagged k -month return should be close to zero for low k and approach -0.5 for high k ; and if there is both stationary and random walk component, a U-shape pattern for $\beta(k)$ may result where $\beta(k)$ is close to zero for small k , moving towards -0.5 at horizons where the transitory component is more important, and then returning to zero for large k where the random walk component dominates.

the nine emerging markets show only a few rejections on the null hypothesis of no temporal dependence in returns, and those rejections that do occur suggest a pattern of positive autocorrelation at short horizons and negative autocorrelations at longer horizons.³⁵ The results for the three month horizon are also found to be qualitatively consistent with the results of the autocorrelations conducted at the shorter horizons (one and two month) by Claessens, Dasgupta and Glen (1995a). Moreover, De Santis and Imrohoroglu (1997) find much stronger support for a fat-tailed conditional distribution of returns for emerging markets relative to developed markets, suggesting that large changes in speculative prices are expected relatively often. Thus, although there is some evidence of positive autocorrelation in emerging market returns at horizons up to six months, there is only mixed evidence for subsequent negative autocorrelation (as implied by models of investor overreaction or bubbles).

With regard to the third type of test, DeBondt and Thaler (1985) suggest a winner-loser methodology applied to stocks in the U.S. market which Richards (1996) applies to emerging markets and finds that at longer horizons there appears to be some evidence tests of negative autocorrelation in relative returns.³⁶ However, because of the short sample available, the estimated return differentials on winner and loser portfolios (being at least 10 percent a year) only show marginal statistical significance.

The handful of studies investigating stock exchanges in Eastern Europe (which have only been or in the process of being recently established in the 1990s since embracing free market economics), in the main, also test for departures from the random walk hypothesis. For instance, Bolt and Milobedzki (1993) using data from 1991-1993 for the stock exchange in Poland, conclude that the non-stationarity of the price series of the few listed firms can not be rejected. However, they also note in their later paper (Bolt and Milobedzki (1994)) that institutional sources of distributional deficiencies of the rates of return quoted on the stock exchange require caution in the use of standard methodology and hence any results should be treated with the appropriate discretion.³⁷ Recognising that such new markets are very unlikely to be efficient, Emerson, Hall and Zalewska-Mitura (1996) undertake an interesting approach

³⁵ Simulated critical values are used in this analysis for a number of reasons, i.e. the bias in estimated autocorrelations, the short sample period necessitating the use of overlapping data which introduces a moving-average error term (see Kim, Nelson and Startz (1991) and, the fact that emerging markets may exhibit non-normality in returns hence rendering conventional test distributions incorrect (see Harvey (1995) and Claessens, Dasgupta and Glenn (1995a)).

³⁶ See Debondt and Thaler (1985) for details and Ball, Kothari and Shanken (1995) for a discussion of possible problems with the winner-loser tests.

³⁷ Since its establishment in 1991, the Warsaw Stock Exchange in Poland has imposed constraints on the movement of returns in an attempt to reduce potential destabilising fluctuations of stock returns on a thinly or narrowly traded market.

considering whether and how the stock markets are becoming *more* efficient over time. They propose a model of excess returns of stocks using a multi-factor model with time-varying coefficients and generalised auto-regressive conditional heteroskedastic (GARCH) errors. Applied to four Bulgarian shares from 1994-1996, the study finds that there seems to be little evidence of the final stage emerging where the market becomes informationally efficient. Finally, Macskasi and Molnar (1996) investigate the market index on the Hungarian Stock Exchange over the period 1991-1996. The study reports highly significant autocorrelation coefficients of daily returns, again providing strong evidence of short-run return predictability.

In summary, there is evidence of positive correlation in short horizon returns in emerging markets (which is significantly greater than the correlation found in industrial markets), and weak evidence of subsequent return reversals over the longer horizon, although this may however be characteristic of the short sample periods available. One explanation often suggested to explain the positive correlation in short horizon returns is the possibility of insider trading by market participants who have superior information to others (see Claessens, Dasgupta and Glen (1995a)). On the other hand, it may be due to uninformed traders, even including foreign investors, who simply just extrapolate past return behaviour. As suggested by Richards (1996), the uninformed traders may also explain the possible negative autocorrelations found at longer horizons since they may cause prices to overreact to information flows, thus requiring subsequent correction.³⁸ Moreover, further complicating the matter, the observed patterns in return behaviour (i.e. positive autocorrelations and subsequent return reversals) are consistent with both various models of investor overreaction and equilibrium models of time-varying risk and required returns. However, as previously noted, structural change, short sample problems and segmentation from the world market make it difficult to assess risk and therefore forcing mere speculation on the causes of the observed patterns in return autocorrelations.

³⁸ It is interesting to note that the return reversals estimated in Richards (1996) are only slightly larger than those observed in developed markets, and in a study by Chan, Jegadeesh and Lakonishok (1995), there is evidence that even large U.S. companies display significant positive (albeit relatively far smaller) autocorrelation over several quarters suggesting that developed markets may be subject to the some of the same influences as developing markets.

Predicting Returns with ex-ante observable variables

There is an increasing body of research documenting the ability of pre-determined variables to predict returns, and more recently, research has focused on variables designed to proxy the expected risk premium in the equity market using variables related to the current level of asset prices. For instance, Harvey (1991) finds that U.S. dividend yield and term structure variables predict monthly returns on a wide range of common stock portfolios and Campbell and Hamao (1992) find similar evidence for Japanese and U.K. stocks (see also Fama and French (1989)). Hence, the general finding that common risk factors explain a large fraction of the time and cross-sectional variation in returns in industrial countries implies that these returns can be predicted using a common set of instruments. Accordingly, this suggests that industrialised economy markets are (at least from 1980 onwards) relatively well integrated and therefore a possible way to measure integration is to test for any commonality in the factors driving the predictability of returns across countries. Another implication of the findings is the argument for a more time-varying expected returns explanation of the results as opposed to an inefficient market explanation. In this section, we review the studies implementing similar approaches when investigating emerging markets.

Many of the studies investigating predictability use a common set of instrumental variables drawing on studies of U.S. and other industrial economy returns. For instance, Buckberg (1995), following Harvey (1991), includes five instrumental variables in the information set containing instrumental variables aiming to replicate the information investors use to predict returns (i.e. to proxy expected excess returns). The common information set used for all markets - developed and emerging - are, the lagged world excess stock return, given that Fama (1970) and many other studies since have found autocorrelations in returns; a dummy variable for the month of January, since Keim (1983) and Gultekin and Gultekin (1983) find systematically higher returns in January in the United States and other industrial economies, and Claessens, Dasgupta and Glen (1993) find statistically significant January effects in seven of eighteen emerging markets; the dividend yield on the MSCI world index given the importance of this term in predicting U.S. returns found by Fama and French (1988, 1989) and also lagged dividend yields in predicting international returns (see Cutler, Poterba and Summers (1989)); a U.S. term structure premium, where Campbell and Hamao (1989) have found that measures of this variable statistically explain returns in Japan and the United States; the U.S. default risk-yield spread,

included following the findings of Keim and Stambaugh (1986) and Fama and French (1989) that the variable helps in predicting stock market returns. In addition, the information set for emerging markets also include local instruments, involving the lagged rate of local return in the local market, the lagged local dividend yield and the lagged dollar-local currency exchange rate. Bekaert and Harvey (1994), Harvey (1993) and Bekaert (1995) also use basically the same (or a sub-set of the) instruments following the finding in Bekaert and Hodrick (1992) that these instruments predict excess returns on equities and foreign exchange in Germany, Japan, the United Kingdom and the United States.³⁹

Bekaert (1995), regressing the dollar index return in excess of the U.S. interest rate for nineteen emerging market economies taken from the EMDDB over the period 1985-92, finds that the joint predictability test for all five instruments rejects the null of no predictability at the one percent level for six economies, namely, Chile, Columbia, the Philippines, Portugal, Venezuela and Zimbabwe. This rejection, except in the case of Portugal, appears to derive from the local instruments and Malaysia, Brazil, the Republic of Korea and Turkey are also found to reject the null for no predictability of the local instruments.⁴⁰ Hence, the studies find that mainly due to the higher autocorrelation of returns in emerging markets, the expected rates of return in these markets are more predictable relative to industrial economies and that they generally vary through time.

On investigating the issue of the possible integration indicated by the commonality of instruments in driving the predictability of excess returns across all markets, Bekaert (1995) finds that global instruments are less important for developing countries than for industrial countries. However, comparing the periods 1985-92 and pre-1985, Bekaert also observes that global predictability has *declined*, and this therefore complicates the interpretation of predictability through common factors as an indication of markets integration, especially since there is no clear pattern on how predictability for individual emerging markets changes over time. For instance, the predictability arising from global factors for Greece, India, Korea, Mexico and Thailand was actually stronger in the early periods. Given these findings, Bekaert therefore concludes that predictability *per se* does not yield much useful information about market segmentation.⁴¹ Nevertheless, the apparent decline in global predictability is not necessarily inconsistent with the fact that most markets became more open to foreign

³⁹ For instance, Bekaert (1995) uses local dividend yield and lagged excess return, and the three global instruments being the U.S. lagged excess return, the U.S. dividend yield and the U.S. interest rate relative to a one year backward moving average.

⁴⁰ Note that this is not necessarily evidence of market inefficiency since the predicative power of the dividend yield drives some of the rejections.

⁴¹ As discussed in section 3.3.2, based on these results, the author derives a more appropriate measure of market

investment during the 1980s. For instance, Buckberg (1995) finds that by comparing correlations for sub-samples 1976-84 and 1985-91, the correlations between emerging and industrial markets have risen over time, and those emerging markets best correlated with industrial markets are those best known to foreign investors.⁴² These include, for example, Malaysia (displaying the highest correlation at 0.51), Thailand, Portugal, Korea, the Philippines, Mexico and Taiwan (China), all exhibiting correlations in excess of 0.25, while economies offering consistent hedges against the world markets comprise Argentina, Indonesia, India, Turkey, Venezuela and Zimbabwe.⁴³

In summary, although predictability *per se* does not provide really useful evidence of market integration and some empirical approaches can be problematic, most of the evidence based on asset prices reviewed so far suggests that emerging markets (i.e. the EMDB of Latin-American and Asian markets) until the mid-1980s were not integrated with the world financial markets. However, the evidence also suggests that they are becoming increasingly integrated. Moreover, recent evidence based on actual investment by Tesar and Werner (1995a, 1995b) shows that the share of recent U.S. outward equity investment going to emerging markets in total U.S. outward equity investment is in line with the share of the market capitalisation of emerging markets in global capitalisation. Hence, although the authors find significant 'home bias' for developing countries, they find that at the margin the home bias has more recently disappeared and markets are becoming *de facto* integrated. Finally, the policy implications of the mentioned studies have been that, in general, it would be beneficial to gradually lower the barriers to investment.

A related concern to barriers to integration is whether there is a relation between large equity flows into the emerging markets and stock return volatility following liberalisation or, in other words, whether allowing foreign access will lead to more volatile domestic markets. Also of interest is whether portfolio flows and equity flows, in particular, received by developing markets are volatile. Both concerns can be potentially destabilising to financial markets and hence to the economy. In the next section we therefore consider the evidence on stock return volatility in emerging stock markets.

integration.

⁴² A consistent finding of all studies has been the relatively lower (or negative) correlation of emerging markets with the world portfolio and industrial markets compared to the correlations between industrial markets and also with the world portfolio.

⁴³ See Bekaert (1993, 1995) for links between market correlation and market integration.

3.3.4 Volatility of Stock Returns

Understanding volatility in emerging markets is important for determining the cost of capital and for evaluating direct investment, portfolio diversification and risk hedging strategies. One recognised characteristic of the volatility of stock returns in emerging markets is the relatively higher volatility compared to mature markets. Since in segmented capital markets risk premiums may be directly related to the volatility of equity returns in the market, the question of higher volatility is an important one. Furthermore, not only will higher volatility imply higher capital costs, it may also delay investments where investors may decide to exercise the 'option to wait'. Therefore, given that it is a key issue in the development of emerging markets and especially to policy-makers deciding on the costs and benefits of various liberalisation initiatives, research investigating volatility on these markets has pursued in a number of different areas. In this section, we provide a brief overview of these areas bearing in mind the difficulties associated with modelling volatility in emerging markets (as noted in Bekaert and Harvey (1997)).⁴⁴

Firstly, there have been concerns that portfolio and equity flows to emerging markets are volatile and hence destabilising to the domestic financial market and economy. The conventional view is that short-term flows and portfolio flows to emerging markets especially, are inherently unstable and therefore may require some policy action. As a result, many developing countries have attempted to encourage longer-term flows (through subsidised foreign direct investment, for example) and positively discourage short-term flows (through quantity constraints, taxes and other instruments). However, Claessens, Dooley and Warner (1995) using data for five developing countries and five industrial countries find that there are no significant differences between the time series properties of short-term and long-term flows. Furthermore, since there also find active substitution between the various capital flows, any policy aimed at discouraging any particular flow because of its apparent volatility may be ineffective. Hence, the authors suggest that if flows are volatile, aggregate macro-policies aimed at achieving desired overall capital behaviour are likely to be more effective.⁴⁵

⁴⁴ For instance, firstly, we have seen that the evidence suggests that market returns are unlikely to be normal and hence the application of the standard modelling techniques are unlikely to be satisfactory (for instance, Engle's (1982) and Bollerslev's (1986) autoregressive conditional heteroskedasticity models) See Bekaert, Harvey and Viskanta (1998) for further discussion on the distributional characteristics of emerging market returns. Secondly, variance specifications should allow for time-conditional means given the earlier evidence on return predictability (see section 3.3.3). Thirdly, given the changing degree of integration of emerging markets over time, models should ideally incorporate the changing importance of local and world information over time.

⁴⁵ This conclusion is supported by Corbo and Hernandez (1994) who, after reviewing the experience with managing capital flows for nine countries, find that aggregate demand measures (fiscal contractions) have been the most effective.

A second concern which is of popular interest is the volatility of stock prices before and after the opening of the stock market to foreign investors or after large foreign capital inflows. There are a number of authors who have investigated such behaviour, for example, Kim and Sengal (1993), De Santis and Imrohorglu (1994), Tesar and Werner (1995a), Levine and Zervos (1995a), Bekaert (1995), Richards (1996), Choudhry (1996) and Bekaert and Harvey (1997). The studies so far, however, have yielded mixed conclusions. For instance, Tesar and Werner (1995) investigating the time series behaviour of U.S. equity flows into emerging markets find no relation between U.S. flows and the volatility of stock returns. In support of this, Kim and Singal (1993) compute estimates of domestic currency monthly returns for twenty emerging markets and conclude that there has been no increase in volatility over time and further that volatility has tended to decrease after market liberalisation. De Santis and Imrohorglu (1997) undertake a detailed study of stock return volatility for fourteen emerging markets from the EMDB over the period 1989 to mid-1996. As well as finding strong evidence of time-varying volatility, they find that although both at the unconditional and conditional level volatility is considerable higher compared to developed markets, the prediction that liberalisation increases market volatility is not supported by their results. In contrast, Levine and Zervos (1995a) suggest that volatility may increase after liberalisation. More generally, Finally, Bekaert and Harvey (1997) test a variety of sophisticated models of conditional volatility and find that, following market liberalisation, volatility is unchanged or lower in thirteen out of seventeen markets. Even after controlling for the potential influences on the time series and cross-section of volatility, they find that capital market liberalisations significantly decrease volatility in emerging markets. Finally, Reinhart and Reinhart (1994) also show that no generalised increase in volatility in emerging markets has accompanied the increase in equity flow into these markets.

In general then, the strength of the early evidence (although it is as yet not conclusive) seems to imply that flows of foreign equity into emerging markets following liberalisation has no effect on short-run volatility and if any, the tendency is for volatility to decrease. Therefore, although the volatility of stock returns is certainly higher in emerging markets relative to industrial markets and large numbers of foreign investors may at times contribute to large changes in asset prices (see Aitken (1998)), the majority of early evidence suggests that foreign inflows do not seem to be a contributing factor to this higher level.⁴⁶

⁴⁶ Mullin (1993) shows that earnings may show greater volatility because of the greater volatility in economic policies in these markets. Bekaert and Harvey (1997) investigate why volatility is different across emerging markets concentrating on factors such as asset concentration, the stage of stock market development, microstructure effects, macroeconomic influences and political risk and see also Richards (1996) for a general

3.4 Concluding Comments

Summarising the research findings, the empirical evidence has found that emerging markets were not well integrated with the world financial markets until the early 1980s and increasingly they are becoming more integrated. For instance, Buckberg (1995) reports rapidly increasing price-earning ratios in selected emerging markets and found that from 1988-1991, in seven of the twenty emerging markets in the EMDb, price-earnings ratios more than doubled, and in four countries (Argentina, Chile, Pakistan and Turkey), the ratio more than tripled. In contrast, the price-earnings ratio of the MSCI world index only rose by 22 percent. These findings suggest that although unexploited profit opportunities still may exist in emerging markets, the change in price-earnings ratios also signal ongoing transition in these markets where the lack of integration has likely motivated the larger inflows of foreign equity recently. Despite the increasing integration (and hence more comparable costs of capital with the world markets), the general policy conclusion has been towards continuing to lower the barriers to foreign equity flows. The most important barriers have been found to be instability, underdeveloped stock markets and a de facto lack of openness, and policies towards providing investor protection, a solid regulatory and accounting framework, fewer restrictions on foreign ownership are at the least the first step in helping to remove the barriers. The stock returns in the short run have been found to be more predictable in emerging markets relative to industrial market although only weak evidence of return reversals has been found over the longer horizon. Predictability *per se* with ex-ante observable variables as an indication of integration has however found to be not altogether useful. Finally, the conventional views that equity and portfolio flows into emerging markets are inherently unstable or cause destabilising effects through the volatility of stock returns have so far been unfounded.

Nevertheless, the research on emerging markets is still in its early stages where many of the empirical studies inevitably suffer from the short sample period available. This is especially true for the relatively new Eastern European stock markets, on which, as observed, there are only a handful of studies. This independent research on Eastern European markets is particularly important due to the different pressures giving rise to these markets (as outlined in chapter 2) and therefore in terms of implications for other infant markets in (Central as

discussion on the causes of high volatility in emerging markets.

well as) Eastern Europe. Further research on the benefits of foreign equity flows on corporate governance, stock markets and economic growth is still required in all emerging markets and again, would provide valuable insights not only for the development of the market concerned but also for those markets which are still being established. Needless to say, this also involves a thorough investigation of the effect of particular barriers to investment. Lastly, the interaction between the stock markets and the whole financial system has important implications for the development of the economy and therefore this, in itself, is a reason for promoting much needed research in the area of emerging stock markets.

CHAPTER 4

THE ECONOMICS OF MARKETS IN DISEQUILIBRIUM

Summary

In this chapter, we consider two main issues in a theoretical framework. The first part basically involves the theoretical formulation of a model representative of a market in disequilibrium such as the WSE, and the second part considers the issue of predictability in such a market facing quantity constraints.

In the first part, we show that the traditional ‘economics of equilibrium’ needs to be abandoned essentially because of the strong underlying assumption of market equilibrium no longer holds and we apply the disequilibrium framework introduced by Benassy (1982) to the market under consideration. We extend the single market setting to that of a multi-market, incorporating cross and intertemporal spillover effects, and note the appropriateness of such a framework to a market mechanism such as that existing on the WSE. Relying on ideas proposed by Benassy (1982) and Dreze (1975), we propose a more explicit model of traders’ behaviour on a market experiencing quantity constraints from which we are able to make inferences about asset predictability in such a market.

In the second part,¹ we propose a model of a disequilibrium trading system such as that existing on the WSE and analyse the predictability on the hypothetical market. We show that the expected value of returns (adjusted for drift) of an asset conditional on the last period information concerning a truncation can be equal to zero in certain circumstances. In particular, if there is some kind of funds withdrawal process due to a quantity spillover in relation to other stocks or to non-market assets, the market for the asset may not be predictable. Hence, the imposition of upper and lower price limits may not necessarily be a source for market predictability.

¹ This part is an extended version of Charemza, Shields and Zalewska-Mitura (1997).

4.1 Introduction

In chapter 2, we noted that the price setting mechanism on the WSE has a number of peculiarities associated with it distinguishing it from the more familiar price setting frameworks on stock exchanges. Briefly, once investors have submitted their limit orders to the exchange, the specialist broker calculates the price of the day of the particular stock with objectives to (i) maximise the turnover for the day; (ii) minimise the difference in the new price from that of the last session; and (iii) match buy and sell orders as closely as possible. However, the computed price of the day can not differ by more than 10 percent from one session to the next, where if this ‘unbalanced’ market does arise, the price is fixed at a value of 10 percent higher or lower than the previous session price. A number of scenarios then follow depending on the severity of the excess demand or supply and the discretion of the specialist. In the ‘balanced’ market case, the price of the day lies within the upper and lower boundaries of the 10 percent change in the price, and any small excesses in demand or supply resulting, once the above three conditions have been taken into account in calculating the price, are reduced or eliminated in the previously described ways by the specialist broker (i.e. overtime trading may ensue, the broker may buy or sell the excess at fixed prices, or he may totally or partly reduce some orders). In this chapter, we consider whether this particular price setting mechanism can simply be embedded in equilibrium theoretical foundations and if not, is there an alternative economic theory which reflects the conditions of ‘disequilibrium’ in a market of the above kind.²

The chapter is divided into two main parts. The first part basically involves the theoretical formulation of a model representative of a market in disequilibrium, i.e. a market that faces quantity constraints, and the second part of the chapter, in the main, concerns the issue of predictability on a market with quantity constraints. The plan of the first part of the chapter is as follows. In section 4.2, in order to clarify the price setting process on the WSE, we first present three alternative scenarios which are referred to as, the ‘equilibrium’ or balanced case, the ‘disequilibrium’ or unbalanced case, and the finally the situation leading to the suspension of transactions. These cases are referred to in the analysis that follows. We then go on to define the concepts of equilibrium and disequilibrium in economics in section 4.3, and explain the shortcomings of market equilibrium models in explaining disequilibrium phenomena. In section 4.4,

² What is meant by the term ‘disequilibrium’ is defined below in section 4.3.

we consider the determination of effective demand in the presence of quantity constraints. The framework outlined follows that of Dreze (1975) and Benassy (1982) who are two of the prominent authors in this particular field. We start by assuming a single market where we consider the existence of possible alternative types of rationing schemes. We then extend this analysis in to a multi-market dimension, which includes the consideration of possible ‘spillover’ effects which may occur when the demand or supply of an asset is constrained. Finally, in this section we discuss the relevance of the Benassy framework to the price setting system relevant to this analysis. Section 4.5 concludes the first part of the chapter by presenting a more explicit theoretical model of trader behaviour under expected quantity constraints bearing in mind the comments made in section 4.4.

The second part of the chapter involves, firstly, a consideration of the issue of predictability on a market with quantity constraints described by the *Einheitskurs*’ system. In section 4.6.1, we define what we mean by efficiency and non-predictability and briefly note the problems with studies attempting to look at efficiency and predictability on a market with disequilibrium trading, namely, the WSE. In section 4.6.2, we go on to present a representative model of a disequilibrium trading system which was first introduced in Charemza, Shields and Zalewska-Mitura (1997). Finally, we consider the implications for market predictability with reference to the model and in light of the theoretical framework presented in the previous section 4.5.

4.2 Worked Illustrations of Price Setting on a Market with Quantity Constraints

In what follows, we illustrate, simply, how the price of the day is calculated and the resulting situations on a hypothetical market characterising the WSE. Table 4.1 refers to what shall be termed an ‘equilibrium’ case for the moment, i.e. as in a balanced market, where the price of the day is within the 10 percent limits imposed on the change in price from one session to the next. Table 4.2 describes a ‘disequilibrium’ or an unbalanced market situation, where the price is limited to a positive or negative 10 percent change depending on whether there is excess demand or supply, respectively, and therefore quantity restrictions are placed on the shares traded. Table 4.3 shows the circumstances under which transactions for the share on the market are suspended.

This will arise, if, even after overtime trading, demand exceeds supply (or vice versa) by more than five times.

Table 4.1: Equilibrium Case

Buy Offers			Sell Offers	
Number of Shares		Price Limit	Number of Shares	
Offered	Cumulated (↓)		Cumulated (↑)	Offered
1500	1500	WPL		
3500	5000	220	11000	3000
2000	7000	215	8000	2000
1000	8000	210	6000	2000
2000	10000	200	4000	2000
		WPL	2000	2000

Notes: WPL refers to orders placed without the specification of a price.

The price for the share for the previous period is assumed to be at 200. This implies that the price of the day is constrained to be in the interval [180, 220]. In this case, the price of the day that will maximise turnover is 215, at which there is also an excess supply of 1000.³ Efforts are made to eliminate this small excess supply, by either, introducing an extra hour of trading which is available to all investors or the specialist broker may intervene and buy the excess shares at fixed prices with disposable funds (or alternatively, sell disposable shares in the opposing case). However, if still the excess supply is not completely removed, then some offers can be totally or partially reduced.⁴

³ Note that the smallest side of the market fully realises its desired trades. The demand side of the market in this case is referred to as the 'short-side' of the market, where trade is determined according to the 'short-side rule'. This is discussed in more detail in the following section 4.2.

⁴ Although Table 4.1 depicts an 'equilibrium' case, note the use of the word equilibrium since it usually refers to the case where trade takes place at the price equating demand and supply. In the given case, however, there is still some excess remaining and therefore the definition is not in its strict sense.

Table 4.2: Disequilibrium Case

Buy Offers		Sell Offers		
Number of Shares		Price Limit	Number of Shares	
Offered	Cumulated (↓)		Cumulated (↑)	Offered
10000	10000	WPL		
10000	20000	230	15000	10000
15000	35000	215	5000	2000
		210	3000	1000
		WPL	2000	2000

Notes: WPL refers to orders placed without the specification of a price.

Assume again that the previous price of the share is equal to 200, so therefore the price interval [180, 220] still holds. In computing the price here, the aim is to maximise turnover and match buy and sell order as closely as possible, but this time the price limit interval also needs to be taken into account. Hence, the new price is 220, which maximises turnover among 20000 buy offers and 5000 sell offers, within the given price range. Excess demand being equal to 15000 is rather large this time, and in this case the specialist will typically reduce all the buy offers by a percentage necessary to eliminate all the excess. The rate of reduction here is therefore 75 percent.

Table 4.3: Suspension of Transactions

Buy Offers			Sell Offers	
Number of Shares		Price Limit	Number of Shares	
Offered	Cumulated (↓)		Cumulated (↑)	Offered
25500	25500	WPL		
8500	33000	215	4000	1000
2000	35000	210	3000	1000
1000	36000	200	2000	500
		195	1500	500
		WPL	1000	1000

Notes: WPL refers to orders placed without the specification of a price.

In Table 4.3, with the previous session price equal to 200, and the constrained price interval for the new price [180, 220] as before, the new price is now 220. Although the declared price that maximises turnover is 215, the demand, however, exceeds supply by more than five times (or in other words the 'rate of satisfaction' is less than 20 percent). In this situation, although the price moves up by the full 10 percent, no trade is permitted to take place. A convenient way of viewing the suspension situation is from the point of view of order completion or satisfaction. The 'rate of satisfaction' measures the proportion or percentage of trades which are allowed to take place. If in a reduction/scaling down situation the buy/sell orders are reduced by say 20% to achieve equilibrium then the rate of satisfaction is obviously 80%. The 5:1 rule can therefore be interpreted to mean that the rate of satisfaction can not fall below 20%. i.e. reductions can not exceed 80%.

4.3 The Concept of Equilibrium and Disequilibrium in Economics

The discussion in the previous section makes clear the mechanism by which prices are set on a market subject to quantity constraints analogous to the WSE. Before we go on to consider whether the mechanism can be explained by the principles underlying equilibrium economics, it would be useful to define first exactly what is meant by the accustomed equilibrium economics and, in doing so, motivate the research that has been carried out in the area of disequilibrium economics.

The basic concept underlying the traditional models of market equilibrium is that, through a particular price mechanism, equilibrium prices are sufficient market signals that correctly represent the existing quantities of economic goods. Hence, the interaction of demand and supply curves, which depend on price signals, will determine the prices and quantities exchanged on the market, this point of interaction being referred to as the equilibrium point. This partial equilibrium depends on 'well-behaved' demand and supply curves i.e. that price rises for a good in excess demand and falls for a good in excess supply, and therefore on perfect competition. For illustrative purposes, let us adopt a partial equilibrium approach, usually associated with the name of Marshall, to describe the functioning of a single market. A partial equilibrium approach basically implies that each market is studied separately assuming all variables pertaining to the other markets remain constant. Although this is the simplest model compared to the more elaborate Walrasian general equilibrium model which describes how the price mechanism functions in a complex economy with many interrelated markets, it nevertheless serves our purpose here in defining the concept of equilibrium. Assume that goods are exchanged for money on markets, and p represents the price of money on one of these markets. Let the demanders and suppliers on this market be denoted by $i=1, 2, \dots, n$, where they express demand and supply as a function of the price p , i.e. $d_i(p)$ and $s_i(p)$, respectively. We shall refer to these demands and supplies as being 'notional', following the terminology of Clower (1965), since each agent can realise his desired trade at the proposed price. Then, on aggregation of the individual functions, we can derive aggregate demand and supply curves, where their interaction determines the equilibrium price p^* , i.e. the equality of $D(p^*)$ and $S(p^*)$, in Figure 4.1 below, where,

$$D(p) = \sum_{i=1}^n d_i(p), \quad \text{and} \quad S(p) = \sum_{i=1}^n s_i(p), \quad (4.1)$$

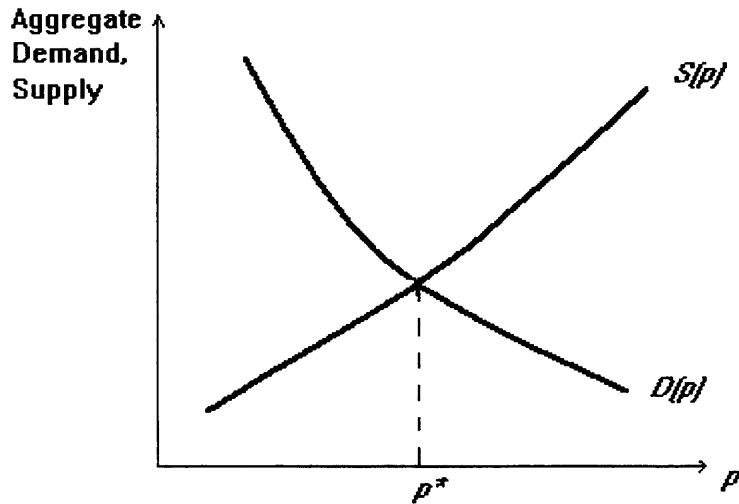


Figure 4.1: Equilibrium point

Once this analysis is extended to all markets, we are able to summarise the main characteristics of models under the concept of equilibrium economics (in the neo-classical sense) as follows⁵:

- (i) there is equilibrium in the above sense of demand and supply on all markets considered;
- (ii) this equilibrium is achieved essentially by price adjustments; and
- (iii) agents on the market react to price signals only.

However, although these characteristics encompass a wide range of models, for instance, from the partial equilibrium models of Marshall (1890), and the general intertemporal equilibrium methods of the Walras-Arrow-Debreu framework (see Walras (1974), Arrow and Debreu (1954), Debreu (1959)) to temporal equilibria developed by Hicks (1939), they cannot explain certain aspects such as Keynes' involuntary unemployment or, more generally, the under-

⁵ Note that there are two main interpretations of the word 'equilibrium'; the first refers to market equilibrium in the above sense where demand and supply are equal; the second refers to a steady state or the state of rest of a system. We relate to the former definition in this context, and if not, hopefully, it will be clear from the discussion exactly which meaning is being used.

utilisation of economic resources.⁶ Furthermore, the models fail to adequately portray existing market mechanisms and the forces of demand and supply due to imperfect competition, for example, there are cases where price competition may partially be replaced by advertising and product differentiation⁷, and also, depending on the type of good, the full adjustment to market equilibrium may not be socially feasible in reality. It also may be the case that some prices may be institutionally constrained such as in planned economies where prices may be fixed for some length of time, or as for the WSE, where limits are imposed on price changes. Apparent reasons for the failure to accommodate such variants is that these phenomena are, by definition, not included in equilibrium economics even though they form the core of Keynesian macroeconomic theory, and therefore, the basic assumptions of equilibrium theory are easily rejected. Moreover, weaknesses arise in the basic Walrasian model due to the fact that market clearing is taken as an axiom rather than being rigorously derived from a micro analysis of price-taking behaviour. Consequently, a 'reappraisal of Keynesian economics' began during the 1960's, addressing the inability of conventional macroeconomic theory to address apparently disequilibrium phenomena such as unemployment and inflation. There have been two main strands of literature which have developed in response; the first concerns the inclusion of uncertainty into microeconomics (see Hey (1979a) for a survey of this literature); the second, which is of relevance here, is the smaller body of literature on the inadequate treatment of quantity constraints in the general equilibrium theory underlying economics. Alternative theories of disequilibrium states have therefore been developed with a view to describing the usual competitive systems as well as systems with imperfect competition with wage and price rigidities. General theories reinterpreting Keynesian economics as the economics of market disequilibrium were first proposed by Clower (1965) and Leijonhufvud (1968) who show that in the absence of a Walrasian auctioneer (through which markets are cleared in equilibrium economics), the probability of equating demand and supply in all markets is very small. In effect, Leijonhufvud (1967) noted that to generate a Keynesian system from a neo-Walrasian model, "it is sufficient only to give up the strong assumption of instantaneous price adjustments To make the transition from Walras' world to Keynes' world, it is thus sufficient to dispense with the assumed *tatonnement* mechanism..... To be a Keynesian,

⁶ It is not difficult to see how macroeconomic models in the tradition of Keynesians violate the above main characteristics; for instance, at least one market, i.e. the labour market is clearly not in equilibrium; adjustments take place through the level of income in the goods market, for example, and therefore not solely through price movements; and agents react to signals other than purely price signals, for instance, to the income level in the consumption function.

one need only realise the difficulties of finding the market-clearing vector” (also in Clower, 1970, pp. 300-2). They both conclude that there are short-run adjustments through quantities as well as through prices, i.e. the level of activity is an adjustment variable as well as the price, and argue that this is central to the ideas presented by Keynes (1936) in the *General Theory of Employment, Interest and Money*. Other authors presenting similar notions include Hansen (1951), Patinkin (1956) and Hicks (1965) (see Weintraub (1979) for a comprehensive assessment of these), where, in general, we can propose the main characteristics of disequilibrium models now to be as follows:

- (i) some markets may not be in equilibrium;
- (ii) adjustments can be made through quantities as well as prices; and
- (iii) agents react to quantity signals as well as price signals.

Having outlined briefly what is meant by the economics of equilibrium and disequilibrium, we can illustrate in more detail the short-comings of the Walrasian-type equilibrium models in explaining disequilibrium phenomena in the form of quantity rationing using a simple example. This understanding is necessary in order motivate the following section which considers the determination of demand or supply (no longer notional) in a market where demand and supply may not be equal and which faces possible quantity constraints, as in the hypothetical market described in section 4.1.

4.3.1 An Equilibrium Approach to Explain Market Disequilibrium

In the simplest isolated market case, let us consider the transactions that will take place when the price is not at its equilibrium point. Although little is said in the literature about transactions realised at the individual level, at the aggregate level, however, it is given that, in the absence of friction, agents on the short side of the market will realise their desired transactions where the ‘short’ side of a market is that where the aggregate volume of desired transactions is smallest.⁸ The short side rule is also known as the ‘rule of the minimum’ stating aggregate transactions will

⁷ Furthermore, increasingly there are prices which are cost-determined.

⁸ Hence, if there is excess supply, the short side will be the demand side, and the ‘long’ side will be the supply side, and vice versa.

take place at the minimum of demand and supply. This is shown in the following Figure 4.2, where transactions take place along the solid line.

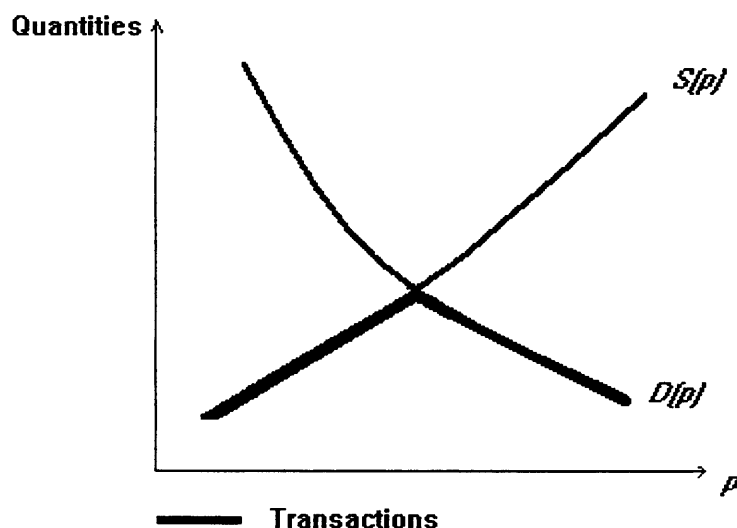


Figure 4.2: The Short Side Rule

Two important properties are satisfied by this rule (see Clower (1960)), i.e.,

- (i) voluntary exchange, implying that no agent is forced to exchange more than he wants; and
- (ii) market efficiency, with the property that in the absence of friction, no extra exchange would be beneficial to both demanders and suppliers.

Once this equilibrium framework is extended to included many markets however, as explained in Benassy (1982), the resulting Walrasian-type general equilibrium model, explicitly introducing interdependencies amongst markets, is unable to explain disequilibria in macroeconomic models. Why would this be the case? We have seen that in the single market case, when the price is out of equilibrium, the short side rule applies. Hence, the logical step in determining the transactions for the Walrasian multi-market system would be to apply the single-market short-side rule so that aggregate transactions for each good would minimise total supply and demand. However, there is an internal consistency in this argument arising from the violating either feasibility or the agents' budget constraints. For example, a firm facing excess demand for its inputs and outputs will

purchase fewer inputs than its Walrasian demand.⁹ But, at the same time, excess demand on the output market implies that sales will equal Walrasian supplies. We therefore have a technologically infeasible situation where Walrasian outputs are produced with fewer inputs than the Walrasian inputs. Similarly, a household's transactions would violate its financial constraint if it faces excess supply for the goods it buys since its sales would be lower than its Walrasian supplies but its purchases equal to its Walrasian demands. Clearly, the short-side rule does not work in a multi-market economy with traditional Walrasian demands and supplies.

We can conclude from this discussion that to study economics in disequilibrium, the standard theory of prices, demand and transactions, where demand represents a first approximation to desired trades and transactions are the exchanges actually carried out on the market, need to be abandoned essentially because the strong underlying assumption of market equilibrium no longer holds. This assumption intervenes firstly in that the condition of equilibrium between supply and demand determines prices and transactions endogenously from the demand and supply functions. Secondly, the demand and supply functions themselves are determined under an assumption concerning equilibrium in that the transactions will be equal to demands and supplies. The following section therefore considers the development of a market disequilibrium framework where demands and supplies need to be reconstructed to deal with possible quantity constraints such as those experienced on the WSE when prices change by more than 10 percent. In view of the above analysis, we will also need to determine how transactions will be carried out in a market in disequilibrium and therefore how quantity signals will be generated in the process in the absence of the equilibrium assumption when demands and supplies are not equal.

4.4 Effective Demand Determination in a Disequilibrium Market

Early works by Clower (1965) and Leijonhufvud (1968) provide the starting points of much work concerning effective demand, where Clower (1965) showed how to re-interpret the Keynesian consumption function in a non-clearing market framework. In this section, however, we concentrate on presenting disequilibrium models relying on the work of Benassy (1975a, 1977b, 1982b) and Drèze (1975) who have been primarily responsible for generating the line of inquiry

⁹ Walrasian demands and supplies refers to those demands and supplies arising in the Walrasian general equilibrium context in which the price vector prevailing is the market clearing one, i.e. desired demands equal desired supplies for all goods. These demands and supplies are also referred to as 'notional'. These concepts however are described in

concerning quantity rationing.

Note firstly that notional demands (i.e. the Walrasian demands found in equilibrium theory being a function of price signals only) are no longer relevant here, and instead we work with *effective* demands and supplies which are functions of price *and* quantity signals, and are those that are expressed on disequilibrium markets. Although ‘effective’ demands and supplies are defined in more detail later in the text, briefly, effective demands and supplies are basically those calculated taking actual constraints on trade into consideration. We begin the analysis in the context of a single market setting for a specific asset assuming alternative types rationing schemes, where the term ‘rationing’ indicates the fact that purchases will differ for demands and sales from supplies in the presence of quantity constraints, and a ‘rationing scheme’ represents the trading process on a market. The two types of rationing schemes considered are ‘manipulable’ and ‘non-manipulable’, and we examine which type may exist on the WSE. A manipulable rationing scheme is basically when an agent, even when rationed, can increase his transactions by announcing higher demands, say, and thus is ‘manipulating’ the exchange process. On the other hand, a non-manipulable rationing scheme is when an agent is faced with bounds on his transactions that depend only on the demand and supply of the other agents and which he cannot manipulate.

The analysis is then extended into a multi-market approach, where it is recognised that quantity constraints on one market not only affects effective demand on the same market, but also affects (differently) effective demand on other markets.¹⁰ More formally, we can say that ‘spillover’ effects occur when an agent who is constrained to exchange less than he wants in a market because of rationing modifies his demands or supplies in the other markets. For example, spillover effects in the Benassy sense can be applied to the stock market where quantity constraints on one stock may cause spillover effects into the effective demand for another stock (on the same market) or even influencing effective demands for goods outside the stock market (i.e. so that there is a withdrawal of funds from the market).¹¹ These can be referred to as cross-spillover effects. We examine how spillovers are dealt with by Benassy in the disequilibrium framework, and we show how the model can be adapted to incorporate intertemporal spillover

more detail later in the text.

¹⁰ These ‘spillover’ effects are traditionally associated with the idea of effective demand in Keynesian theory.

¹¹ As a more familiar illustration in the Benassy spirit, labour income constraints will clearly affect the effective demand for goods of households and hence, agents constrained to exchange less than they want in one market has caused the modification of demand and supply in another market.

effects where an asset constrained in one time period may affect effective demand in the next period for the same asset. Note already that the meaning of effective demands and supplies reflects a certain ambiguity relative to notional demands supplies, since one can envisage a number of ways that an agent may take constraints into account when calculating his optimal strategy. Therefore, in considering the Benassy approach to the determination of effective demands and supplies, we also need to assess its relevancy to the quantity-constrained price-setting mechanism existing on the WSE. Hence, we finally conclude the section by discussing the Benassy framework in general and with reference to the pricing mechanism presented in section 4.1.

4.4.1 Disequilibrium Trading on a Single Market

We start by assuming that traders' effective demands and supplies expressed on a single market are given by \tilde{d}_i and \tilde{s}_i , where, *a priori*, there is no reason to assume that they balance, i.e.,

$$\tilde{D} = \sum_{i=1}^n \tilde{d}_i \neq \sum_{i=1}^n \tilde{s}_i = \tilde{S} \quad (4.2)$$

Nevertheless, the market rationing scheme generates from these inconsistent effective demands and supplies, a set of realised transactions given by d_i^* representing purchases and s_i^* denoting sales. By definition these balance since they reflect actual exchanges that take place, i.e.,

$$D^* = \sum_{i=1}^n d_i^* = \sum_{i=1}^n s_i^* = S^* \quad (4.3)$$

We can also note that the rationing scheme reflecting the price setting process on the WSE satisfies the properties of voluntary exchange, i.e.,

$$d_i^* \leq \tilde{d}_i, \quad s_i^* \leq \tilde{s}_i, \quad \text{for all } i. \quad (4.4)$$

where no agent is forced to exchange more than he wants, and of market efficiency where all mutually advantageous trades are carried out, when there is a balanced situation in the market but

it still may not completely clear and also when there is an unbalanced market where quantity restrictions are imposed. Both these properties imply that there will not be rationed suppliers and rationed demanders at the same time on the market, and hence (as can be seen from Tables 4.1 and 4.2), the short side rule is a consequence.

In addition to the existence of a rationing scheme on a disequilibrium market, Benassy postulates that the agent (assumed to be rational) must still perceive some relation between transactions and demands in order to link his demands and the eventual transactions. This relation is referred to as a perceived rationing scheme which expresses transactions as a function of the demand that the agent will express. The perceived rationing scheme is an *expected* relation between transactions and demand. Therefore, the scheme may be stochastic and hence represented by a probability distribution on the transaction being conditional on the effective demand or supply expressed, or it may be deterministic. We assume, for simplicity, a deterministic perceived rationing scheme; see Benassy (1982b), Appendix B, where implications of a stochastic scheme is considered. Hence, if these expectations are held with certainty, we can write the perceived rationing scheme as the following functions,

$$d_i = \phi_i(\tilde{d}_i) \quad \text{for a demander,} \quad (4.5)$$

or,

$$s_i = \phi_i(\tilde{s}_i) \quad \text{for a supplier.} \quad (4.6)$$

In general, we assume that ϕ_i is a non-decreasing function and that the voluntary exchange assumption holds, so that,

$$\phi_i(\tilde{d}_i) \leq \tilde{d}_i, \quad \phi_i(\tilde{s}_i) \leq \tilde{s}_i \quad (4.7)$$

Having defined the main notation, then with a given perceived rationing scheme, effective demand will be the outcome of the agent maximising the utility of the transaction that he expects to result from his demand. This can be written as the solution of the following optimisation program,

$$\begin{aligned} &\text{Maximise } V_i(d_i) \\ &\text{subject to } d_i = \phi_i(\tilde{d}_i) \end{aligned} \tag{4.8}$$

However, the application of this, depending on the type of the rationing scheme, causes a few problems. Earlier we distinguished between a manipulable and non-manipulable rationing scheme. We find that a few problems arise depending on whether agents perceive the rationing scheme to be manipulable or non-manipulable. Let us consider the non-manipulable case first.

Non-manipulable rationing scheme

A non-manipulable rationing scheme can be shown as in Figure 4.3, where an agent is unable to manipulate the amount of transactions received once he has been rationed.

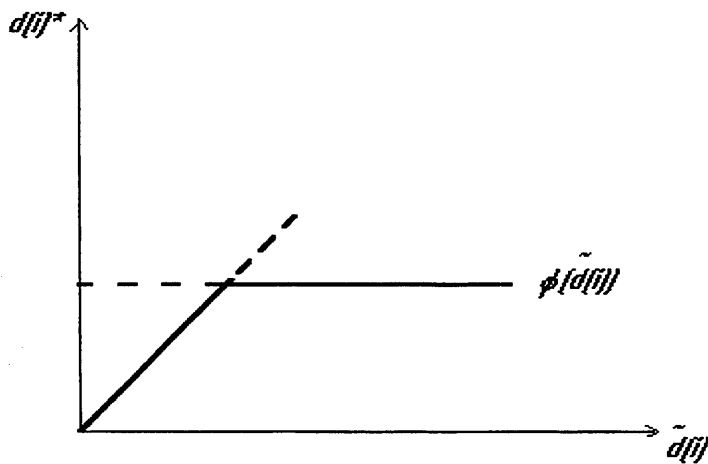


Figure 4.3: Non-Manipulable Rationing Scheme

Therefore, if \bar{d}_i^e represents the *expected* bound on agent i 's purchases, then the non-manipulable

perceived rationing scheme can be expressed as follows,

$$\phi_i(d_i) = \min(\tilde{d}_i, \bar{d}_i^e) \quad (4.9)$$

Then, effective demand becomes a solution in \tilde{d}_i of

$$\begin{aligned} &\text{Maximise} && V_i(d_i) \\ &\text{subject to} && d_i = \min(\tilde{d}_i, \bar{d}_i^e). \end{aligned} \quad (4.10)$$

However, if the target demand is denoted by \hat{d}_i , i.e. so that it is ‘notional’ given that it is constructed under the assumption that the transaction will equal the demand, then the solution to the above problem will differ in nature depending on the position of \bar{d}_i^e with respect to \hat{d}_i . For instance, if $\bar{d}_i^e \geq \hat{d}_i$, then the agent can realise his optimal transaction and express it as his effective demand, i.e. $\tilde{d}_i = \hat{d}_i$. But if $\bar{d}_i^e < \hat{d}_i$, then the agent is constrained to trade less than desired and the best transaction expected is \bar{d}_i^e . However, this transaction will be obtained by expressing any demand between \bar{d}_i^e and infinity, implying that the above program giving effective demand will have an infinity of solutions thus suggesting that there is a problem in its definition. Nevertheless, we can still show that in the absence of manipulation, the agent will express his target transaction as effective demand, i.e. $\tilde{d}_i = \hat{d}_i$. One reason because \hat{d}_i is in the set of solutions to the above program *whatever* the value of \bar{d}_i^e , and it is the *only* demand to have this property. Any uncertainty in the forecast of the constraint that the agent face’s will therefore lead him to chose \hat{d}_i as his effective demand, since it will be the only demand which will ensure the best possible transaction against *any* constraint.¹²

¹² Note that since the perceived rationing scheme reflects an *expected* relation between the transaction and demand, it may be stochastic. In this case, Benassy (1982) shows that if \bar{d}_i^e is forecasted probabilistically with a cumulative subjective probability distribution $\psi_i(\cdot)$, then when an agent maximises the expected utility of his transaction with respect to this probability distribution, he will express a well-defined effective demand equal to the target transaction \hat{d}_i .

Manipulable rationing scheme

The manipulable rationing scheme (perceived) can be shown in Figure 4.4, where agent i , even once rationed can manipulate the rationing process to increase his transactions.

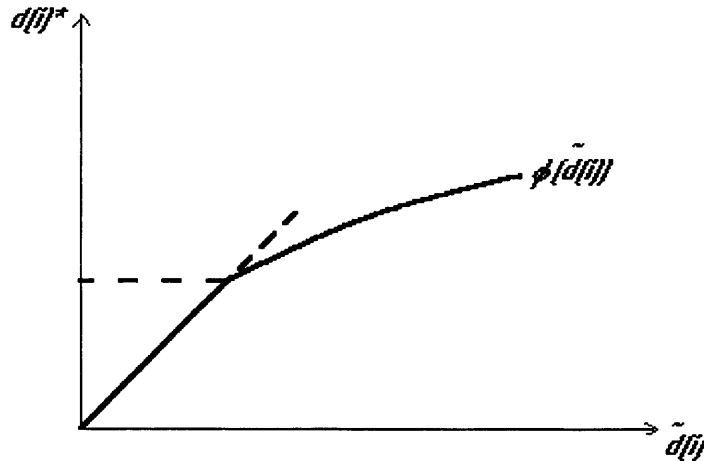


Figure 4.4: Manipulable Rationing Scheme

For this type of scheme to exist on the WSE is not as unlikely as it first may seem. For instance, a common characteristic of a stock market in the first few years of its development is the small or shallow nature of the exchange. i.e. there are few firms with relatively low turnover. It is therefore possible that in some stocks, one or a small group of individuals can strongly affect a stock's price and use this to their advantage. This situation is compounded by the way transactions are organised and conducted. Firstly large investors can act during the extended session by buying and selling at the days price which is *known* to them unlike small investors who have to estimate the price before the session starts. Secondly all brokers (not just specialists) collect information on orders in advance of a session. It is therefore likely that if they hold a sizable share of the market in a particular stock that they have a fair idea of the direction that price will take in the forthcoming session. Hence there is scope and incentive for the larger investors to manipulate the rationing scheme to their advantage and obtain increases in their trade even once rationed.

On similar application of the methodology applied in the non-manipulable case to the manipulable case (i.e. maximising an agent's utility of the transaction that he expects to result

from his demand), we end up with a perverse phenomenon of overbidding, assuming no transaction costs, when there is an expectation of being rationed and the agent has an ability to manipulate the rationing scheme. Therefore, in this framework, if an agent expects to be on the long side and he wants to obtain a given transaction, he will express a demand higher than his desired transaction, and the more severe the rationing is expected to be the higher will be the demand. Hence, if there are many constrained agents expressing higher than usual bids in a similar manner, and the perceived rationing scheme is not stable, there will be a downward shift in the perceived rationing scheme. In other words, the same level of demand will result in a decreasing amount of transaction or it will be necessary to express ever-increasing demands to obtain the same level of transaction, *ex ante*.

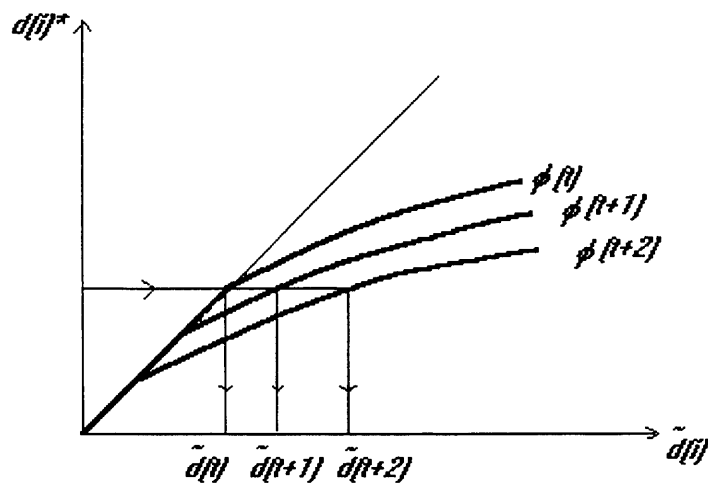


Figure 4.5: Overbidding and Manipulable Rationing Schemes

This phenomena can be illustrated in the following example where we consider a ‘proportional’ rationing scheme. This, for example, often exists on the WSE, either in a balanced market or in an unbalanced market (when the excesses are not too large), where agents on the short side realise their demands or supplies and agents on the long side receive a level of transaction proportional to their demand or supply. Assuming that the rationing coefficient is the same for all agents on the long side, the proportional rationing rule can therefore be written as,

$$d_i^* = \tilde{d}_i \times \min[1, \tilde{S} / \tilde{D}], \quad (4.11)$$

with,

$$s_i^* = \tilde{s}_i \times \min[1, \tilde{D} / \tilde{S}],$$

$$\tilde{D} = \sum_{j=1}^n \tilde{d}_j, \quad \text{and} \quad \tilde{S} = \sum_{j=1}^n \tilde{s}_j \quad (4.12)$$

Assume that there are two demanders and one supplier in the market, where at each session (denoted by t), they express demands $\tilde{d}_1(t)$, $\tilde{d}_2(t)$ and supply $\tilde{s}(t)$, respectively. We can write the rationing scheme as,

$$d_i^*(t) = \tilde{d}_i(t) \times \min \left[1, \frac{\tilde{s}(t)}{\tilde{d}_1(t) + \tilde{d}_2(t)} \right], \quad i = 1, 2. \quad (4.13)$$

$$s^*(t) = \min[\tilde{s}(t), \tilde{d}_1(t) + \tilde{d}_2(t)].$$

We shall assume that each trader knows the rationing rule and the demands and supplies of the other agents, once they have been expressed, and that he expects these to remain the same from one session to the next. Then the perceived rationing scheme at session t for the first demander is,

$$\phi'_1(\tilde{d}_1) = \tilde{d}_1 \times \min \left[1, \frac{\tilde{s}(t-1)}{\tilde{d}_1 + \tilde{d}_2(t-1)} \right]. \quad (4.14)$$

Each trader also has a target transaction resulting from the unconstrained utility maximisation, denoted by \hat{d}_1 , \hat{d}_2 and \hat{s} , and these are assumed to be constant for all periods. Finally, we assume that although the supplier can serve each demander separately, he can not meet both the demands, i.e.,

$$\hat{d}_1 < \hat{s}, \quad \hat{d}_2 < \hat{s}, \quad \hat{s} < \hat{d}_1 + \hat{d}_2. \quad (4.15)$$

Since the supplier is unconstrained, he will express his target transaction as his effective supply,

$$\tilde{s}(t) = \hat{s}. \quad (4.16)$$

The demanders, however, will be rationed, where their effective demands will be given by,

$$\phi'_1(\tilde{d}_1(t)) = \hat{d}_1 \quad \text{and} \quad \phi'_2(\tilde{d}_2(t)) = \hat{d}_2 \quad (4.17)$$

From these equations we get,

$$\tilde{d}_1(t) = \tilde{d}_2(t-1) \times \frac{\hat{d}_1}{\hat{s} - \hat{d}_1}, \quad \text{and} \quad (4.18)$$

$$\tilde{d}_2(t) = \tilde{d}_1(t-1) \times \frac{\hat{d}_2}{\hat{s} - \hat{d}_2}.$$

If we then combine the latter two equations, we obtain,

$$\tilde{d}_1(t) = \tilde{d}_1(t-2) \times \frac{\hat{d}_1}{\hat{s} - \hat{d}_1} \times \frac{\hat{d}_2}{\hat{s} - \hat{d}_2}, \quad (4.19)$$

where this expression is a divergent since $\hat{d}_1 + \hat{d}_2 > \hat{s}$, and therefore makes this case impractical to study. However, in the case of the WSE, there are a number of reasons why it would be valid to consider the rationing scheme to be non-manipulable. The first is that on the WSE, if excessive overbidding occurs by the larger companies, then this strategy could backfire because if demand exceeds supply (or vice versa) by more than five times after overtime trading, as seen in Table 4.3, then transactions for the day are suspended so that no trade takes place at all. Secondly, as the market capitalisation increases and there are an increasing number of traders and listed companies on the stock market, it will become increasingly more difficult for a few of the larger traders to manipulate the demands of other large traders. One of the reasons for this is the increase in transactions costs in co-ordinating the behaviour of firms, especially since insider trading is illegal and therefore collusion needs to be discrete. Furthermore, even if a few large firms do try

and influence the market and attempt to push the price to the limit, they may have little effect due to the larger number of diversified investors who also exist as the market grows. Finally, and most importantly, if constraints are manipulable, as described in the above sense, then one can envisage a great deal of complexity in behaviour, particularly if *all* investors know that constraints are manipulable. For instance, in the simplest case, even a single investor, ignoring the behaviour of other investors on the market, may decide to place a larger order than otherwise, in the hope of obtaining a larger settlement. However, once he acknowledges the behaviour of the other investors, then a complex set of strategies could be envisaged as he places his order. For instance, in his information set, he will now be aware of the fact that if all investors overbid, there would be potential for no trade at all to take place. Moreover, if investors, in the first instance, place their orders independently (i.e. with out any co-operation) as well as simultaneously, then alternative complicated forms of the Cournot-type game can result. For example, each investor places an order whilst taking into account other investors' behaviour. If an investor further perceives the occurrence of overtime trading, then the strategic behaviour of the investor could become extremely involved. It is therefore clear that, once differing information sets, alternative types of investors and a changing nature of the market over time are assumed, many various complex games could result. Hence, mainly for the sake of simplicity, in the rest of the analysis, we shall consider the rationing scheme to be of the non-manipulable sort only.

In summary, so far we have considered the determination of effective demand and supply in a market of a single good, where effective demand and supply is treated as the choice of an optimal action aimed at giving the best possible transaction in the presence of possible quantity rationing. At the same time, we developed the concept of a perceived rationing scheme, relating expected demand and supplies to the transaction, and we were therefore able to compare effective demand and supplies (\tilde{d}_i or \tilde{s}_i) to the demands and supplies resulting if the market had cleared, i.e. \hat{d}_i or \hat{s}_i . We made a distinction between manipulable and non-manipulable rationing schemes and found that although there was a perverse phenomenon of overbidding in the manipulable case, this phenomenon may be stable on the WSE. However, we justified the case for considering a non-manipulable scheme only, where we found that, assuming no transaction costs, the agent would express his target transaction (or his Walrasian demand) (\hat{d}_i or \hat{s}_i) as his effective demand,

thereby ignoring the presence of the quantity constraint on the market.¹³ Nevertheless, up until now, we have only considered a single market excluding their influence across different markets. In the next section, we consider these spillover effects in the Benassy sense, and how Benassy incorporates them into a multi-market framework.

4.4.2 Effective Demand Determination with Spillover Effects

We start this section with a few definitions in order to generally introduce the concept of effective demand in a multi-market setting which we will then go on to consider in more detail.

We shall say that there is a spillover effect when an agent who is constrained to exchange less than he wants in a market, modifies his demands or supplies in the other markets. Hence, spillover effects reflect the repercussions of imbalances in one market. On the WSE, for example, there will be two types of spillover effects. The first is a *cross-spillover* effect, which implies that a constraint on one market causes demand and supplies on other markets to change also. This could either be a withdrawal of funds from the market, the funds being alternative employed or into another asset on the market. Secondly, (and which is not analysed explicitly in Benassy's framework, although it is easily adapted) is an *intertemporal spillover* effect, which involves a modification of demand or supply in the *next* time period, once the agent has been rationed in *this* time period. We will investigate the determination of effective demand in the presence of both these spillovers once the general Benassy framework has been presented.

We noted in the previous section that in the non-manipulable rationing scheme, the agent receives a quantity signal which always has the form of an upper bound on purchases or sales. These bounds are denoted as \bar{d}_i or \bar{s}_i , and will be referred to as *perceived constraints*, where we saw that when agent is rationed, the perceived constraint is always equal to the realised transaction. We can now define effective demand in a multi-market monetary economy where the price may be different to its market clearing price and transactions are determined according to a rationing scheme specific to the market. In line with the Benassy definition, effective demand of an agent on a market is determined by maximising its utility function subject to the budget constraint and perceived constraints on *other* markets. Note that in this definition, the agent does

¹³ Note that, apart from being optimal actions as far as the agent is concerned, the demands and supplies are also quantity 'signals' where they are often interpreted as providing an indication of disequilibrium on markets, since if an agent's demand is rationed, it is a signal to the market that he would have desired more.

not take into account the perceived constraint on the market where he expresses his effective demand. Hence, if the agent is rationed, then this demand can be greater than the perceived constraint and the transaction. This will then act as a signal to the market that he is constrained and would like to exchange more. This reasoning is justified due to it being important that agents do not limit their demands and supplies to what the market lets them exchange since otherwise profitable exchange opportunities would be missed.¹⁴

We consider these concepts in more detail in what follows in the determination of effective demand in a multi-market setting. The institutional framework is set up first and for comparison purposes, we briefly describe the Walrasian demands and the equilibrium that would result if there were no constraints on demands and supplies. We then go on to examine the case where we do not have a situation of Walrasian equilibrium, whereby we develop a few non-Walrasian equilibrium concepts (some of which have already been briefly introduced) referred to by the term 'k-equilibria'.¹⁵ The main characteristic of these concepts is that, in the adjustment process, quantity signals are just as important as price signals, and prices, even if flexible, do not necessarily adjust to equate demand and supply on all markets. Finally, we consider the determination of effective demand and incorporate spillover effects of the mentioned kind. Note that the concepts to be studied are of short-run equilibria or temporary non-Walrasian equilibria, where agents' actions are made consistent with each other in the current period, although agents' expectations of future plans are not necessarily mutually consistent.

Assume as in the single market framework that there is a monetary exchange economy where money, as well as a medium of exchange, also acts as a numeraire and a reserve of value.¹⁶ Let there be l active markets (alternatively, different assets in one market) where on each market, good h , $h=1,2,\dots,l$, is exchanged against money. Assume that agent i , has a quantity of money $\bar{m}_i \geq 0$, and non-monetary goods at the start of the period, where the non-monetary goods are represented by a vector $w_i \in R_+^l$, with $w_{ih} \geq 0$ for all h , at the start of the period. After trading, the agent has a quantity of money $m_i \geq 0$ for future periods, and a quantity of goods represented by vector $x_i \in R_+^l$, with $x_{ih} \geq 0$ for all h , where x_i is a consumption vector. We shall use z_{ih} to

¹⁴ For instance, an unemployed worker would remain unemployed forever if he limited his labour supply to what he succeeded in selling.

¹⁵ K-equilibria is short for Keynesian equilibria.

¹⁶ See Benassy (1982), p. 72.

denote the net volume of transactions, where,

$$z_{ih} = d_{ih} - s_{ih} \quad (4.20)$$

where reciprocally, $d_{ih} = \max(z_{ih}, 0)$, and $s_{ih} = -\min(z_{ih}, 0)$, z_{ih} being positive when there is a purchase and negative when there is a sale. z_{ih} can be stacked, where we refer to $z_i \in R^I$ as the vector of these net transactions for agent i . Hence, if p is the price (vector) on the market, then we can express the final holdings of money and goods as the following relations,

$$\begin{aligned} x_i &= w_i + z_i \\ m_i &= \bar{m}_i - pz_i \end{aligned} \quad (4.21)$$

If agent i has a utility function $U_i(x_i, m_i)$, assumed to be continuous and concave in its arguments, with strict concavity in x_i , then, for comparative purposes, the Walrasian net demand function $z_i(p)$ is the solution in z_i of the following optimisation,

$$\begin{aligned} &\text{Maximise } U_i(x_i, m_i) \text{ s.t.} \\ &x_i = w_i + z_i \geq 0 \\ &m_i = \bar{m}_i - pz_i \geq 0 \end{aligned} \quad (4.22)$$

and the short-run equilibrium price vector is given by the condition that the net excess demands equal zero on all markets, i.e. $\sum_{i=1}^n z_{ih}(p) = 0$, for all h .

However, where a Walrasian equilibrium does not exist, we need to again make the distinction between transactions and effective demands. Analogous to the single market case, net transactions, denoted by

$$z_{ih}^* = d_{ih}^* - s_{ih}^* \quad (4.22)$$

must identically balance on each market so that $\sum_{i=1}^n z_{ih}^* = 0$ for all h . The net effective demand

of agent i , i.e.

$$\tilde{z}_{ih} = \tilde{d}_{ih} - \tilde{s}_{ih} \quad (4.23)$$

need not balance, and so, often, $\sum_{i=1}^n \tilde{z}_{ih} \neq 0$. We have noted, that there also exists a rationing scheme on each market transforming inconsistent demands and supplies to a consistent set of transactions. The rationing scheme on a market h can be expressed as a set of n functions, where, each transaction is a function of all agents' net effective demands on the market, the sum of all transactions being zero, i.e.,

$$z_{ih}^* = F_{ih}(\tilde{z}_{1h}, \dots, \tilde{z}_{nh}) \quad i = 1, \dots, n \quad (4.24)$$

such that,

$$\sum_{i=1}^n F_{ih}(\tilde{z}_{1h}, \dots, \tilde{z}_{nh}) = 0 \quad \text{for all } \tilde{z}_{1h}, \dots, \tilde{z}_{nh}^{17} \quad (4.25)$$

As before, we assume that the property of voluntary exchange holds¹⁸, and that the rationing scheme is of the non-manipulable kind. More precisely, a non-manipulable scheme can now be written in the following form,

$$z_{ih}^* = \begin{cases} \min(\tilde{z}_{ih}, \bar{d}_{ih}) & \tilde{z}_{ih} \geq 0 \\ \max(\tilde{z}_{ih}, -\bar{s}_{ih}) & \tilde{z}_{ih} \leq 0 \end{cases} \quad (4.26)$$

where the bounds \bar{d}_{ih} and \bar{s}_{ih} depend *only* on the net demands of other agents, which are independent of the net effective demands of agent i , \tilde{z}_{ih} . We can formalise this relationship, by expressing the net effective demands of agent i , as,

¹⁷ F_{ih} is assumed to be continuous in its arguments and non-decreasing in \tilde{z}_{ih} .

¹⁸ Recall that if voluntary exchange holds together with frictionless markets, the implication is the short-side rule. It is

$$z_{ih}^* = F_{ih}(\tilde{z}_{ih}, \tilde{Z}_{ih}) \quad (4.27)$$

with,

$$\tilde{Z}_{ih} = \{\tilde{z}_{1h}, \dots, \tilde{z}_{i-1,h}, \tilde{z}_{i+1,h}, \dots, \tilde{z}_{nh}\} \quad (4.28)$$

where, \tilde{Z}_{ih} is the set of net effective demands of all agents on the market *excluding* agent i 's net effective demand. Therefore, the bounds \bar{d}_{ih} and \bar{s}_{ih} can be seen as *perceived constraints* which are equal to the maximum demand and supply of agent i , respectively, which could be exactly satisfied by the market, taking into account the all the other agents' net effective demands on the same market, namely, \tilde{Z}_{ih} . These perceived constraints can hence be written as,

$$\bar{d}_{ih} = G_{ih}^d(\tilde{Z}_{ih}) = \max\{\tilde{z}_{ih} \mid F_{ih}(\tilde{z}_{ih}, \tilde{Z}_{ih}) = \tilde{z}_{ih}\}, \quad \text{and} \quad (4.29)$$

$$\bar{s}_{ih} = G_{ih}^s(\tilde{Z}_{ih}) = -\min\{\tilde{z}_{ih} \mid F_{ih}(\tilde{z}_{ih}, \tilde{Z}_{ih}) = \tilde{z}_{ih}\}. \quad (4.30)$$

Having defined the main concepts, we can now on to the issue of the determination of effective demand.

We have seen, so far, that in a market for good h , an agent i obtains a transaction equal to z_{ih}^* , which is a function of all the net demands in the rationed market as in equation (4.28). Moreover, assuming that the rationing scheme is non-manipulable, each agent receives quantity signals which are the perceived constraints, \bar{d}_{ih} and \bar{s}_{ih} , which are functions of the net demands expressed by all the other agents in the market other than agent i , as in expressions (4.30) and (4.31), respectively. To simplify the notation in the following analysis, we shall express the rationing functions and perceived constraints as the following vector functions,

$$z_i^* = F_i(\tilde{z}_i, \tilde{Z}_i), \quad (4.32)$$

$$\bar{d}_i = G_i^d(\tilde{Z}_i), \quad (4.33)$$

$$\bar{s}_i = G_i^s(\tilde{Z}_i). \quad (4.34)$$

Thus in the determination of effective demand, we are concerned with agent i choosing a vector of effective demands, \tilde{z}_i , leading him to the optimum transaction while faced with a price vector p and vectors of perceived constraints, \bar{d}_i and \bar{s}_i . The agent knows that his transactions are limited to the interval defined by the perceived constraints, i.e.,

$$-\bar{s}_{ih} \leq z_{ih} \leq \bar{d}_{ih} . \quad (4.35)$$

Then the optimal transaction that he can obtain, denoted by $\zeta_i^*(p, \bar{d}_i, \bar{s}_i)$, is therefore the solution in z_i of (see Benassy (1982, p. 74),

$$\begin{aligned} &\text{Maximise } U_i(x_i, m_i) \text{ s.t.} \\ &x_i = w_i + z_i \geq 0 \\ &m_i = \bar{m}_i - pz_i \geq 0 \\ &-\bar{s}_{ih} \leq z_{ih} \leq \bar{d}_{ih} \quad h=1,2,\dots,l. \end{aligned} \quad (4.36)$$

The assumption of strict concavity of U_i in x_i implies that the solution of the program is unique and ζ_i^* is therefore a function. However, in this framework, an agent does *not* directly choose the level of transactions (since they are determined from the effective demands expressed by all the agents on the market), but instead, attempts to determine a vector of net effective demands \tilde{z}_i that will lead to the optimal transaction vector $\zeta_i^*(p, \bar{d}_i, \bar{s}_i)$. We have seen that if agent i expresses a net demand \tilde{z}_{ih} on market h , the resulting transaction will be,

$$z_{ih}^* = \begin{cases} \min(\tilde{z}_{ih}, \bar{d}_{ih}) & \tilde{z}_{ih} \geq 0 \\ \max(\tilde{z}_{ih}, -\bar{s}_{ih}) & \tilde{z}_{ih} \leq 0 \end{cases} \quad (4.37)$$

or,

$$z_{ih}^* = \min[\bar{d}_{ih}, \max(\tilde{z}_{ih}, -\bar{s}_{ih})] \quad . \quad (4.38)$$

Consequently, the effective demand vector yielding the best possible transactions is a solution in \tilde{z}_i of the following program,

$$\begin{aligned} &\text{Maximise } U_i(x_i, m_i) \text{ s. t.} \\ &x_i = w_i + z_i \geq 0 \\ &m_i = \bar{m}_i - pz_i \geq 0 \\ &z_{ih}^* = \min[\bar{d}_{ih}, \max(\tilde{z}_{ih}, -\bar{s}_{ih})], \quad h=1,2,\dots,l, \end{aligned} \quad (4.39)$$

and in order to obtain the optimal transaction ζ_i^* , we must therefore have that,

$$\min[\bar{d}_{ih}, \max(\tilde{z}_{ih}, -\bar{s}_{ih})] = \zeta_i^*(p, \bar{d}_i, \bar{s}_i). \quad (4.40)$$

This has a unique solution if ζ_i^* is between $[\bar{s}_{ih}, \bar{d}_{ih}]$, but an infinity of solutions if ζ_i^* is equal to either \bar{d}_{ih} or \bar{s}_{ih} .

We can now define a non-Walrasian K-equilibrium concept assuming, for now, that the price vector p is exogenous as are the rationing schemes on markets. The fixprice equilibrium concept will involve the three types of quantities for each agent, i.e. his vectors of effective demands, \tilde{z}_i , of transactions, z_i^* , and of perceived constraints, \bar{d}_i and \bar{s}_i , and can be defined as follows (as in Benassy (1982), p. 76);

Definition: A K-equilibrium associated with a price system p and rationing schemes represented by functions $F_i, i=1,2,\dots,n$, is a set of effective demand functions \tilde{z}_i , transactions z_i^ , and perceived constraints \bar{d}_i and \bar{s}_i such that,*

$$\tilde{z}_i = \zeta_i(p, \bar{d}_i, \bar{s}_i) \quad i=1,\dots,n \quad (4.41)$$

$$z_i^* = F_i(\tilde{z}_i, \tilde{Z}_i), \quad i=1, \dots, n \quad (4.42)$$

$$\bar{d}_i = G_i^d(\tilde{Z}_i), \quad i=1, \dots, n \quad (4.43)$$

$$\bar{s}_i = G_i^s(\tilde{Z}_i). \quad i=1, \dots, n. \quad (4.44)$$

Intuitively, the quantity constraints from which the agents construct their effective demands will be the ones that are actually generated by the exchange process. The implication is all agents will have a correct perception of quantity signals at equilibrium.¹⁹ So far, we have assumed a completely fixed price system. If, however, the pricing mechanism is as described in section 4.2, then we can introduce some price flexibility without completely reverting to the traditional Walrasian equilibrium. For instance, given the previous period's observed price, agents know that the price in this period is flexible but between two predetermined bounds. If the price remains between the bounds, then it, generally, reacts 'competitively' to excess effective demand (or if small disequilibria exist, then the short-side rule or proportional rationing applies, as described above). If the price, on the other hand, hits one of these bounds (the price bounds depending on the price in the previous session), there will be excess demands and supplies.

If we assume that, in terms of price vectors, the price vector p , must remain between the lower bound, \bar{p} , and the upper bound, $\bar{\bar{p}}$, and we define total excess demand on each market as,

$$\tilde{z}_h = \sum_{i=1}^n \tilde{z}_{ih} \quad (4.45)$$

then, at equilibrium, there are three types of situations that may arise. These can be written as follows,

$$\tilde{z}_h = 0 \quad \bar{p}_h \leq p_h \leq \bar{\bar{p}}_h \quad (4.46)$$

$$\tilde{z}_h < 0 \quad p_h = \bar{p}_h \quad (4.47)$$

$$\tilde{z}_h > 0 \quad p_h = \bar{\bar{p}}_h, \quad (4.48)$$

¹⁹ Benassy (1982) proves the existence of the equilibrium under the usual concavity and continuity conditions for the utility functions and assuming the rationing schemes are continuous.

where (4.46) refers to a situation where demand and supply are equal on a market; (4.47) refers to a market in excess supply; and (4.48) represents a market in excess demand. In the previous K-equilibrium, we had considered quantity constraints, but for a given price vector. In the following K-equilibrium concept, agents still perceive quantity constraints, but now the equilibrium will be one with bounded prices and therefore we shall simply add the conditions relating prices and effective demand just outlined; it can be defined as follows (Benassy (1986), p. 51);

Definition: A K-equilibrium associated with bounded prices corresponding to bounds \bar{p} and $\bar{\bar{p}}$ is a set of vectors \tilde{z}_i , z_i^ , \bar{d}_i and \bar{s}_i and a price vector p^* such that,*

(1) \tilde{z}_i , z_i^* , \bar{d}_i and \bar{s}_i form a K-equilibrium for the price p^*

(2) $\bar{p}_h \leq p_h \leq \bar{\bar{p}}_h$

(3) $\tilde{z}_h < 0 \Rightarrow p_h = \bar{p}_h$
 $\tilde{z}_h > 0 \Rightarrow p_h = \bar{\bar{p}}_h$, for all h .

Finally, so far we have not considered the presence of any spillover effects. Benassy incorporates the cross-spillovers in a simple way into the above framework. Referring to the optimisation program (4.36), where the final constraint is represented by,

$$-\bar{s}_{ih} \leq z_{ih} \leq \bar{d}_{ih}, \quad (4.49)$$

then if it is transferred into the following,

$$-\bar{s}_{ik} \leq z_{ik} \leq \bar{d}_{ik}, \quad k \neq h, \quad (4.50)$$

then the effective demand on a market will correspond to the exchange that maximises utility, taking into account the constraints on the *other* markets.

Although this seems to be valid approach in its own right, it does not appear to reflect the situation of spillovers that occurs on the disequilibrium market described in section 4.2. In the

next section, using the general framework of Benassy, we derive an effective demand function more explicitly, but incorporating spillover effects resulting from quantity constraints imposed on the market that agent i is trading *in*. By doing so, we can obtain an expression for cross spillovers *and* intertemporal spillover effects. As for more general observations about the outlined framework, we have seen that if the agent is specialised in one good, the question of agent i 's perceived transaction constraint involves observing the demands expressed by all the other agents. These perceived constraints are assumed to have the properties that (i) if an agent is on the long side of the market, his realised transaction is his perceived constraint; (ii) if the agent can fulfil his demand, because he is on the short side, for instance, then he may subjectively perceive more possibility for trade in the same direction; and (iii) the perceived constraints being a function of all other demands are assumed to be continuous. However, quite clearly, the problem is how the perceived constraints are generated (even though there is the unrealistic assumption that agents have the ability to perceive them correctly), since they drive the system to the new states. In this framework, the optimal exchange plan involves taking into account the perceived constraints on all the other markets and then the effective demand is expressed against money. This evidently involves a complexity of process and trades with the added restriction that all transactions must go through the money commodity. Moreover, as Hey (1981) notes, since the agent ignores that perceived constraint for his particular good, but accommodates all the other perceived constraints on the other markets *as well* as the budget constraint, there may be a situation where the chosen effective demand may violate the perceived constraint. If this occurs, the trader is communicating to the market that he wants to buy (sell) more than he will perceives that he will be able to buy (sell). Therefore, after finding himself successfully overcoming all the perceived constraints, he may not be able to meet all his commitments. Exactly how the model will cope is unclear. Nevertheless, in the next section we present a model representing traders' behaviour in a market with quantity constraints, generally relying on the ideas of Benassy.²⁰

4.5 Investor Behaviour in a Market with Quantity Constraints and Spillover Effects

In order to explain investor behaviour on a stock market where a binding constraint on a quantity

²⁰ This follows Charemza, Shields and Zalewska-Mitura (1997).

of shares is expected, let us assume that a representative trader faces in time 0 an intertemporal allocation decision of how much to invest in asset x in the present time $t=0$ and how much to invest in the future time $t=1$. The quantities can be denoted by x_0 and x_1 , respectively. According to the price setting process described in section 4.2²¹, the price is announced at the end of the trading day, so that the trader does not have the possibility of withdrawing or indeed altering his demand (supply) in time t . Hence, the investor can only act while considering the future or the next session constraint. For our purposes it is convenient to simplify the portfolio optimisation problem into the question of maximising the expected gain function in time t by a representative trader, i.e.,

$$U = U(x_0, x_1, w), \quad (4.51)$$

with the financial constraint,

$$\bar{w} = p_0 x_0 + p_1 x_1, \quad (4.52)$$

where p_0, p_1 are prices for the financial asset, x , at time $t=0$ and time $t=1$, and \bar{w} stands for the initial endowment of wealth w of the trader. Maximisation of (4.51) with the financial constraint gives the notional (Walrasian) demand functions for the asset x in the absence of any constraints on the market at time 0 and 1 (see for example, Benassy (1982)):

$$\hat{x}_0^d = \hat{x}_0^d(\bar{w}, p_0, p_1), \quad (4.53)$$

$$\hat{x}_1^d = \hat{x}_1^d(\bar{w}, p_0, p_1). \quad (4.54)$$

The Walrasian quantities satisfy the financial constraint, and therefore the prices and quantities for time 1 can be written as being conditional on information related to time 0 as,

$$p_1 x_1 = \bar{w} - p_0 \hat{x}_0^d \quad (4.55)$$

²¹ Also known as an ‘*Einheitskurs*’ system.

Given that the right hand side of (4.55) is a function of prices and the initial financial endowment only, then under the standard assumptions of efficient markets (see LeRoy (1989) and section 4.6.1), the expected price p_1 can be given by the martingale hypothesis²²,

$$p_1 = p_0 \quad (4.56)$$

Suppose now that, in time 0, the trader expects a binding transactional constraint to appear on market, that is,

$$x_0 = \bar{x}_0. \quad (4.57)$$

Assuming that the constraint is not manipulable, then maximising (4.51) under the financial constraint (4.52) and under the quantity constraint (4.57) gives the following effective demand function for asset x in time $t=1$, which is also a function of the quantity constrained asset in time $t=0$,

$$x_1^d = x_1^d(\bar{w}, p_0, p_1, \bar{x}_0). \quad (4.58)$$

It follows that since constraining an investor to his Walrasian or notional choice does not impose an effective constraint, so that $x_1 = \hat{x}_1^d$, then assuming that effective demands are linear in spillover terms, this enables the expansion of expression (4.58) (x_1^d) in a Taylor series around the Walrasian notional \hat{x}_0 gives,²³

$$x_1^d \approx x_1^d(\bar{w}, p_0, p_1, \hat{x}_0^d) + (\bar{x}_0 - \hat{x}_0^d).C_x = \hat{x}_1^d + (\bar{x}_0 - \hat{x}_0^d).C_x, \quad (4.59)$$

²² See the Appendix to this Chapter.

²³ See also Gouriéroux, Laffont and Monfort (1980a) for a similar formulation. Note that the system suggested by Benassy (1975) differs in that it measures spillovers as discrepancies between realised transactions and effective demands and supplies rather than notional ones.

where,

$$C_x = \frac{\partial x_1^d}{\partial \bar{x}_0}(\bar{w}_i, p_0, p_1, \hat{x}_0^d) . \quad (4.60)$$

For analysis concentrating solely on a single security market, an important conclusion given by equation (4.59), is that expected shortages might affect demand on this market. Assuming homogeneity of agents this would in turn be reflected in aggregate demand (supply) and hence affect the price of this security. Let us consider these spillover effects in a little more detail.

The term C_x represents the intertemporal spillover effect that appears in the market due to the presence of excess demand in period zero. The expected sign of C_x will be negative since the investor is likely to increase trading in security x in time 1 by a portion of the demand that was not satisfied in the previous period, time 0. Hence, if C_x tends towards zero, then the trader decides to withdraw a relatively large part of the excess demand (i.e. the part of demand not satisfied being equal to $(\bar{x}_0 - \hat{x}_0^d)$) from the market for x into another market, or wealth. This type of spillover can be termed a cross-spillover effect. We can consider in more detail the cases for the polar values of C_x and the implications for the martingale hypothesis (4.56) assuming that the function C_x is linearly homogenous in price, i.e. $C_x^* = p_0 C_x$. In the case of a full cross-spillover effect and no intertemporal spillover, where any excess demand is completely withdrawn from the market for security x at any point in time, then this is the case for which $C_x = 0$. Substitution of this condition into expression (4.59) reveals,

$$x_1^d \approx \hat{x}_1^d , \quad (4.61)$$

so the effective demand equals the notional demand with the financial constraint being given by,

$$p_1 x_1 = \bar{w} - p_0 \hat{x}_0^d , \quad (4.62)$$

which is the same as the constraint in expression (4.55). Note that this financial constraint

doesnot depend on the constraint \bar{x}_0 . Hence, this implies that despite the presence of a binding constraint on the market, price expectations are formed purely on the basis of prices observed in time $t=0$, and the martingale hypothesis in (4.56) can be maintained.

The other extreme case of $C_x = -1$, reflects the situation of a full intertemporal spillover effect and no cross-spillover. Substitution of this into expression (4.59) gives,

$$x_1^d \approx \hat{x}_1^d - p_0 \bar{x}_0 + p_0 \hat{x}_0^d, \quad (4.63)$$

with the corresponding financial constraint,

$$p_1 x_1 = \bar{w} - p_0 \bar{x}_0 \quad . \quad (4.64)$$

Since \bar{x}_0 doesnot depend on the price, then in general, the martingale hypothesis (4.56) can no longer be maintained.²⁴

One direct consequence of the analysis of traders' behaviour presented in this section is a model of price setting which reflects both the fact that prices are not allow to move beyond a pre-set boundary, and also that a price in time t , may, even if not constrained, be affected by a previous hit of a price into the boundary. Moreover, there can be inferences made about asset predictability in a market that is quantity constrained; the existence of certain spillover effects (i.e. cross-spillovers), according to the framework presented, can result in the prices following a martingale process, and the return on the constrained asset in fact being non-predictable. In following section 4.6, we develop an explicit model of a disequilibrium trading system, such as the system operating on the WSE, bearing in mind the theoretical considerations of investor behaviour made in this section. In doing so, we consider further the issue of predictability using this disequilibrium trading model. First, however, we formalise definitions of what is meant by efficiency, martingale processes and non-predictability.

²⁴ Note that it is, however, possible to find a 'vital' price \bar{p}_0 which would support both the financial constraint and the Walrasian demand, such that, $p_0 \bar{x}_0 = p_0 \hat{x}_0^d$. If such a price were known, then by substitution into (4.64), $p_1 x_1 = \bar{w} - \bar{p}_0 \hat{x}_0^d$, implying that the expected price can be given by $p_1 = \bar{p}_0$.

4.6 Predictability in a Market with Quantity Constraints

In this section we consider the issue of predictability on a market with quantity constraints described by the *Einheitskurs*' system. We start in section 4.6.1 by defining what we mean by efficiency and non-predictability and the distinction between them. We have already reviewed studies in Chapter 2 that have attempted to look at efficiency and predictability on a market with disequilibrium trading, namely, the WSE, where we noted that these studies had failed to consider the constraints on the market. Hence, in section 4.6.1, we present a representative model of a disequilibrium trading system which was first introduced in Charemza, Shields and Zalewska-Mitura (1997). Finally, we consider the implications for market predictability with reference to the model and in light of the theoretical framework presented in the previous section 4.5.

4.6.1 Definitions of Market Efficiency and Non-Predictability

The Efficient Market Hypothesis (EMH) has probably been one of the most extensively tested hypotheses in the area of finance economics. There are a number of ways in which it can be expressed (not all of which are equivalent, see LeRoy (1989))²⁵. A formal definition of the EMH according to Cuthbertson (1996) can be given as follows;

Definition: Suppose that at any point in time, all relevant (current and past) information for predicting the return on an asset is denoted Ω_t , while market participants p , have an information set Ω_t^p which is assumed to be available without cost. If the market is efficient, agents are assumed to know all relevant information (i.e. $\Omega_t^p = \Omega_t$) and they know the complete (true) probability density function of the possible outcomes for returns,

$$f^p(R_{t+n}|\Omega_t^p) = f(R_{t+n}|\Omega_t)$$

Therefore, in an efficient market, investors know the true (stochastic) economic model that

²⁵ LeRoy (1989) proposes that the EMH implies that returns follow the fair game property and that agents have rational expectations. For practical purposes, this definition is not that dissimilar to the one adopted by Cuthbertson (1996) as above.

generates future returns and use all relevant information to form their optimal forecast of the expected return. (This is the *rational expectations* element of the EMH). *Ex-post* profits or losses made by the agents will be given by,

$$\eta_{t+1}^p = R_{t+1} - E^p(R_{t+1}|\Omega_t^p)$$

where the superscript ‘*p*’ indicates that the expectations and forecast errors are conditional on the equilibrium model of returns used by investors. According to the EMH, the excess returns or ‘forecast errors’ only change in response to news, so that η_{t+1}^p are innovations with respect to the information available. Informally, the EMH basically states that because current prices reflect all public information, it is impossible for one market participant to have an advantage over another and reap excess profits. A capital market is thus said to be efficient if it fully and correctly reflects all ‘relevant information’ in determining security prices. The notions underlying efficient market can be summarised as follows:

- (i) All agents are homogenous and act as if they have an equilibrium model of returns of a price valuation model;
- (ii) In determining the fundamental value of shares, agents process all relevant information in an identical manner. Hence, forecast errors or excess returns are unpredictable from the information available at the time of making the forecast;
- (iii) Excess or abnormal profits cannot be consistently made.

Assuming that the researcher has complete knowledge of the true model used by agents in their valuations, then tests in (ii) are analogous to testing the axioms of rational expectations, i.e. unbiasedness, orthogonality e.t.c.. These tests are commonly known as tests of informational efficiency. Tests based on (iii) differ slightly in that although excess returns may be predictable, whether or not abnormal profits can be made will depend on the adjustment for return, risk and transaction costs. This version of the EMH is a less stricter version, relating to the impossibility of making ‘economic profits’.²⁶

Since Roberts (1967), three levels of market efficiency based on three different types of

²⁶ Economic profits refer to ‘the risk adjusted rate of return, net of all costs’, (see Jensen (1978)).

information sets have been identified;

(i) The weak form of the Efficient Market Hypothesis (EMH), which states that prices fully reflect the information contained in the historical sequence of prices. Hence, abnormal profits can not be consistently made through the examination of past patterns of prices; i.e. technical analysis will not be successful. This form of efficiency is alternatively known as the 'Random Walk Hypothesis'. If, for example, investors in the market expect prices to double next week, then instead of prices gradually approaching a new equilibrium value, they will adjust immediately. If they do not adjust, then a profitable arbitrage opportunity would exist and expected to be exploited immediately in an efficient market.²⁷ This is the most commonly tested form of efficiency, the literature being extensive.²⁸

(ii) The semi-strong form of EMH asserts that current stock prices reflect all publicly available information relevant to a company's assets, as well historical price information. If this is the case, then fundamental analysis, i.e. the analysis of company accounts and relevant public information, will not yield abnormal profits. A common line of approach in testing this hypothesis, is through the examination of the effects of stock splits on equity prices. Stock splits, although provide no economic benefit, do convey to the market the confidence of the firm with regard to its future. Consequently, stock splits are usually accompanied or followed by an increase in dividends.²⁹

(iii) The strong form of EMH maintains that all information that is known to any market

²⁷ Samuelson (1965) and Mandelbrot (1966) provide rigorous analytical proofs that for a continuous flow of information where there are no transaction costs, then tomorrow's price change in speculative markets will reflect only tomorrow's 'news' and independent of the price change today. But, since 'news', by definition, is unpredictable, it follows that the resulting price changes must also be unpredictable and random. This is alternatively known as the Random Walk, which forms the underlying basis for this research. See the Appendix for details of the random walk formulation.

²⁸ Bachelier (1900) performed the earliest empirical study on the random walk hypothesis, in which he found that commodity prices accorded to the random walk. Other early studies that found that the serial correlation between successive price changes was essentially zero were those by Working (1934), who investigated several time series, Cowles and Jones (1937) considered US stock prices, and Kendall (1953) examined US stock and commodity prices. Roberts (1959) also found that a time series generated from a sequence of random numbers had a similar appearance to a time series of US stock prices, and Osborne (1959) found that the movements of stock prices were very similar to the random Brownian motion of physical particles. Merton (1980) has shown that changes in the variance of a stock's return can be predicted from its variance in the recent past. Although in this case, the weak form of the EMH is not violated, the probability distributions of stock prices may be a submartingale rather than a random walk.

²⁹ Fama et al's (1969) investigation revealed that, although substantial returns can be earned prior to the split announcement, there was no evidence of abnormal returns after the public announcement. Similarly, Dodd (1981) finds no evidence of abnormal returns following public information about a merger. Studies not supporting the semi-strong form include Ball (1978), Watts (1978), Rendleman, Jones and Latane (1982) and Roll (1984). However, although abnormalities have been found, many have not been shown to exist consistently over time, and in most cases have only been small enough to give only a professional broker-dealer economic profits.

participant about a company is fully reflected in market prices. Thus 'insiders' will not have superior information to consistently make abnormal profits.

However, although there are a multitude of studies investigating stock price behaviour and the EMH, there is ambiguity regarding 'relevant information', and one of the main obstacles to inferences about the market efficiency, is the 'joint hypothesis' problem, which means that market efficiency per se is not testable; it has to be tested jointly within the context of a pricing model. Hence, if evidence is found of market inefficiency, this could imply that there does in fact exist inefficiency of the type being examined in the market, or that the model chosen to represent market equilibrium, is not a good one.

In this investigation, however, we are concerned with a less stricter version of the EMH, and rather than focusing on the issue of efficiency in the defined sense, we concentrate on the *non-predictability* of stock returns. The concept of non-predictability stems from efficiency; although 'efficiency' in this context (informally), more often than not, implies the inability, *on average*, to make systematic abnormal profits, non-predictability, on the other hand, refers to the inability to make abnormal profits. Hence, if a market is non-predictable, it will be efficient (in the above sense), yet, if a market is efficient, it is possible that it may be predictable. This distinction needs to be borne in mind on the interpretation of any findings.

Another reason to focus on non-predictability concerns the difficulties in defining market efficiency when there are institutional constraints on the movement of prices since a problem in the terminology becomes immediately apparent. In particular, in the definitional sense, it is difficult to apply the traditional Roberts (1967) definition³⁰ directly to the prices on the WSE. For instance, in testing for weak form efficiency in such a market, traders also have current public information on whether prices have hit one of the limits or not, thus suggesting a form of semi-strong efficiency which also needs to be incorporated. Therefore, since weak-form efficiency implies the inability, on average, to make abnormal profit based on information about past prices, in the situation of the WSE, when investors invest, not only do they have information concerning the history of prices, but inevitably, they also have information about the existence of price limits and thus whether or not prices have hit one of the limits in the previous period. Hence, there is information from an institutional factor involved and the form of efficiency cannot be strictly be defined as weak-form. Rather, a form of efficiency between the weak-form and the semi-strong

form (which incorporates public information), would be a closer accordance to the WSE. However, as already discussed, difficulties with defining efficiency, makes it preferable to concentrate on the issue of non-predictability instead.

4.6.2 A Model of a Disequilibrium Trading System

In this section, we show that using the proposed model of a disequilibrium trading system, the fact that the upper and lower price limits are imposed might not necessarily be a source for market predictability. In particular, if there is some kind of funds withdrawal process due to a quantity spillover in relation to other stocks or to non-market assets, the market might not be predictable.

From the analysis of investor behaviour in section 4.5 results a model of price setting which reflects both the fact that prices are not allow to move beyond a pre-set boundary, and also that a price in time t , may, even if not constrained, be affected by a previous hit of a price into the boundary. It is initially assumed that the process representing the observed prices, p_t , and the underlying (unrestricted) prices, p_t^* , in their logarithms on a market with disequilibrium trading, is given as:

$$p_t^* = \theta p_{t-1}^* + (1-\theta) p_{t-1} + \varepsilon_t, \theta \in [0,1] \quad (4.65)$$

$$p_t = \begin{cases} p_t^* & \text{if } |p_t^* - p_{t-1}| < \omega \\ \omega + p_{t-1} & \text{if } p_t^* - p_{t-1} > \omega \\ -\omega + p_{t-1} & \text{if } p_t^* - p_{t-1} < -\omega \end{cases} \quad (4.66)$$

where $E(\varepsilon_t) = 0$, and $E(\varepsilon_t, \varepsilon_{t-\tau}) = 0, \tau = 1, 2, \dots$, and constant ω represents the upper and lower limit for the allowable price movement.

Ignoring the possible payments of dividends, returns $r_t = p_t - p_{t-1}$ are defined as:

³⁰ As in Section 4.6.1.

$$r_t = \text{sgn}(\varepsilon_t) \cdot \min(\omega, |\varepsilon_t|) .$$

The artificial process above seems to represent the empirical series of returns from a market with disequilibrium trading satisfactorily. Figure 4.1 compares time series of returns simulated by the process (4.65)-(4.66) with $\theta = 0.5$ and returns of an exemplary security from the Warsaw Stock Exchange (returns on *Próchnik* shares). The similarity of the series is evident.³¹

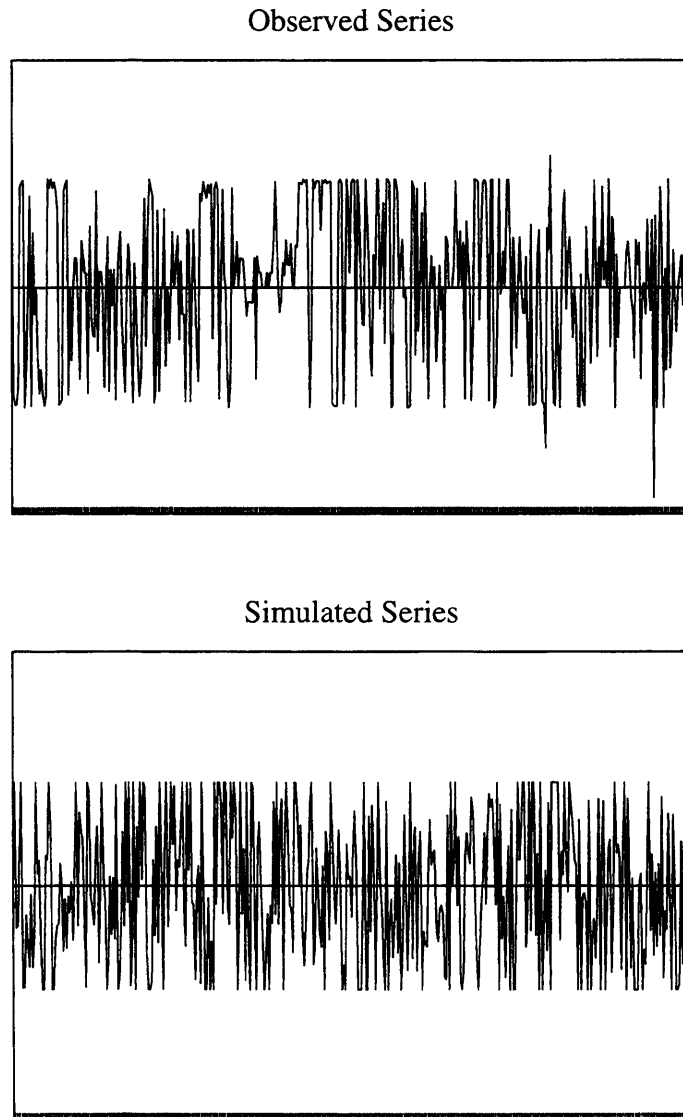


Figure 4.6: Returns from a typical series on the Warsaw Stock Exchange and the simulated disequilibrium trading process

³¹ The outliers exceeding the 10% limit for the *Próchnik* returns result from occasional suspension of the limit.

Implications for Market Predictability

The weight θ which aggregates the lagged underlying and observed processes plays an important role in the evaluation of market predictability. If neither floor nor ceiling is hit, then the underlying process becomes equal to the observed process for any θ . With this assumption, the market becomes efficient (unpredictable in mean of returns) and the process (4.65) becomes a martingale, and the usual assumptions for the efficient market hypothesis have to hold.

If one of the boundaries is hit, then $p_t \neq p_t^*$ and then θ decides about the nature of the market. In the extreme case, where $\theta = 1$, there is a recursive influence of the underlying process on that of the observed prices, without a feedback. In practice this means that, despite information that a boundary was hit, no capital is to be reallocated to or from the market. Recalling the analysis given in Section 4.5, $\theta = 1$ implies the case of the full intertemporal spillover and no cross-spillover effect, i.e. when $C_x = -1$. Clearly, the returns $p_t - p_{t-1}^*$ are not martingale differences if $p_t = p_t^*$.

If $\theta = 0$, then there is full feedback from the constrained price to the underlying price and the quantity constraint is fully binding. Effective demand becomes equal to the notional demand, so that demand carried forward from time $t-1$ to time t is zero even if there is (positive or negative) excess demand on the market in time $t-1$. This happens in the case described where there is a full cross-spillover effect and no intertemporal spillover, i.e. $C_x = 0$.

For the intermediate case $0 < \theta < 1$, there will be a partial withdrawal of funds from the market under disequilibrium trading, either on the supply or demand side.

Conditions for Market Non-Predictability³²

In this section we show that the market model described by the system (4.65)-(4.66) is predictable only if $0 < \theta \leq 1$, and hence inefficient, in the sense that the expected value of returns conditional of information that the upper (lower) bound is hit, is non-zero. If $\theta = 0$, the market is not predictable. The strongest possible case of predictability in model (4.65)-(4.66) is where $\theta = 1$. The situation where $0 < \theta < 1$ represents an intermediate situation, where θ can be interpreted as

a measure of market predictability.

In order to prove predictability it is sufficient to show that the expected value of returns conditional on the information on hitting the upper (lower) bound at a previous session is non-zero. Recalling the notation introduced above, the proposed model of disequilibrium trading (4.65)-(4.66). Assume that in time $t-1$ an equilibrium trade takes place, i.e. so that $p_{t-1} = p_{t-1}^*$, and in time t the upper bound was hit so that $\varepsilon_t > \omega$. Hence, the price generating process for time $t+1$ can be described as:

$$\begin{aligned} p_{t+1}^* &= \theta p_t^* + (1-\theta)p_t + \varepsilon_{t+1} \\ &= p_{t-1}^* + \theta\varepsilon_t + \omega - \theta\omega + \varepsilon_{t+1} \end{aligned}$$

$$p_{t+1} = \begin{cases} p_{t+1}^* & \text{if } |p_{t+1}^* - p_t| < \omega \\ \omega + p_t & \text{if } p_{t+1}^* - p_t > \omega \\ -\omega + p_t & \text{if } p_{t+1}^* - p_t < -\omega \end{cases}$$

or,

$$p_{t+1} = \begin{cases} p_{t-1}^* & \text{if } |\theta\varepsilon_t - \theta\omega + \varepsilon_{t+1}| < \omega \\ 2\omega + p_{t-1}^* & \text{if } \theta\varepsilon_t - \theta\omega + \varepsilon_{t+1} > \omega \\ p_{t-1}^* & \text{if } \theta\varepsilon_t - \theta\omega + \varepsilon_{t+1} < -\omega \end{cases} ,$$

and the returns are given by,

$$r_{t+1} = \begin{cases} \theta\varepsilon_t - \theta\omega + \varepsilon_{t+1} & \text{if } |\theta\varepsilon_t - \theta\omega + \varepsilon_{t+1}| < \omega \\ \omega & \text{if } \theta\varepsilon_t - \theta\omega + \varepsilon_{t+1} > \omega \\ -\omega & \text{if } \theta\varepsilon_t - \theta\omega + \varepsilon_{t+1} < -\omega \end{cases} .$$

³² Readers are referred to the Appendix of Charemza, Shields and Zalewska-Mitura (1997).

The sign of returns is positive if,

$$0 < \theta \varepsilon - \theta \omega + \varepsilon_{t+1} < \omega \quad \text{or} \quad \theta \varepsilon_t - \theta \omega + \varepsilon_{t+1} > \omega .$$

The sign of returns is negative if,

$$-\omega < \theta \varepsilon_t - \theta \omega + \varepsilon_{t+1} < 0 \quad \text{or} \quad \theta \varepsilon_t - \theta \omega + \varepsilon_{t+1} < -\omega .$$

Thus, the expected value of returns in time $t+1$, conditional on $\varepsilon_t > \omega$, can be written as,

$$\begin{aligned} E(r_{t+1} | \varepsilon_t > \omega) &= \omega \int_{\omega}^{\infty} f(x) \int_{\omega(\theta+1)-\theta x}^{\infty} f(y) dy dx + |\varepsilon_{t+1}| \int_{\omega}^{\infty} f(x) \int_{-\theta x + \theta \omega}^{\omega(\theta+1)-\theta x} f(y) dy dx + \\ &|\varepsilon_{t+1}| \int_{\omega}^{\infty} f(x) \int_{(\theta-1)\omega - \theta x}^{-\theta x + \theta \omega} f(y) dy dx - \omega \int_{\omega}^{\infty} f(x) \int_{-\infty}^{(\theta-1)\omega - \theta x} f(y) dy dx \\ &= \int_{\omega}^{\infty} f(x) \int_{\omega(\theta+1)-\theta x}^{(1-\theta)\omega + \theta x} f(y) dy dx + |\varepsilon_{t+1}| \int_{\omega}^{\infty} f(x) \left[\int_{-\theta x + \theta \omega}^{\omega(\theta+1)-\theta x} f(y) dy - \int_{(\theta-1)\omega - \theta x}^{-\theta x + \theta \omega} f(y) dy \right] dx \end{aligned}$$

which is *not* equal to zero if $0 < \theta \leq 1$. For $\theta = 0$, it simplifies to,

$$\begin{aligned} E(r_{t+1} | \varepsilon_t > \omega) &= \omega \int_{\omega}^{\infty} f(x) dx \int_{\omega}^{\infty} f(y) dy + |\varepsilon_{t+1}| \int_{\omega}^{\infty} f(x) dx \int_0^{\omega} f(y) dy - \\ &|\varepsilon_{t+1}| \int_{\omega}^{\infty} f(x) dx \int_{-\omega}^0 f(y) dy - \omega \int_{\omega}^{\infty} f(x) \int_{-\infty}^{\omega} f(y) dy = 0 \end{aligned}$$

due to the symmetry of the constraint, implying that the market is not predictable according to

this framework.³³

Therefore, according to this model, the expected value of returns conditional on information from the previous period relating to a constraint, is non-zero only if the value of the weight is non-zero.

4.7 Concluding Comments

In this chapter, we have considered two main issues in a theoretical framework. The first part basically involves the theoretical formulation of a model representative of a market in disequilibrium, and the second part considers the issue of predictability in a market facing quantity constraints.

In more detail, we first consider whether a particular price mechanism, such as on the WSE, can simply be embedded in equilibrium theoretical foundations and, if not, whether there is an alternative economic theory which reflects the conditions of disequilibrium in a market which faces quantity constraints. We find that the traditional ‘economics of equilibrium’ forming the standard theory of prices, demand and transactions needs to be abandoned essentially because of the strong underlying assumption of market equilibrium no longer holds. Applying the disequilibrium framework introduced by Benassy (1982) to market under consideration, we find that notional demands found in equilibrium theory are no longer relevant and instead, that effective demands and supplies which are functions of price *and* quantity signals are those which are expressed on markets in disequilibrium. Working initially within the market for a single good, where effective demand (supply) is treated as the choice of an optimal action aimed at giving the best possible transaction in the presence of possible quantity rationing, we develop the concept of a perceived rationing scheme. This relates expected demand and supply to the transaction and we were therefore able to compare effective demand and supply to the demand and supply resulting if the market had cleared. In a multi-market setting, an investor’s effective demand (supply) is determined by maximising his utility function subject to the budget constraint and the perceived constraints on *other* markets. We extend this Benassy (1982) framework to incorporate cross and intertemporal spillover effects, and note the appropriateness of such a framework to a market mechanism such as that existing on the WSE.

³³ It is worth noting that the non-predictability of returns would not hold if the constraints become asymmetric and

Relying on ideas proposed by Benassy (1982) and Dreze (1975), we propose a more explicit model of traders' behaviour on a market experiencing quantity constraints. In the model, we present an investor's effective demand for a single asset when facing a binding constraint of the quantity of asset traded in an intertemporal framework. We show that effective demand for the asset in time period one (expressed at time zero) is a function of the quantity constrained asset in time zero and also of the part of demand expected not to be satisfied in period zero. Incorporating such spillover effects, being cross or intertemporal, we also conclude that in the case of a full cross-spillover effect, effective demand equals notional demand and the martingale hypothesis in prices can be maintained despite the presence of a binding transactional constraint on the market.

The second issue considered is that of predictability on a market with quantity constraints. With regard to this, bearing in mind theoretical inferences from the analysis of trader behaviour for a single asset, we propose a model of a disequilibrium trading system such as that existing on the WSE. We show that, using the proposed model for a single asset, the imposition of upper and lower price limits may not necessarily be a source for market predictability. In particular, if there is some kind of funds withdrawal process due to a quantity spillover in relation to other stocks or to non-market assets, the market might not be predictable. A formal proof of this is provided for the proposed model.

Appendix 4

4.1 The Random Walk Model

The Random Walk (RW) model can be represented in the following form;

$$P_t = P_{t-1} + \varepsilon_t \quad (\text{A4.1})$$

where $E(\varepsilon_t) = 0$, $\text{Cov}[\varepsilon_t, \varepsilon_{t-s}] = 0$, for all $s \neq 0$. P_t represents the price at time t and ε_t the residual series. If this relationship holds then the best predictor of tomorrow's price is today's price, or analogously, price changes can not be predicted from previous prices.

A possible version of the RW model is in the case where the value of P_t depends to some extent on previous prices. The conditional distribution of P_t given P_{t-j} , $j > 0$, will have a mean or expected value $E[P_t | P_{t-j}, j > 0]$. This conditional mean is the expected value of P_t given that previous prices have specific given values. Hence, the conditional mean would be expected to depend on previous prices, and can be represented as

$$E[P_t | P_{t-j}, j > 0] = f[P_{t-1}, P_{t-2}, \dots] \quad (\text{A4.2})$$

A price series is said to be *martingale* if the function $f[\dots]$ takes the simple form $f[\dots] = P_{t-1}$, so that

$$E[P_t | P_{t-j}, j > 0] = P_{t-1} \quad (\text{A4.3})$$

It follows that, in terms of prediction theory, if we attempt to predict P_t using previous prices and all possible functions $f[P_{t-1}, P_{t-2}, \dots]$, then the series is martingale if the optimal least squares predictor of P_t is simply P_{t-1} . Hence, the martingale process denotes efficiency in the variable of interest to reflect all relevant information available in the market.

Practically, it is of course statistically impossible to consider all possible functions of previous prices. If, say, consideration is limited to only linear functions so that predictors of P_t of the form $\sum_{j=1}^{\infty} a_j P_{t-j}$ only are considered, then the minimisation of the variance of the prediction errors results in P_{t-1} as the best linear predictor of P_t . This model is referred to as the *second-order martingale* model. Alternative restrictions can also be placed on this model; for instance, independence of the residuals as well as no correlation. However, the majority of empirical investigations are concerned with the martingale form, as they concentrate on the observed correlation between the residuals through different points in time.

4.2 A Logarithmic Transformation of the Random Walk Model

In empirical studies, a common transformation - which is also made in this thesis - is to use the logarithm of prices, hence it is of concern as to whether the transformed series also conform to a random walk. The logarithm transformation, in fact, does not change the model fundamentally, (except at low frequencies).

For instance, consider the following two equations;

$$p_t = p_{t-1} + e_t \quad (\text{A4.4})$$

$$\text{Log} p_t = \text{Log } p_{t-1} + v_t \quad (\text{A4.5})$$

Both the residual terms have zero means and are uncorrelated with past values. If it is assumed that the percentage change in price is small, as usually the case in practice, then the two models are approximately equal. To see this, the first equation can be written as,

$$p_t/p_{t-1} = 1 + e_t / p_{t-1} \quad (\text{A4.6})$$

and so the models would be identical if

$$\text{Log}(1 + e_t / p_{t-1}) = v_t \quad (\text{A4.7})$$

Expanding the right hand side as a power series and ignoring terms of higher order, we have the following,

$$e_t / p_{t-1} \approx v_t \quad (\text{A4.8})$$

For the two equations to be essentially equal,

$$e_t = p_{t-1} v_t \quad (\text{A4.9})$$

So, if it is assumed that p_{t-1} is independent of v_t , then if $\text{Log} p_t$ obeys equation (A4.5), it follows that p_t will obey equation (A4.4).

CHAPTER 5

PREDICTABILITY OF RETURNS ON THE WARSAW STOCK EXCHANGE

Summary

In this chapter, we firstly undertake a time series analysis of return series on the WSE. In the analysis, particular attention is paid to the limits censoring the movement of returns especially since this feature has important implications for the econometric techniques applied relying on the assumption of underlying Gaussian distributions. We find that, generally, the data series investigated over the given time period exhibit similar characteristics. Secondly, we propose an approach to modelling the predictability of returns for stock markets with disequilibrium trading.¹ Empirical test statistics are presented, based on the corrected Student-*t* statistic of a regression of returns of some information concerning the previous truncation. The empirical analysis of six main time series of returns on the Warsaw Stock Exchange confirms their *ex-ante*, but not *ex-post*, predictability.

¹ This section draws from the work in Charemza, Shields and Zalewska-Mitura (1997).

5.1 Introduction

In this chapter, we firstly undertake a time series analysis of six return series on the WSE over the period April 1991-May 1995. In this investigation, however, careful consideration is required because of the limits on the return generating process on the WSE resulting in non-standard distributions of returns. This subsequently has important implications for the econometric techniques applied relying on the assumption of underlying Gaussian distributions. Hence, section 5.2 begins by considering the characteristics of the data used, involving an autocorrelation analysis of equilibrium and censored returns, as well as an investigation of possible calendar effects caused by unequal weekly trading days. This is followed by a non-stationarity analysis, in section 5.3, using Monte Carlo methods to simulate the appropriate critical values.

Secondly, section 5.4 investigates the issue of predictability of these series on a market facing constraints on the return generating process using the proposed model in Chapter 4, section 4.6.2. We propose three simple regression tests of predictability based on regressions of returns of some information concerning the previous truncation and proceed to examine the size and power of these tests through Monte Carlo simulation experiments. A non-parametric correction is suggested which, in some circumstances, we find through further Monte Carlo experiments improves their power. Given this finding, we suggest a strategy to undertake the 'corrected' tests. Finally, in section 5.4.4, we present some preliminary results of testing for market predictability on the Warsaw Stock Exchange for the six series over the early years of operation of the exchange, April 1991 to May 1995. Section 5.5 concludes.

5.2 Data and Sample Characteristics

The plan of this section is as follows; section 5.2.1 gives a description of the data; section 5.2.2 presents summary statistics and the distributions of the series investigated; section 5.2.3 provides an empirical and simulation analysis of censored returns characterising those on the WSE; and finally, section 5.2.4 examines the existence of calendar effects caused by unequal weekly trading days on the exchange.

5.2.1 Description of the Data

The decision in the selection of price series from the WSE, and the sample period over which they are analysed, is made with regard to the consideration of the usefulness of the knowledge of early experiences on the stock exchange in a developing financial system of a country which was in its early stages of transforming to a market economy. The sample period in this analysis therefore ranges from the start of operations on the WSE, 16th April 1991, until mid-May 1995. More importantly, this was a period in which the overall level of foreign investment in the primary market of the exchange was a lot less than 20%.² This is an extremely relevant concern for new or 'infant' exchanges which may choose not to open their exchanges to foreign investors in the early stages, at the least for fear of excess volatility, or, as in the case of Poland, initial preference may for domestic investors.

The data used in this analysis has been made available by the Macroeconomic and Financial Data Centre at the University of Gdansk. The resulting six series chosen from the primary market of the WSE are on the basis of the largest number of observations. These are Tonsil, Prochnik, Kable, Exbud, Swarzedz and Wolczanka. All of these companies are involved in either manufacturing or construction where, in more detail, Tonsil is one of the main domestic producers of electro-acoustic converters (i.e. loud-speakers, microphones and earphones); Prochnik is a dominant Polish producer of men's coats and jackets; Kable is one of the leading producers of electrical cables and wires in Poland; Exbud is a construction company, its primary activity centring on the export of construction services and construction related products; Swarzedz is one of the largest furniture manufacturers and a leading exporter of furniture, and Wolczanka is a clothing manufacturer, dealing in imports and exports. None of these companies offer dividends.

The first four companies started trading on the WSE on the date of its opening, and Swarzedz and Wolczanka commenced trading on 25th June, 1991 and 16th July, 1991, respectively. This gives the number of observations for Tonsil, Prochnik, Kable, Exbud and the WIG being equal to approximately 477, 468 for Swarzedz, and 465 for Wolczanka. The number of sessions for each stock differs marginally due to various reasons contributing to non-trading days. For example, as described in Chapter 1 and 3, there may be suspended trading if the demands exceeds supply, or vice versa, by a ratio greater than 5:1, even after the overtime trading session. Alternatively, as in the case of Tonsil in January 1995,

authorities of the WSE suspended trading because the company had failed to submit satisfactory company reports. These few data points were deleted from the data set to avoid the incorporation of spurious zero returns. In very occasional circumstances (as will be seen in the graphs in section 5.2.2), the limits have been suspended due to an enormous degree of excess demand, in order to clear the market and prevent successive hits of the upper limit. In these cases, the sample outliers are censored to the upper 10 percent limit.

The other series considered for the WSE is the total return market 'WIG' index consisting of all companies listed on the primary market excluding foreign companies and investment funds. The same time period is chosen corresponding to the price series, and hence there are 477 observations. The index can be defined as,

$$\text{WIG}(t) = K(t) * \frac{M(t)}{M(0)} * 1000 \quad (5.1)$$

where t denotes the number of the session, $M(t)$ is the real capitalisation for session t , $M(0)$ is the base capitalisation (on session April 16, 1991) and $K(t)$ is the chain index factor for session t .³ In the simplest case, however, when no corporate action has taken place, the WIG Index is calculated according to the following formula,

$$\text{WIG}(t) = \text{WIG}(t-1) * \frac{M(t)}{M(t-1)} \quad (5.2)$$

where $\text{WIG}(1)$ takes the value of 1000 at the base date of 16 April 1991.

Figure 5.1 shows the price series graphed against the number of sessions, and Figure 5.2 (i) shows the time path of the WIG index, up until the May 1995 from the first session of each of the series. The price series all exhibit similar tendencies, where it is clear that in the first year,

² This compares to approximately 38% at the end of 1997, implying a huge increase in 2.5 years resulting in the WSE being commonly termed a 'big' emerging market. Note that these figures, especially the early ones, are approximate; Source: WSE.

³ $K(t)$ was introduced to avoid non-market changes in the index of portfolio capitalisation, and can be defined as $K(t) = K(t-1) * (\bar{M}(t) / M(t))$, where $\bar{M}(t)$ is the modified capitalisation for session t , being equal to $\bar{M}(t) = M(t) - I(t) - R(t) - N(t) + Q(t-1) + D(t) + V(t)$. $I(t)$ represents the market value of new emissions on the primary market in session t ; $R(t)$, the market value of equities issued with rights to new issue, $N(t)$, the market value of new primary issued equities; $Q(t-1)$, the market value of shares removed from the index after session $t-1$ and before session t ; $D(t)$, the equity's dividend which in session t is primary quoted without right to dividend (ex-dividend); and $V(t)$, the value of rights to new issue, which in session t is quoted for the first time after the day of established rights to the new issue.

the exchange performed badly in general - as did the Polish economy in 1991 - with the WIG Index dropping to about 600 point by October 1991. However, the improvement in macroeconomic fortunes in Poland in the first quarter of 1992 shows prices stabilising to an extent, but this is followed by a three month long slump with the WIG dropping to 635 points on June 26th. The rest of 1992, aided with a new government and greater political stability, is reflected by a positive tendency in all the price series. In all the price series, there is the period from February 1993 until June 1993 where the enactment of the new budget on February 22nd, 1993, coupled with a reduction of 3 percent in the re-finance credit interest rate and the consequent reduction in the deposit rates by the commercial banks contributed to the first experience, by the WSE, of a boom or 'hossa'. As mentioned in the first chapter, these series of events led to the WSE being the best performing stock exchange in the world, in terms of the largest amount of turnover produced. The market reversed itself in early June 1993, where the WIG subsequently dropped by 30 percent. After this collapse, the market, in general, fluctuated substantially, with a few large dips such as at the end of August 1993 and mid-September 1993. The series show a relatively smaller peak following the large peak, and this reflects the first quarter of 1994, when again the WSE was showing promising signs of recovery. However, this was not long-lived and since the end of April 1994, the exchange lost confidence, resulting with it performing badly during the rest of 1994. Since this period and up until mid-1995, all the series display a depressed, although apparently more stable state, with the WIG fluctuating around the 8000 mark.

In the next sub-section, we examine in more detail the statistical characteristics exhibited by the series over the given sample period.

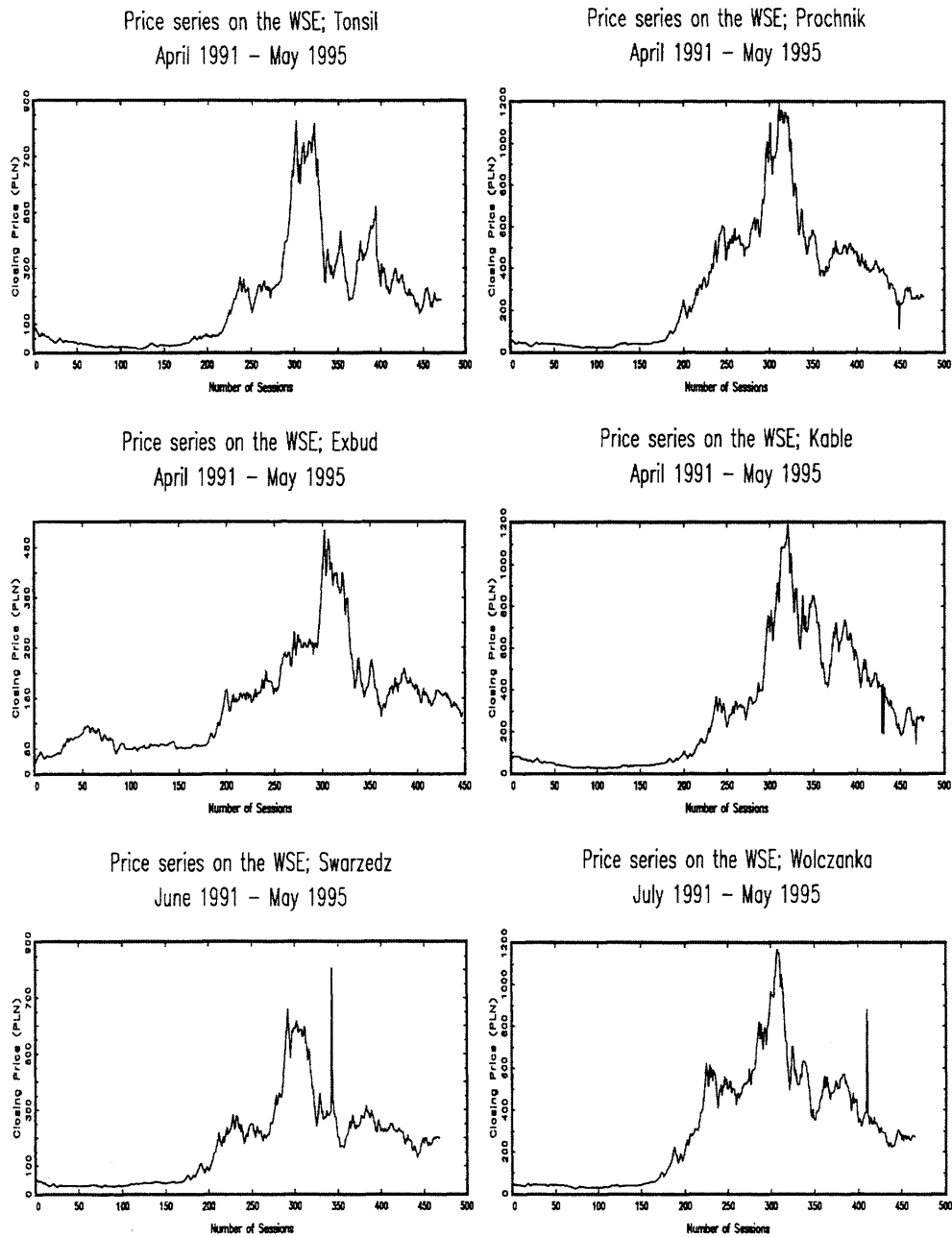


Figure 5.1: Price Series on the WSE, mid-April 1991 to mid-May 1995.

5.2.2 Summary Statistics and the Distribution of Returns

In the following analysis, all the series of raw returns were transformed into log returns, using the formula:

$$r_t = 100 * \ln\left(\frac{P_t}{P_{t-1}}\right) \approx 100 * \left(\frac{P_t - P_{t-1}}{P_{t-1}}\right) \quad \text{for small returns} \quad (5.3)$$

This logarithmic transformation has become standard in the finance literature in particular, since not only does this transformation facilitate computations, it avoids the problem of returns asymptotically diminishing towards zero with respect to the price variable.

Table 5.2 presents the summary statistics for the return series on the WSE including the WIG Index, Figures 5.3 and 5.4 respectively graph the return series and the distributions of the return series on the WSE, where the corresponding graphs for the WIG Index were shown in Figure 5.2.

From the return series in Figure 5.3, the censoring of returns is immediately apparent, and observing the corresponding distributions for the series in Figure 5.4a-b, the clustering of return observations at the upper and lower limits is again clearly seen for all the six series. Where the returns exceed the limits shows occasions at which the authorities have chosen to remove these limits. When compared to a normal distribution imposed on the six histograms, we can see that the distortion from the distribution appears to be quite marked. We also observe from the return series that accompanying the rise in turnover coupled with the increased in the number of trading days in 1992 (twice weekly) and thereby, the increased volume of trading, that there also seems to be significant increase in the volatility of returns. In addition, these return series show strong signs of volatility clustering, i.e. periods of extreme activity with large changes (of either sign) following large changes, and periods of relative calm where small changes (of either sign) follow small changes.⁴ Table 5.2 considers statistical measures of these distortions amongst other informative summary measures of the series to which we now turn.

⁴ This suggests the presence of ARCH-type effects, which have been the motivation behind the formulation of the ARCH family of models introduced by Engle (1982). These effects will be investigated further in chapter 5.

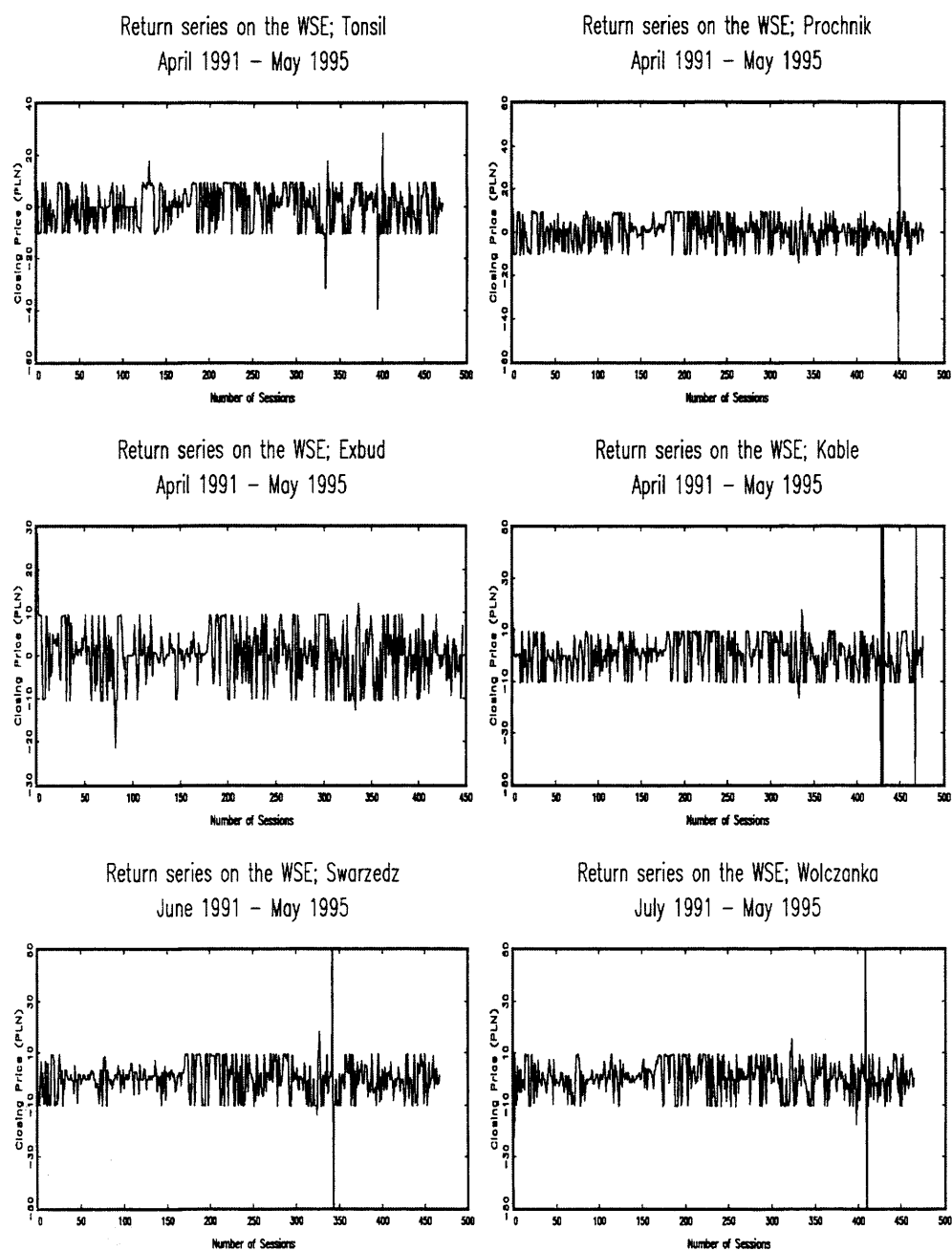


Figure 5.3: Return Series on the WSE, mid-April 1991 to mid-May 1995.

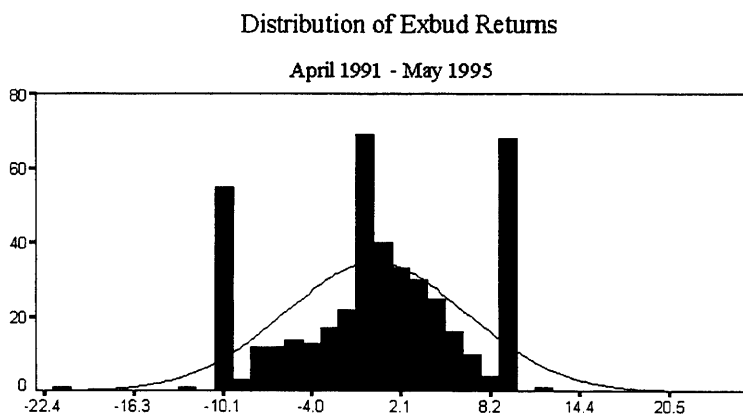
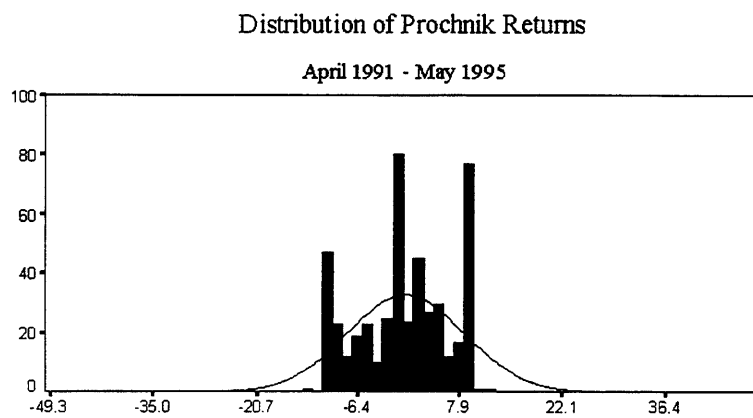
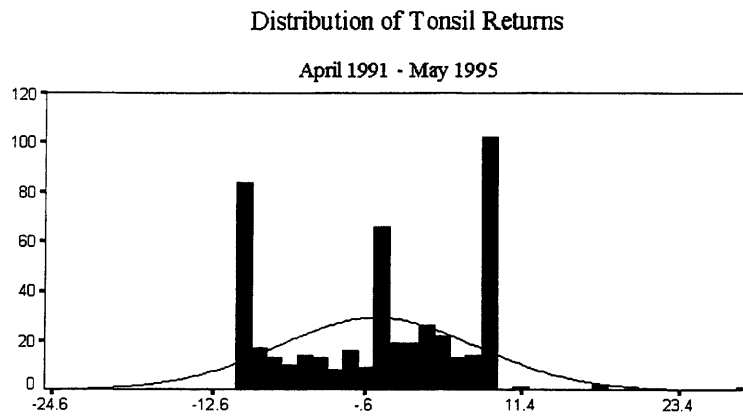


Figure 5.4a: Distribution of Returns on the WSE, mid-April 1991 to mid-May 1995.

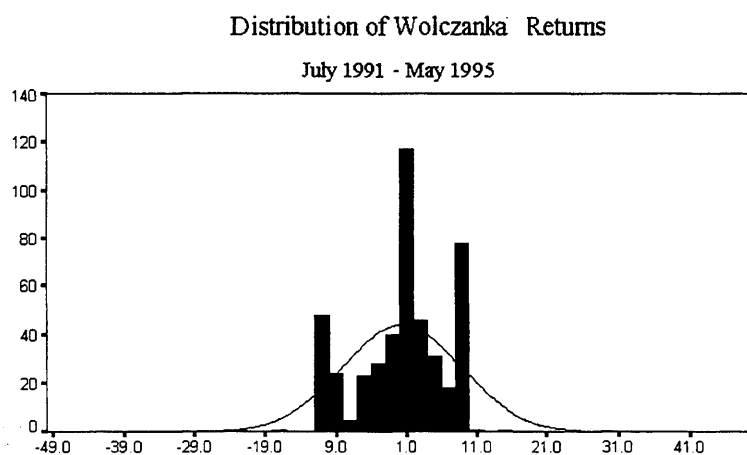
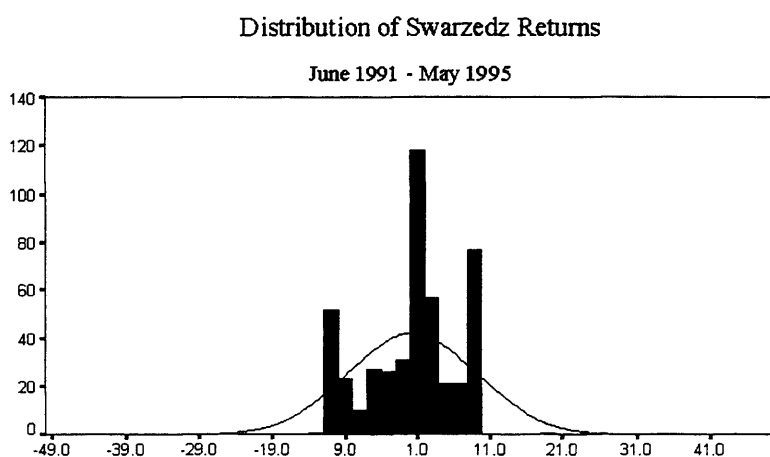
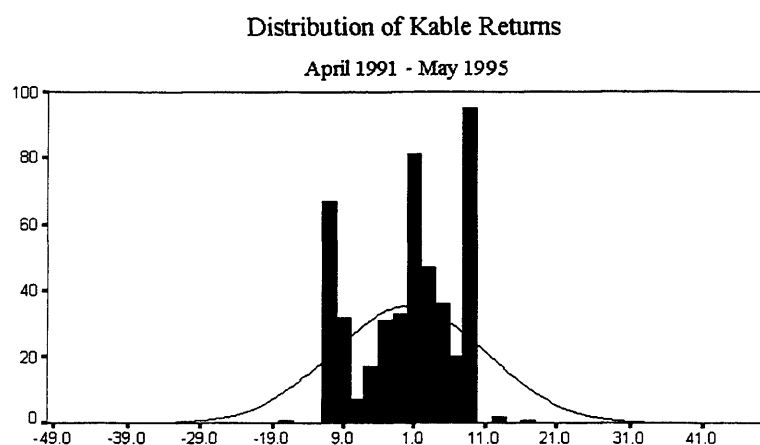


Figure 5.4b: Distribution of Returns on the WSE, mid-April 1991 to mid-May 1995.

Table 5.2: Summary Statistics for Return Series on WSE.

	Tonsil	Prochnik	Kable	Exbud	Swarzedz	Wolczanka	WIG Index
No. of Observations	471	476	476	476	467	464	476
Sample Mean	0.18	0.35	0.28	0.37	0.29	0.36	0.43
SE of Sample Mean	0.35	0.38	0.49	0.29	0.41	0.38	0.20
Variance	58.99	66.59	63.69	50.08	67.38	70.02	18.16
Standard Error	6.80	6.10	6.44	5.80	5.89	5.84	4.26
Skewness	-0.43	-0.51	0.02	-0.12	1.03	-0.51	-0.22
Kurtosis	0.91	34.07	26.89	0.15	56.74	43.85	0.48
No. of Upper Hits	40	55	47	46	58	38	-
No. of Lower Hits	91	60	90	57	64	58	-
Freq. of Hits	0.25	0.24	0.29	0.22	0.26	0.20	-

Notes: Returns are measured by $r_t = 100 * \ln(P_t / P_{t-1})$ for each series, from the start of trading of each series (mid-April 1991) until mid-May 1995. The number of upper and lower hits are measures of the number of times returns were closer than 0.05% to its upper or lower boundary, i.e. if the published price was equal or higher than 1.095 times the previous session price or 0.905 times lower than the previous session price. Measures of skewness and kurtosis are defined as in expressions (5.4) and (5.5), respectively, in the text.

In general, the descriptive statistics show a relative homogeneity of the data set. The sample means for each return series are approximately equal and range from 0.18 with a standard error of 0.35 for Tonsil to 0.37 for Exbud with a standard error of 0.49, with the WIG Index showing the highest mean of 0.43 (standard error 0.20). Moreover, the standard errors are of similar magnitudes.

The measures of skewness and kurtosis can be used to detect departures from normality in the distribution of returns. The skewness statistic can be defined by,

$$\text{Skewness} = \frac{m_3}{m_2^{3/2}} \quad (5.4)$$

and kurtosis by,

$$\text{Kurtosis} = \frac{m_4}{m_2^2} - 3 \quad (5.5)$$

where, in both,

$$m_k = \sum_{i=1}^n (r_i - \bar{r})^k / n \quad k = 2, 3, 4. \quad (5.6)$$

Skewness statistics are used to assess the symmetry of distributions. A non-zero skewness statistic indicates an asymmetrical distribution, where a negative statistic implies a skewness to the right and a positive statistic indicates a skewness to the left. The signs of the skewness statistics are varied with Tonsil, Prochnik, Exbud, Wolczanka and the WIG Index exhibiting negative skewness, and Kable and Swarzedz displaying positive skewness, although generally the statistics for the series are close to zero, indicating that the sample distributions are approximately symmetric.⁵

Normal distributions, with kurtosis being defined as in expression (5.5), have kurtosis equal to zero. A positive value usually indicates a uni-modal non-normal distribution with thicker tails than the normal distribution, and a negative, distributions with thinner tails than the normal distribution (see D'Agostin et al. (1990) for further details).⁶ All the kurtosis statistics are positive, supporting the observations from the histograms of the return series, from which can be seen quite clear departures from normality.

Hence, as anticipated, the distribution of returns of the series are not expected to be normal or even Gaussian distributed, due to the 10 percent limit on the change in price from one session to the next. If this limit were not operational, then we would perhaps expect the more commonly exhibited higher peaked and fatter tailed distributions relative to the Normal distribution characteristic of many financial time series.

Finally, during the period up until mid-May 1995 from the start of operations, representing the early years of the stock exchange, we can see that the frequency of 'hits', being defined as the number of times returns were closer than 0.05% to its upper or lower boundary, is approximately 25%.⁷ This is a large enough percentage to significantly distort the distribution of returns away from a Normal or Gaussian distribution. For the WIG Index, though, since it

⁵ The standard error of the statistic can be calculated by $\sqrt{6/n}$ for a random sample from a normal distribution. Quite clearly, in the case of the given series, this formula is of little value.

⁶ Again, the standard error given by $\sqrt{24/n}$ for Gaussian white noise is of little use here.

is an aggregate of all the main price series on the stock exchange, we would expect the role of the censored returns to diminish and thus the distribution more closely resemble a typical financial return series distribution. These conjectures are confirmed by the histograms in Figures 5.2 and 5.4a-b illustrating the distribution of returns of the WIG Index and individual series on the WSE, and the super-imposed curve representing an estimated kernel density plot of a Gaussian distribution with the same mean and variance in each case. All the graphs show significant evidence of leptokurtosis found earlier, with the distributions for the price series supporting a tri-modal shape. Interestingly, we find that the number of lower hits generally exceed the number of upper boundary hits, and in the case of Tonsil and Kable, the difference is over two times as many. However, Figure 5.5 plots the cumulative frequency of hits at each session denoted by,

$$fr = \frac{\sum_{j=1}^t h_j^u}{t} \quad \text{for } t = 1, 2, \dots, n \quad (5.7)$$

where, h_j^u equals 1 for every hit of an upper limit in the session j (where u represents the upper boundary and is substituted for l for the lower boundary), t is the number of sessions at a particular time and n is the total number of sessions. From the graphs, we can see that it is generally the case that as the exchange matures, both the upper and lower hits have been declining over time (with the exception of Swarzedz in the case of the cumulative frequency of upper hits, although the series does show a tendency to decline at a relatively later stage).

⁷ In other words, a 'hit' occurs if the published price is equal or higher than 1.095 times the previous session price or 0.905 times lower than the previous session price (due to rounding errors etc).

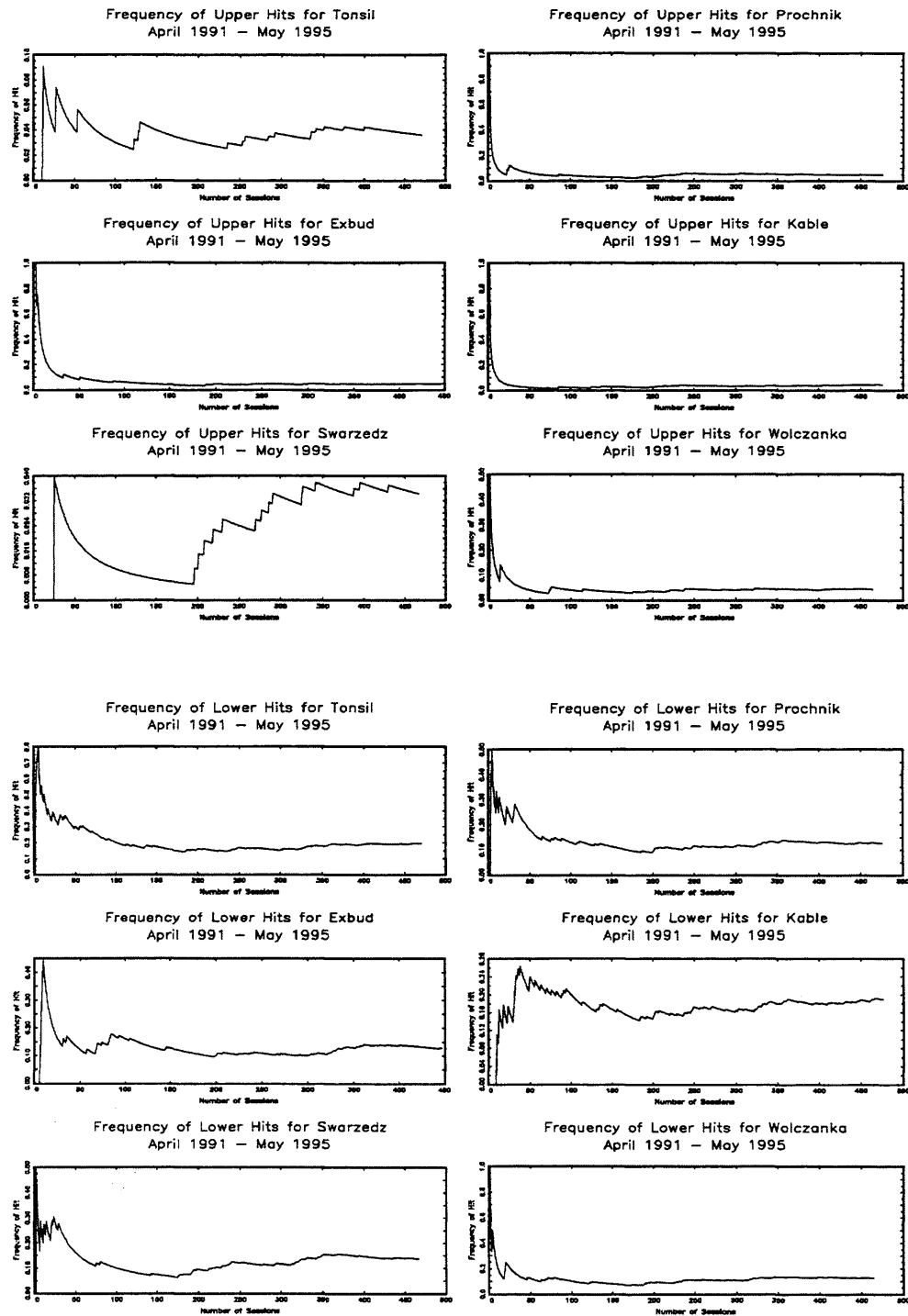


Figure 5.5: The Number of Upper and Lower Hits at Time t as a Proportion of the Number of Sessions at Time t .

5.2.3 An Empirical and Simulation Analysis of Autocorrelation

An Empirical Analysis

In this section, we undertake an autocorrelation analysis of the return series on the WSE, where any process is defined to be autocorrelated if the correlation between two random variables r_i and $r_{i+\tau}$ is not significantly equal zero for all i and all $\tau > 0$. Generally, they can be thought of as diagnostic checks aimed at detecting general departures from white noise (since the random variables are assumed to be obtained from a stationary process). Table 5.3 presents the autocorrelation coefficients with standard errors for the six series on the WSE, Figures 5.6a-b graph the corresponding autocorrelation coefficients and Tables 5.4 and 5.5 further provide diagnostic tests from various portmanteau statistics. We discuss each of these in turn.

The l -th autocorrelation coefficients presented in Table 5.3 for the return series on the WSE, can be calculated as,

$$R_l = \frac{C_l}{C_0} \quad \text{for } l = 1, 2, \dots, (n/3), \quad (5.8)$$

where,

$$C_l = n^{-1} \sum_{t=l+1}^n (r_t - \bar{r})(r_{t-l} - \bar{r}). \quad (5.9)$$

The standard errors (approximately given by \sqrt{n} where n denotes the total number of observations) are also presented so an approximate indication can be obtained of the significance of the coefficients. However, as noted earlier, since the underlying distribution of returns is unlikely to be $N(0,1)$, we cannot typically reject the null of no autocorrelation at the 0.05% significance level if $\sqrt{n} \cdot |R_l| > 1.96$. However, from the Table and the autocorrelation functions graphed in Figures 5.6a-b, it is clear that all the returns series display significant autocorrelation, with t-ratios at the first order ranging from -1.96 for Prochnik up to -6.78 for Kable. Beyond the fourth lag at the most, as seen in the Table and from the graphs, the

correlations tend to insignificance for all the series concerned, with largely damped fluctuations of the autocorrelation functions around zero.

Table 5.3: Autocorrelation Coefficients of WSE Return Series (standard errors in brackets).

Order	Autocorrelation Coefficients for:					
	Tonsil	Prochnik	Kable	Exbud	Swarzedz	Wolczanka
1	0.268	-0.090	-0.312	0.253	-0.092	-0.130
	(0.046)	(0.046)	(0.046)	(0.047)	(0.046)	(0.046)
2	0.107	0.053	0.232	-0.032	-0.007	0.057
	(0.049)	(0.046)	(0.050)	(0.050)	(0.047)	(0.047)
3	0.048	-0.030	-0.160	-0.031	-0.063	-0.033
	(0.050)	(0.047)	(0.053)	(0.050)	(0.047)	(0.047)
4	0.052	0.061	0.001	0.018	0.022	0.019
	(0.050)	(0.047)	(0.053)	(0.050)	(0.047)	(0.047)
5	0.049	0.047	0.032	-0.018	0.024	0.038
	(0.050)	(0.047)	(0.053)	(0.050)	(0.047)	(0.047)
6	-0.056	-0.011	-0.009	-0.049	0.029	-0.019
	(0.050)	(0.047)	(0.054)	(0.050)	(0.047)	(0.047)
7	0.013	-0.020	0.007	0.047	-0.070	-0.038
	(0.050)	(0.047)	(0.054)	(0.050)	(0.047)	(0.048)
8	0.004	0.011	0.050	-0.009	0.076	0.086
	(0.050)	(0.047)	(0.054)	(0.051)	(0.047)	(0.048)
9	0.002	-0.023	-0.016	-0.025	-0.008	-0.040
	(0.050)	(0.047)	(0.054)	(0.051)	(0.047)	(0.048)
10	0.041	0.037	-0.047	0.045	-0.063	-0.072
	(0.050)	(0.047)	(0.054)	(0.051)	(0.047)	(0.048)
11	0.031	0.020	-0.031	0.039	0.007	0.023
	(0.050)	(0.047)	(0.054)	(0.051)	(0.047)	(0.048)
12	0.019	-0.003	0.026	0.034	-0.029	0.042
	(0.050)	(0.047)	(0.054)	(0.051)	(0.047)	(0.048)

Notes: The autocorrelation coefficients are defined as in expressions (5.8) and (5.9) in the text. Standard errors are given in parenthesis.

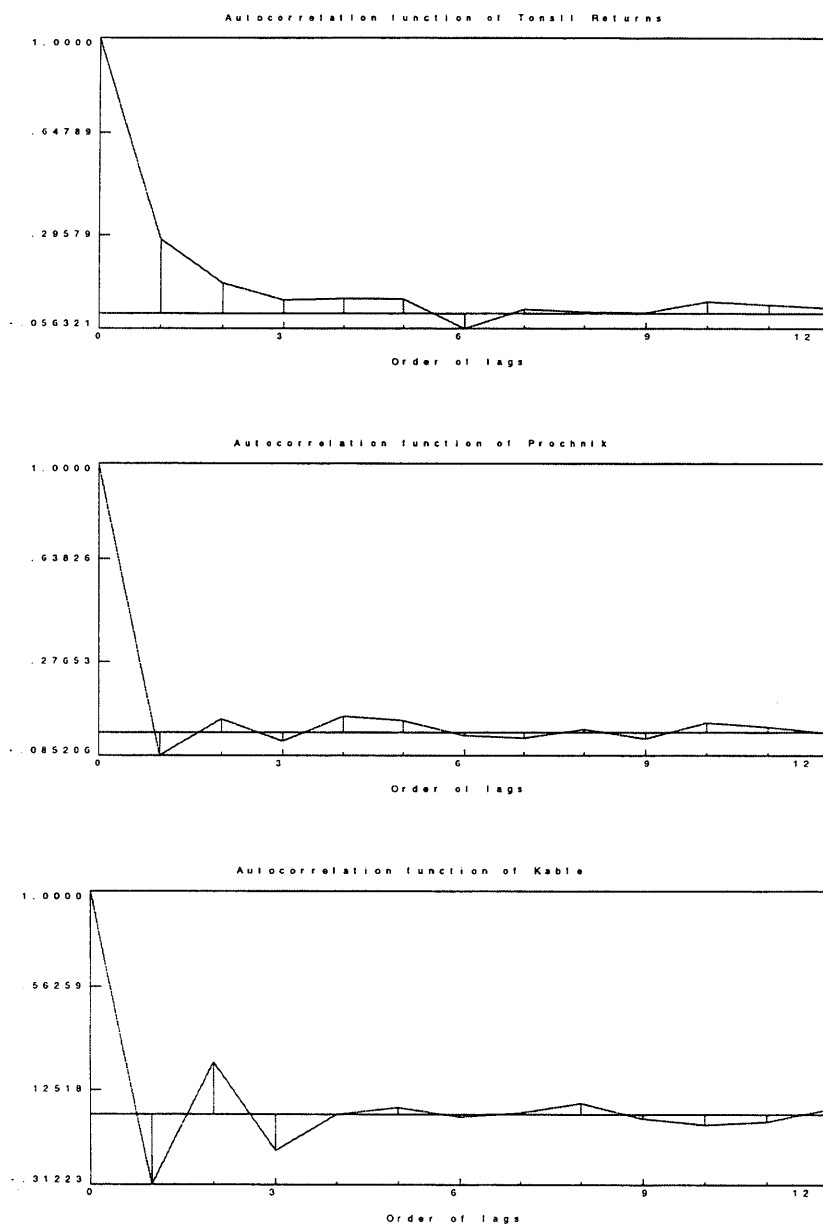


Figure 5.6a: Autocorrelation Functions for Series on the WSE

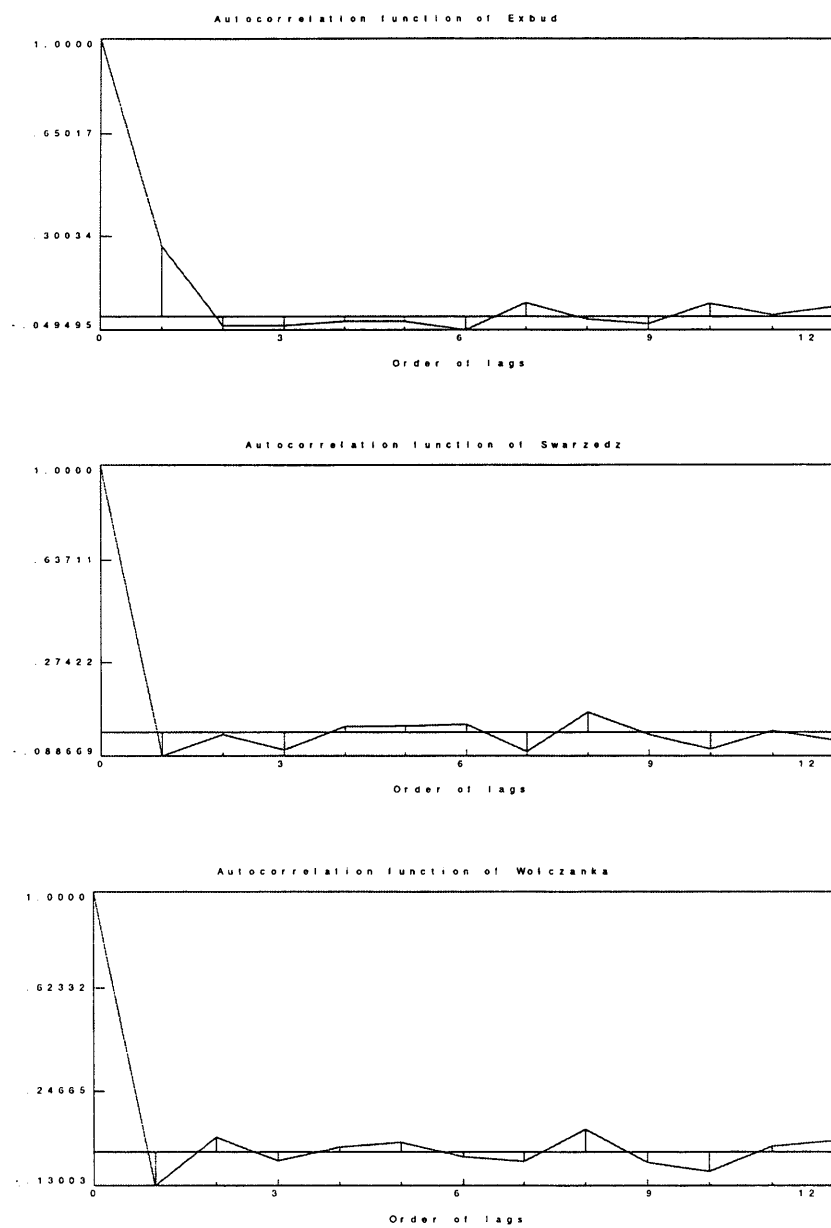


Figure 5.6b: Autocorrelation Functions for Series on the WSE

If a set of autocorrelation coefficients are solely considered however, then some will probably be significant even if the null is true; for instance, on average one out of twenty would be significant at the 0.05 significance level. In order to gain robustness in the results in such circumstances, portmanteau statistics such as the Box-Pierce Q-Statistic and the Ljung-Box Statistics can be used. Note again that under the random walk null (where the series r_t are serially uncorrelated), both statistics are distributed asymptotically as chi-squared variates with the degrees of freedom being equal to the order of the tests.⁸ Hence, the significance of such statistics when applied to the return series on the WSE may be required to be treated with the appropriate caution.

The Box-Pierce Q-Statistic, introduced by Box and Pierce (1970), was originally designed for testing autocorrelation in the residuals of a model. The test can also, however, be applied directly to raw data (or the square of raw data), and can be given by,

$$Q = n \sum_{j=1}^p R_j^2, \quad (5.10)$$

where R_j is defined as in expression (5.8). Ljung and Box (1978) modify this original Q -statistic, so that it has a closer approximation to the actual null distribution and tends to be more reliable in smaller samples. The modified Q -statistic, Q^* , is given by,

$$Q^* = n(n+2) \sum_{j=1}^p (n-j)^{-1} R_j^2, \quad (5.11)$$

where both statistics are $\chi^2(p)$ are distributed.

Table 5.4 reports both the portmanteau statistics at the sixth and twelfth order of autocorrelation coefficients for the six return series on the WSE. Noting the caveat above with regard to the null assumed in these diagnostic tests, the figures in parentheses denote the

⁸ Note that both statistics do not require a specific alternative hypothesis and are hence referred to as diagnostic tests hopefully with some power against the null for a wide range of alternatives.

marginal significance levels (or the p -values) referring to the probability of falsely rejecting the null hypothesis of no serial correlation in the return series. However, at least for Tonsil, Kable, Exbud and Wolczanka, these concerns are mitigated due to the high values of both statistics providing clear evidence of serial correlation in their return series. Both Prochnik and Swarzedz provide weaker evidence against the null, at the lower orders for Prochnik, and for the Swarzedz return series, there is approximately a 33% chance of falsely rejecting the null of no serial correlation.

Table 5.4: Portmanteau Statistics for Returns on the WSE

	Ljung-Box Statistic of Order:		Box-Pierce Statistic of Order:	
	(6)	(12)	(6)	(12)
Tonsil	44.97 (0.00)	46.53 (0.00)	44.43 (0.00)	46.15 (0.00)
Prochnik	8.07 (0.23)	9.50 (0.66)	8.00 (0.24)	9.39 (0.67)
Kable	84.64 (0.00)	87.81 (0.00)	83.99 (0.00)	87.07 (0.00)
Exbud	31.23 (0.00)	34.06 (0.00)	31.00 (0.00)	33.76 (0.00)
Swarzedz	6.52 (0.36)	13.96 (0.30)	6.47 (0.37)	13.74 (0.31)
Wolczanka	10.97 (0.08)	19.53 (0.07)	10.88 (0.09)	19.25 (0.08)

Notes: The Box-Pierce and Ljung-Box portmanteau statistics reported for the sixth and twelfth order are defined respectively as in expressions (5.10) and (5.11) in the text. The figures in parenthesis are the marginal significance levels (or the p -values) referring to the probability of falsely rejecting the null hypothesis of no serial correlation in the return series. Note that the p -values are calculated under the assumption that the null follows a random walk.

In general, the return series on the WSE reject the null no autocorrelation, suggesting that the return series are not realisations of a strict white noise process (where returns would be

independently and identically distributed). In order to establish this conclusion more decisively and therefore attempt to detect the presence of some non-linear structure in the series, Granger and Anderson (1978) were the first to suggest the testing for autocorrelation in a transformed series, where, if the original series follows a strict white noise process, then so will the transformed series.⁹ Table 5.5 presents the Ljung-Box statistics (at the twelfth order) for the six series on the WSE, where the figures in parentheses are again the marginal significance levels. All the results provide strong evidence of the presence of a non-linear structure, where the series convincingly reject strict white noise.¹⁰

Table 5.5: Ljung-Box Statistics for Squared Returns on the WSE.

	Ljung Box Q-Statistic of Order (12)
Tonsil	46.34 (0.00)
Prochnik	59.19 (0.00)
Kable	50.18 (0.00)
Exbud	87.81 (0.00)
Swarzedz	164.99 (0.00)
Wolzcanka	132.68 (0.00)

Notes: The Ljung-Box portmanteau statistic reported for the twelfth order is defined in expression (5.11) in the text. The figures in parenthesis are the marginal significance levels (or the p -values) referring to the probability of falsely rejecting the null hypothesis of no serial correlation in the return series.

A Simulation Analysis

So far, although we can conclude that the return series on the WSE exhibit autocorrelation, we cannot, however, make informed deductions concerning whether or not the price-setting process on the stock exchange itself is inefficient. This is because the censoring of returns on the exchange complicates the issue. For instance, the autocorrelation could be caused by the imposition of limits on the change in prices or by inefficiencies in the price-setting process, or

⁹ The 'transformation' represents the series squared, for instance.

both. In this section, we attempt to isolate the issue by undertaking a simulation analysis investigating the impact of limits on a price-setting process which is efficient, i.e. which follows a random walk process.

Assume that, in the simplest case, prices follow a pure random walk process without a drift such that,

$$p_t = p_{t-1} + v_t, \quad (5.12)$$

where v_t follows a white noise process (i.e. $v_t \sim i.i.d(0, \sigma^2)$). Then for 500 observations, for example, returns defined as in expression (5.3) can be graphed as in Figure 5.7(a) and its distribution in Figure 5.8(b) can be seen as approximating a normal distribution. However, if symmetric limits are now imposed on the change in price of a series from one period to the next, as in the WSE, then the price-setting procedure can be characterised as the following process,

$$p_t = \begin{cases} p_{t-1} + v_t & \text{if } |p_t - p_{t-1}| < w \\ p_{t-1} + w & \text{if } p_t - p_{t-1} \geq w \\ p_{t-1} - w & \text{if } p_t - p_{t-1} \leq -w \end{cases}, \quad (5.13)$$

where, w represents the imposed limit, which is equal to 0.1 in the case of the WSE.¹¹ Since (5.13) is a model without a drift term originally, then the of hits of the limits will depend on the size of σ^2 . Assuming that there are *no* spillover effects and or any withdrawal of funds from the share in the market, Figure 5.7(b) and Figure 5.8(b) graph the original random walk process in equation (5.12) subject to the restrictions in model (5.13), where σ^2 is such that the approximate frequency of hits is 25% (as in the empirical series on average), and the sample size is equal to 500. The censoring restrictions are clear in the simulated returns graph and we can see the radical effect on the distribution of returns in Figure 5.8(b).

¹⁰ The significant autocorrelation in the squared data given support for the ARCH formulation; this is considered in Chapter 5.

¹¹ Note that $\ln(1+x) \approx x$ if x is small, therefore we can write $w = \ln(1.1)$.

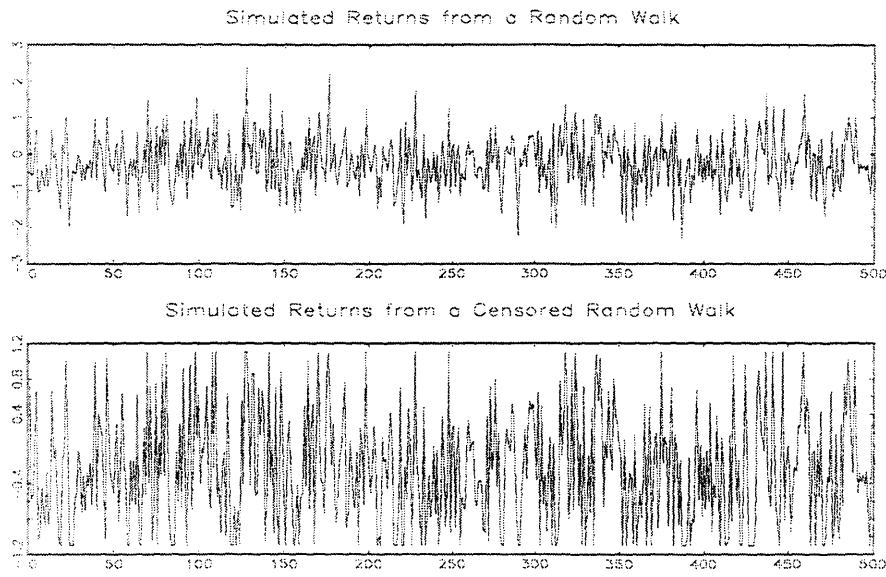


Figure 5.7: Simulated Returns from a Pure Random Walk (a) and a Censored Random Walk (b).

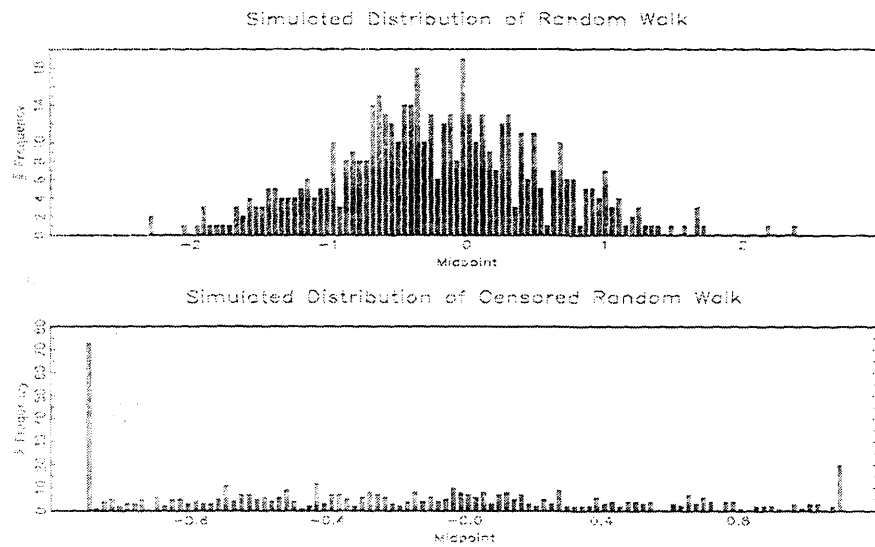


Figure 5.8: Distribution of Simulated Returns from a Pure Random Walk (a) and a Censored Random Walk (b).

Let us now consider the effect on the size of the autocorrelation coefficients when the ‘underlying’ process is a random walk (and hence the autocorrelation coefficients should be insignificant) compared to when the same process is subject to the limits on the change in price, characteristic of the restrictions on the WSE. Table 5.6 presents the autocorrelation coefficients for both the model and the corresponding Ljung-Box statistics. As expected, for the pure random walk model, the autocorrelation coefficients are all insignificant and the marginal significance levels (in square brackets) for the Ljung-Box statistics all very strongly indicate the presence of no autocorrelation. In comparison, it can be seen for the censored random walk model, that, not only are the autocorrelation coefficients generally higher than the corresponding random walk coefficients, the first order coefficient is over three times higher in absolute magnitude. Moreover the very low p -values indicate the convincing evidence of autocorrelation. Bearing in mind the assumptions made above, the addition of a drift term to model (5.12) further increases the frequency of hits of the limits hence strengthening the result that the imposed restrictions on the movement of returns partly contribute to the resulting autocorrelation observed on the empirical return series on the WSE.

Finally, Table 5.7 shows similar statistics to Table 5.6, but for the simulated squared returns from each process (5.12) and (5.13), in order to infer if the limits also contribute to the non-linearity observed in the empirical series on the WSE in Table 5.5. As expected, the marginal significance levels for the Ljung-Box statistics for the squared returns from the random walk series indicate the absence of autocorrelation. However, the corresponding statistics for the square returns from the censored random walk series *also* strongly suggest the presence of no autocorrelation, thus suggesting that the process of empirical returns themselves may be subject to some sort of non-linear structure which is not greatly influenced by the presence of the limits. These general results are however based on the fact that there have been no spillover effects or withdrawal of funds assumed and therefore although the results provide some valuable insights, they need to be treated with the appropriate caution.

Table 5.6: Autocorrelation Coefficients and Ljung-Box Statistics for Returns from a Simulated Random Walk and Simulated Censored Random Walk.

Order	Pure Random Walk		Censored Random Walk	
	Autocorrelation Coefficient	Ljung-Box Statistic	Autocorrelation Coefficient	Ljung-Box Statistic
1	-0.031 (0.045)	0.49 [0.483]	0.104 (0.045)	5.46 [0.019]
2	0.025 (0.045)	0.81 [0.665]	0.051 (0.045)	6.74 [0.034]
3	0.040 (0.045)	1.65 [0.658]	0.066 (0.045)	8.94 [0.030]
4	-0.027 (0.045)	2.02 [0.732]	-0.020 (0.045)	9.08 [0.059]

Notes: The pure random walk model and the censored random walk models are respectively as according to (5.12) and (5.13) in the text. The Ljung-Box portmanteau statistic reported for orders 1 to 4 is defined in expression (5.11) and the autocorrelation coefficients are defined as in expressions (5.8) and (5.9). The figures in square brackets are the marginal significance levels (or the p -values) referring to the probability of falsely rejecting the null hypothesis of no serial correlation in the return series. Standard errors are given in parenthesis.

Table 5.7: Autocorrelation Coefficients and Ljung-Box Statistics for Squared Returns from a Simulated Random Walk and Simulated Censored Random Walk.

Order	Pure Random Walk		Censored Random Walk	
	Autocorrelation Coefficient	Ljung-Box Statistic	Autocorrelation Coefficient	Ljung-Box Statistic
1	-0.021 (0.045)	0.24 [0.622]	0.002 (0.045)	0.002 [0.963]
2	-0.031 (0.045)	0.73 [0.694]	-0.011 (0.045)	0.0706 [0.965]
3	-0.031 (0.045)	1.21 [0.749]	-0.035 (0.045)	0.697 [0.874]
4	-0.050 (0.045)	2.49 [0.646]	-0.030 (0.045)	1.167 [0.883]

Notes: The pure random walk model and the censored random walk models are respectively as according to (5.12) and (5.13) in the text. The Ljung-Box portmanteau statistic reported for orders 1 to 4 is defined in expression (5.11) and the autocorrelation coefficients are defined as in expressions (5.8) and (5.9). The figures in square brackets are the marginal significance levels (or the p -values) referring to the probability of falsely rejecting the null hypothesis of no serial correlation in the return series. Standard errors are given in parenthesis.

5.2.4 Calendar Effects

Although the WSE is now trading five days a week, as mentioned previously, it has not always done so. Hence, equal treatment to returns obtained during different trading day weeks would be incorrect if, for example, returns for when there was one day a week trading is significantly different to returns in periods of an increased number of trading days a week.

On the WSE, for a series trading from the beginning of the operations of the exchange, the first 36 sessions were once a week on Tuesdays; the next 100 sessions involved Tuesdays and Thursdays; three days a week pursued for the following 229 sessions where Monday was included; Wednesday was the next day to be added for four trading days a week for 50 sessions; and finally, since the 418th session, there has been five days of weekly trading. Table 5.8 presents *t*-statistics comparing the means of two samples at a time assuming that the standard deviations of the samples being compared are not equal. Again, although the censoring of the returns makes it highly unlikely for the returns to follow a normal distribution, the test statistics will provide a indication of whether it is appropriate to consider the returns obtained from different trading days symmetrically. The test statistics are only reported for Tonsil, Prochnik and Kable since they do not generally differ from the rest of the series, where as seen in Table 5.8, the *t*-statistics on the whole are small enough in absolute magnitude to treat returns in different trading days equally.

Table 5.8: Heteroskedastic two-sample t-statistics; Null: two sample mean returns are equal.

Days Trading/week		Sample Size	Mean Return	Variance	Days Trading/week; <i>t</i> -statistics			
					2	3	4	5
Tonsil:	1	36	-1.807	66.09	-1.01	-1.60	-1.13	-0.88
Tonsil:	2	100	-0.253	43.43	-	-1.21	-0.44	0.11
Tonsil:	3	229	0.764	60.05	-	-	0.20	1.11
Tonsil:	4	47	0.452	97.83	-	-	-	0.48
Tonsil:	5	60	-0.372	46.33	-	-	-	-
Prochnik:	1	36	-0.585	78.23	-0.23	-1.07	-0.36	0.49
Prochnik:	2	100	-0.204	37.34	-	-1.60	-0.24	0.20
Prochnik:	3	229	1.073	43.07	-	-	1.24	0.83
Prochnik:	4	51	0.020	26.66	-	-	-	0.30
Prochnik:	5	60	-0.619	73.92	-	-	-	-
Kable:	1	36	-0.825	53.15	-0.20	-1.49	-0.16	0.01
Kable:	2	100	-0.450	34.31	-	-1.50	-0.39	0.13
Kable:	3	229	1.121	52.18	-	-	1.04	0.62
Kable:	4	51	-0.005	46.31	-	-	-	0.10
Kable:	5	60	-0.878	89.21	-	-	-	-

Notes: The *t*-statistics reported test the null that the two sample means of the return series on the WSE are equal assuming that the variances of both ranges of data are unequal.

5.3 Critical Value Generation and Stationarity Tests for Price Series on the Warsaw Stock Exchange

There is well-known literature on unit root processes and the fact that their presence generates misleading coefficient estimates in regression analysis. For instance, Phillips (1986) shows that if regression analysis is undertaken using non-stationary time series, then the statistical properties of the regression are difficult to interpret since the distributions of the series do not

follow the familiar Gaussian or Normal and so inferences based on these will be incorrect.¹² Therefore, in order to carry out any sensible regression analysis, it is important to first determine the order of integration of the series.

Stated simply, a series is said to be ‘stationary’ if its probabilistic properties do not change over time, and in particular, if the mean and variance of the series remain unchanged over time.¹³ If a series is non-stationary, but becomes stationary on differencing d times, it contains d unit roots and is said to be ‘integrated of order d ’. Hence, if a process is integrated of order one, i.e. an $I(1)$ process, then the series must be differenced once in order to make it stationary.¹⁴

The most simplest and widely used tests for unit roots were developed by Fuller (1976) and Dickey and Fuller (1979) and are commonly referred to as the Augmented Dickey-Fuller tests (see Dickey, Bell and Miller (1986) for a detailed exposition). A typical null model is written as follows,

$$\Delta p_t = \psi p_{t-1} + v_t, \quad H_0 : \psi = 0; H_1 : \psi < 0, \quad (5.14)$$

to which there is an addition of a constant (or drift) term and/or a trend and where $v_t \sim i.i.d(0, \sigma^2)$. It is well known that the test statistic $\tau = \hat{\psi} / se(\hat{\psi})$ does not follow usual t -distribution under the null hypothesis, since the null is one of non-stationarity, but instead follows a non-standard distribution. Critical values for these non-standard distributions have been derived by various numerical methods, including Monte Carlo simulation. The best known reference is probably Fuller (1976) in which certain asymptotic critical values for the unit root tests are tabulated as well as for a few selected sample sizes and response surface critical values have also been computed by Mackinnon (1991). However, all these critical values have been simulated according (or similar) to model (5.14) which depend on the assumption that the error terms are normally distributed. However, in the case of the WSE, the return generating process is censored. This suggests that in order to obtain a more accurate

¹² See Newbold and Davies (1978) and Granger and Newbold (1986) for further illustrations of spurious relationships.

¹³ The inclusion of a deterministic element in the model of the series, such as a time trend, does not affect the stationarity of the series, the probabilistic properties of the series not being altered by an element which is known with certainty.

¹⁴ Note that a unit root is only one possible form of non-stationarity; processes containing an explosive root or a higher order process are also examples of non-stationary processes. See Banerjee et al (1993) for further details on non-stationary processes.

inference on the non-stationarity of the price series on the WSE, a new set of critical values need to be computed.

The following model can be considered to capture the restrictions imposed on the movement of prices as on the WSE, and is a modification of the random walk generating process in equation (5.14). A drift term is included in this model to capture the observed drift in the empirical price series graphed in Figure 5.1.

$$p_t = \begin{cases} \mu + p_{t-1} + v_t & \text{if } |p_t - p_{t-1}| < w \\ p_{t-1} + w & \text{if } p_t - p_{t-1} \geq w \\ p_{t-1} - w & \text{if } p_t - p_{t-1} \leq -w \end{cases}, \quad (5.15)$$

where $v_t \sim i.i.d(0, \sigma^2)$ as before, and $w = \ln(1.1)$ and the price series p_t are also in logarithmic form. This process can be transformed by taking first differences (where $r_t = p_t - p_{t-1}$ as before), and can be written as,

$$\Delta p_t = \mu + \psi p_{t-1} + v_t, \quad (5.16)$$

where the statistical significance of the coefficient ψ is tested for. Model (5.16) however only reflects the restrictions on the movement of prices. In order to be more representative of the actual return series on the WSE, the size of the drift term and the variance of the error term v_t need to be adjusted to approximate the with which prices hit the limits on the WSE. Through the analysis of the descriptive statistics in section 5.2, the characteristics of the empirical return series have revealed relative homogeneity and the average frequency of hits has been approximately 25%. The GAUSS program for the generation of critical values has been included in the Appendix, where the frequency of hits for the simulated series is approximately 25%, and the standard deviation of the simulated series is close to average of those observed for the return series on the WSE (i.e. approximately 6; see Table 5.1). There are basically two main steps involved in generating the critical values. Firstly, the price series are simulated a number of times from random draws from a Gaussian distribution subject to the above restrictions in (5.16) and the mentioned specifications, for a sample size of 500 to approximately correspond to the size of the data set. Secondly, ADF tests are carried out calculating the t-ratio for the coefficient ψ in equation (5.16) for each price series generated.

In this case, the number of iterations is equal to 50000 giving a distribution from which critical values may be obtained at various probability levels. Table 5.9 and 5.10 present the ADF tests for the log of the prices series on the WSE and the return (or first difference) series, respectively, with the appropriate critical values at the 5% level of significance for a sample size of 500 and varying levels of augmentation (of the lagged dependent variable). For each level of augmentation, the two information criteria have been computed, namely the Akaike Information Criterion and the Schwarz-Bayesian Criterion, where an ‘*’ indicates the optimal level of augmentation according to each criterion. As usual, a more negative ADF test statistic relative to the critical value indicates a rejection of the null hypothesis of a unit root, i.e. that $\psi = 0$.

Table 5.9 shows that the presence of a unit root in the (log) price series cannot be rejected for the series on the WSE when the ADF t-statistics are compared to the modified critical values.¹⁵ From Table 5.10 however, there is definite rejection of a further unit root, therefore implying that the empirical return series on the WSE can be considered to be stationary or integrated or order zero.

¹⁵ We note that the modified critical values are smaller than the traditional critical values and are fairly close together. The former finding is in accordance with Charemza and Deadman (1997), p.284-295, who show that once a drift term is included in the traditional DF null, the resulting critical values are distinctly smaller. Secondly, the empirical distribution underlying the censored random walk is now forced to lie between two limits (rather than tending towards unlimited values), and it is this factor which contributes to the relative closeness of the critical values.

Table 5.9: ADF Tests for (Log of) Price Series on the WSE, with Drift.

Null model: $\Delta p_t = \mu + \psi p_{t-1} + \sum_{i=0}^{\rho} \theta_i \Delta p_{t-i} + v_t$, $\rho = 0,1,..,4$. $H_0 : \psi = 0$; $H_1 : \psi < 0$;

Critical Values: 5%=-1.1369; 1%=-1.1948.

Series	ADF t-statistic	Order of Augmentation	AIC	SBC
Tonsil	-0.627	0	535.65	531.50
Tonsil	-0.854	1	551.99*	545.77*
Tonsil	-0.891	2	551.36	543.07
Tonsil	-0.904	3	550.42	540.06
Tonsil	-0.941	4	549.76	537.32
Prochnik	-1.011	0	505.73	501.58*
Prochnik	-0.981	1	506.59*	500.37
Prochnik	-0.998	2	506.11	497.82
Prochnik	-0.988	3	505.18	494.82
Prochnik	-1.010	4	504.92	492.48
Kable	-0.931	0	378.49	374.34
Kable	-0.682	1	401.40	395.18
Kable	-0.789	2	405.79*	397.50*
Kable	-0.745	3	405.55	395.19
Kable	-0.686	4	404.30	394.86
Exbud	-0.861	0	605.17	601.08
Exbud	-0.871	1	617.85	611.71
Exbud	-0.860	2	620.11*	611.92*
Exbud	-0.859	3	619.11	608.88
Exbud	-0.750	4	618.15	605.87
Swarzedz	-1.039	0	466.66	462.53*
Swarzedz	-0.972	1	467.50*	461.29
Swarzedz	-0.962	2	466.53	458.26
Swarzedz	-0.915	3	466.57	456.13
Swarzedz	-0.922	4	465.50	453.09
Wolczanka	-1.160**	0	490.94	486.81
Wolczanka	-1.162**	1	493.62*	487.42*
Wolczanka	-1.171**	2	493.03	484.77
Wolczanka	-1.174**	3	492.24	481.91
Wolczanka	-1.166**	4	491.26	487.31

Notes: The modified null model described relates to models (5.15) and (5.16) in the text, which censor the movement in prices. The ADF t-statistic denotes the t-ratio of the coefficient ψ ; this is compared to the 5% generated critical values for the given null, which has a 25% probability of hitting the imposed limits. The ‘*’ denotes the optimal level of augmentation according to either the Akaike Information Criterion (AIC) or the Schwarz-Bayesian Criterion (SBC). A ‘***’ denotes statistical significance at the 5% level.

Table 5.10: ADF Tests for Return Series on the WSE, with Drift.

Null model: $\Delta p_t = \mu + \psi \Delta p_{t-1} + \sum_{i=0}^p \theta_i \Delta p_{t-i} + v_t$, $\rho = 0, \dots, 4$, $H_0 : \psi = 0$; $H_1 : \psi < 0$;

Critical Values: 5%=-1.1369; 1%=-1.1948.

Series	ADF t-statistic	Order of Augmentation	AIC	SBC
Tonsil	-16.488**	0	-1594.5*	-1598.7*
Tonsil	-12.660**	1	-1595.2	-1601.4
Tonsil	-10.823**	2	-1596.2	-1604.5
Tonsil	-9.348**	3	-1596.8	-1607.2
Tonsil	-9.359**	4	-1597.7	-1610.1
Prochnik	-23.682**	0	-1639.7*	-1643.8*
Prochnik	-15.302**	1	-1640.3	-1646.5
Prochnik	-12.789**	2	-1641.2	-1649.5
Prochnik	-10.443**	3	-1641.4	-1651.7
Prochnik	-8.866**	4	-1641.5	-1653.9
Kable	-29.784**	0	400.80	396.65
Kable	-14.988**	1	405.10	398.89*
Kable	-13.024**	2	406.90*	396.61
Kable	-12.312**	3	406.69	396.33
Kable	-10.026**	4	406.57	394.14
Exbud	-16.452**	0	616.10	612.01
Exbud	-14.709**	1	618.62*	612.48*
Exbud	-12.210**	2	617.64	609.46
Exbud	-10.890**	3	616.79	606.59
Exbud	-9.961**	4	615.83	603.55
Swarzedz	-23.475**	0	466.78*	462.65*
Swarzedz	-16.029**	1	465.83	459.62
Swarzedz	-13.709**	2	465.86	457.59
Swarzedz	-11.433**	3	464.88	454.54
Swarzedz	-9.822**	4	464.04	451.63
Wolczanka	-24.252**	0	492.43*	488.30*
Wolczanka	-15.351**	1	491.85	485.66
Wolczanka	-12.859**	2	491.08	482.82
Wolczanka	-10.861**	3	490.12	479.79
Wolczanka	-9.244**	4	489.62	477.23

Notes: The modified null model described relates the first difference of models (5.15) and (5.16) in the text, which censor the movement in prices. The ADF t-statistic denotes the t-ratio of the coefficient ψ ; this is compared to the 5% generated critical values for the given null, which has a 25% probability of hitting the imposed limits. The '*' denotes the optimal level of augmentation according to either the Akaike Information Criterion (AIC) or the Schwarz-Bayesian Criterion (SBC). A '**' denotes statistical significance at the 5% level.

5.4 Predictability of Returns on the Warsaw Stock Exchange¹⁶

One of the primary issues of the time series analysis of financial markets is the forecastability of stock returns. It is generally claimed that if returns are not forecastable (in mean), the market is, in some sense, efficient.¹⁷ However, we noted in Chapter 4, section 4.5.1 that results of empirical testing of predictability of returns on various stock markets are often inconclusive, and it is often admitted that proving the existence, or non-existence of such predictability, is not feasible (see e.g. the seminal papers by Fama (1965) followed by Fama (1976) and (1991), Grossman and Stiglitz (1980), Granger (1992), and Williams (1994) for a historical review).

The fact whether a market is predictable or not does not decide upon the existence, or non-existence, of speculation. Stock market speculation is generally regarded as a negative phenomenon which should be eliminated or at least reduced. One of the well-known attempts to curb speculation is by introducing so-called '*par casier*' or '*Einheitskurs*' system of quotations, that is where upper and lower limits on price movements are introduced. We have seen that one of its variations exists on the WSE and similar systems have been used periodically on other exchanges where we have seen that if the price, calculated by the end of trading session, reaches its lower or upper limit, it is not allowed to move further and trading is either suspended, or the transactions volume reduced proportionally on the 'long' side. Following the terminology of Chapter 4, we refer to this system as a disequilibrium trading system.

In section 5.2.3, from the results of the simulation analysis of autocorrelation, we saw that, assuming that there were no spillover effects or withdrawal of funds, the imposed restrictions could be a source of predictability. Using the model of a disequilibrium trading system developed in Chapter 4, section 4.5.2, we also saw that the fact that the upper and lower price limits are imposed might not necessarily be a source for market predictability. In particular, if there is some kind of funds withdrawal process due to a quantity spillover in relation to other stocks or to non-market assets, the market might not be predictable. In this chapter, in light of the proposed model of a disequilibrium trading system, we undertake an analysis of predictability of six main series on the WSE. The plan of this section is as follows. In section 5.4.1, we undertake three simple regression tests of predictability and proceed to examine the

¹⁶ This section draws largely from the discussion paper by Charemza, Shields and Mitura (1997).

¹⁷ The literature on this subject is voluminous. See references made in Chapter 3, section 3.5.1 for a review of literature on various types of research into the efficient market hypothesis, and more generally, see, for example, Baillie (1989), LeRoy (1989) and Peters (1991) for the non-linear generalisation of this concept.

size and power of these tests through Monte Carlo simulation experiments in section 5.4.2. In section 5.4.3, we suggest a non-parametric correction which, in some circumstances, we find through further Monte Carlo experiments, improves their power. Given this finding, we suggest a strategy to undertake the ‘corrected’ tests. In section 5.4.4, we present some preliminary results of testing for market predictability on the Warsaw Stock Exchange for the six series (Tonsil, Prochnik, Kable, Exbud, Swarzedz and Wolczanka) over the early years of operation of the exchange, April 1991 to May 1995. Section 5.5 concludes the section.

5.4.1 Three Simple Predictability Tests

As previously discussed, a direct consequence of the analysis of investor behaviour presented in Chapter 4, section 4.4 is a model of price setting which reflects both the fact that prices are not allowed to move beyond a pre-set boundary, and also that a price in time t , may, even if not constrained, be affected by a previous hit of a price into the boundary. Recall the model presented in Chapter 4, section 4.5.2, where it is initially assumed that the process representing the observed prices, p_t , and the underlying (unrestricted) prices, p_t^* , in their logarithms on a market with disequilibrium trading, can be given as,

$$p_t^* = \theta p_{t-1}^* + (1 - \theta)p_{t-1} + \varepsilon_t \quad ; \quad \theta \in [0, 1] \quad (5.17)$$

$$p_t = \begin{cases} p_t^* & \text{if } |p_t^* - p_{t-1}| < w \\ w + p_{t-1} & \text{if } p_t^* - p_{t-1} > w \\ -w + p_{t-1} & \text{if } p_t^* - p_{t-1} < -w \end{cases} \quad (5.18)$$

where ε_t are random errors and w , as before, represents the upper and lower limit for the allowable price movement.

Ignoring the possible payments of dividends, and returns ($r_t = p_t - p_{t-1}$) being defined as,

$$r_t = \text{sgn}(\varepsilon_t) \cdot \min(w, |\varepsilon_t|) \quad (5.19)$$

the stylised model in expressions (5.17) and (5.18) seems to represent the empirical series of returns from a market with disequilibrium trading satisfactorily as seen in Figure 4.6.

For an empirical investigation of a market with disequilibrium trading, it seems to be important to decide whether the parameter θ in (5.17) is equal to zero. For instance, recall from the discussion in Chapter 4, section 4.5.2, that if $\theta = 0$, then the market is not predictable in mean. In other words, there is a complete feedback from the constrained price into the underlying price and the demand carried forward from time $t-1$ to time t is zero even if there is (positive or negative) excess demand on the market in time $t-1$.¹⁸

The first simple test can be based on a linear regression approximation to $E(r_t | \varepsilon_{t-1} > w)$, that is a regression of returns (where the mean of the returns are adjusted to equal zero), on dummy variables representing a hit of the barrier in time $t-1$ and will be referred to as Test I, i.e.,

$$r_t = \beta_1 d_{t-1}^+ + \beta_2 d_{t-1}^- + error \quad , \quad (5.19)$$

where,

$$d_t^+ = \begin{cases} 1 & \text{if } \varepsilon_t > w \\ 0 & \text{otherwise} \end{cases} \quad , \quad d_t^- = \begin{cases} 1 & \text{if } \varepsilon_t < -w \\ 0 & \text{otherwise} \end{cases} \quad . \quad (5.20)$$

Regression (5.20) can be estimated by ordinary least squares (*OLS*) and then the hypotheses that $\beta_1 = 0$ and $\beta_2 = 0$ can be tested using the standard Student- t test.

Another possibility is to use a simplification of this test by exploiting the symmetry of the positive and negative constraints and assuming that $\beta_1 = \beta_2$. In this case regression (5.19) becomes (Test II),

$$r_t = \beta d_{t-1}^\pm + error \quad (5.21)$$

¹⁸ Note that this happens, if, for instance, (a) there is total withdrawal of the unspent funds from the market on which the upper or lower price limit is hit in time $t-1$ and (b) there is the martingale process for expectations of the constraints (that is, if the upper or lower boundary was hit in time $t-1$ it is also expected that the boundary will be hit in time t). As discussed previously, this is the case of a full cross-spillover and no intertemporal spillover.

where,

$$d_t^{\pm} = \begin{cases} 1 & \text{if } \varepsilon_t > w \\ -1 & \text{if } \varepsilon_t < -w \\ 0 & \text{otherwise} \end{cases} \quad (5.22)$$

Ideally, if any information concerning the volume of transactions not realised on the market is available, it is possible to carry out a third test where the quantitative information concerning excess demand enters the regression equation in place of the qualitative dummy variables (Test III), i.e.,

$$r_t = \gamma(p_{t-1}^* - p_{t-1}) + \text{error} \quad (5.23)$$

It should be noted that in regression (5.23) the variable $p_{t-1}^* - p_{t-1}$ takes a non-zero value only if a barrier was hit in time $t-1$.

The above tests are however *ex-ante* predictability tests, since they do not take into account the fact that, while a disequilibrium state occurs in time $t-1$, it might also occur in time t , preventing the expected abnormal profits to materialise. There is a possibility for a development of analogous *ex-post* predictability tests, which would concentrate on predicting abnormal returns from time $t-1$ for time t if, in time t , $r_t = \varepsilon_t$. This problem is, however, beyond the scope of this analysis.

5.4.2 Investigation in the Size and Power of the Predictability Tests; A Simulation Analysis

Due to the truncation nature of arguments in the above tests, it would be useful to evaluate the empirical size and power of these tests. In particular, because of the difference in dispersion of arguments and the dependent variable for a high frequency of truncations, the power of these tests may be affected for large values of θ .

In order to assess this, we can perform a series of Monte Carlo experiments, consisting of the computation of empirical frequencies of rejection of the null hypothesis that $\beta_1 = 0$ (for Test I), $\beta = 0$ (for Test II) and $\gamma = 0$ (for Test III). The data generating process for these experiments is given by equations (5.17) and (5.18), with $\varepsilon_t \sim N(0, 1)$, $w = \ln(1.1)$, which corresponds to the 10% upper and lower limit on price movements, usually imposed at the Warsaw Stock Exchange. The sample size is set equal to 100, 250 and 500 and θ is changed from 0 to 1.0 using a step of 0.1. Hence, the total number of simulation experiments is 33 and in each 5,000 replications are performed.

Figure 5.9 shows the empirical frequency of rejections of the null hypothesis of a standard Student- t at the 5% level of significance test. The figure indicates that size of the Student- t test is not affected, that is the empirical frequency of rejections for $\theta = 0$ (that is, for the case where the market is not predictable) is close to 5% for all three tests. Generally, the most powerful is Test III; this is not surprising, since it uses quantitative rather than qualitative information concerning excess demand. The empirical power of all the tests increases until θ reaches high values, where it starts to decrease more prominently for the larger sample sizes. This can be explained by considering a simple regression Student- t statistic in the following regression equation,

$$y_t = \alpha'x_t + u_t, \quad (5.24)$$

where α is the vector of the regression coefficients, x_t are the explanatory variables and u_t denotes the error term. All three tests discussed in this paper can be represented by this regression. For the i -th regression coefficient, the Student- t statistic is given by:

$$t_i = \frac{\hat{\alpha}_i}{S_{\alpha_i}} \quad (5.25)$$

where $\hat{\alpha}_i$ is the *OLS* estimate of the i -th element in α , $S_{\alpha_i} = S_u \cdot \sqrt{\text{diag}_{ii}(X'X)^{-1}}$ where S_u is the standard error of the residuals, and X is the matrix of observations on the variables in x_t . The most probable reason for the decrease of power for large θ , is the fact that when the frequency of the barrier hits is increasing, the variation of the observed returns is reduced. At

the same time the variation of the dependent variables is either decreasing at a slower pace (for Tests I and II), or is increasing (for Test III), forcing the estimated regression coefficient $\hat{\alpha}_i$ to become smaller. Moreover, the corresponding elements $diag_{ii}(X'X)^{-1}$ are forced to

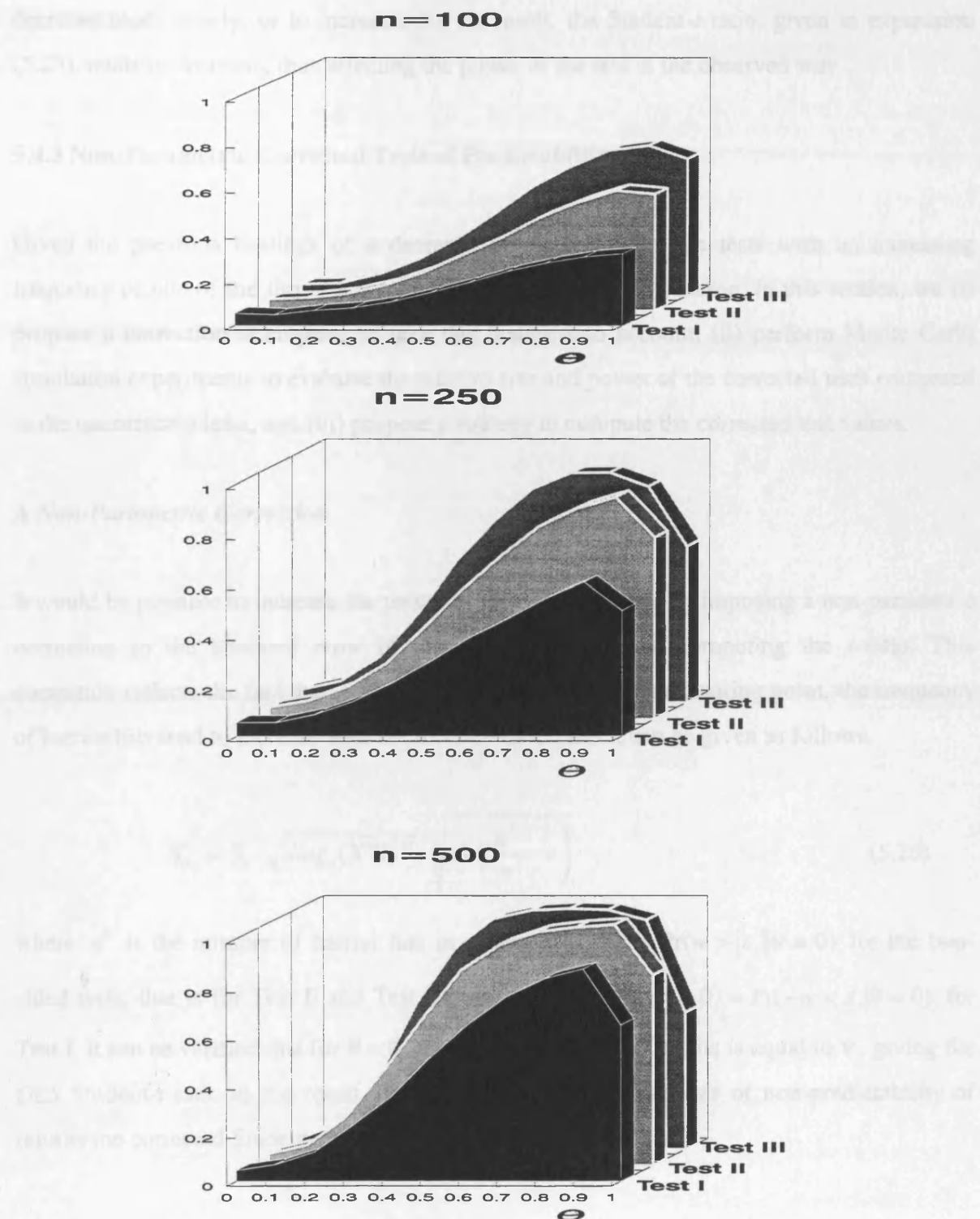


Figure 5.9: Empirical frequency of rejection of the null hypothesis

decrease more slowly, or to increase. As the result, the Student- t ratio, given in expression (5.25), tends to decrease, thus affecting the power of the test in the observed way.

5.4.3 Non-Parametric Corrected Tests of Predictability

Given the previous findings of a decrease in the power of the tests with an increasing frequency of hits of the limits and a discussion of the probable reason, in this section, we (i) propose a correction attempting to take this feature into account, (ii) perform Monte Carlo simulation experiments to evaluate the relative size and power of the corrected tests compared to the uncorrected tests, and (iii) propose a strategy to compute the corrected test values.

A Non-Parametric Correction

It would be possible to increase the power of the Student- t tests by imposing a non-parametric correction to the standard error of the estimates, used for computing the t -ratio. This correction reflects the fact that, for a given sample size and the censoring point, the frequency of barrier hits tend to increase with the increase of θ , and it can be given as follows,

$$S_{\alpha_i}^* = S_u \cdot \sqrt{\text{diag}_{ii}(X'X)^{-1}} \cdot \sqrt{1 - \left(\frac{n^h}{n} - \nu \right)}, \quad (5.26)$$

where n^h is the number of barrier hits in a sample and $\nu = \Pr(w > |\varepsilon_i| | \theta = 0)$ for the two-sided tests, that is for Test II and Test III, and $\nu = \Pr(w > \varepsilon_i | \theta = 0) = \Pr(-w < \varepsilon_i | \theta = 0)$ for Test I. It can be verified that for $\theta = 0$, the expected frequency of hits is equal to ν , giving the *OLS* Student- t ratio as the result. Hence, under the null hypothesis of non-predictability of returns the corrected Student- t ratio given by,

$$t_i^* = \frac{\hat{\alpha}_i}{S_{\alpha_i}^*} \quad (5.27)$$

has an approximate Student- t distribution with $n-k$ degrees of freedom (where k is the number of estimated parameters).

The Size and Power of the Corrected Tests

In order to evaluate the efficiency of the corrected tests (denoted as CTEST I, II and III respectively) using the test statistic given in expression (5.27), in comparison with the original uncorrected t -tests given in (5.25), Monte Carlo experiments, analogous to those previously described and using the same random numbers, have been performed. Figure 5.10 shows the efficiency gains (averaged for the sample sizes 100, 250 and 500), measured by the ratio of empirical frequencies of rejections of the null hypothesis, of the corrected tests relatively to the corresponding uncorrected ones.

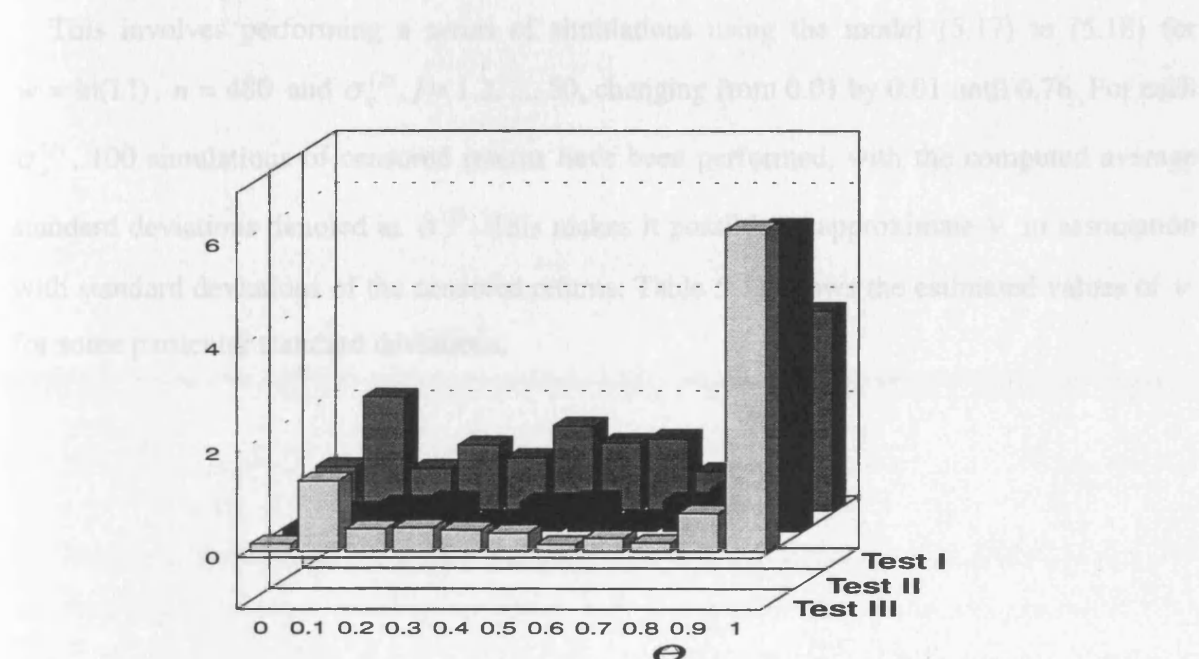


Figure 5.10: Average efficiency gains of the corrected tests relative to the uncorrected tests.

Figure 5.10 shows that, for low values of θ , the gains in power of the corrected tests are trivial, although clearly being the highest for Test I. However, as θ approaches unity, substantial efficiency gains become evident. It seems that the proposed corrections are appropriate where there is a possibility of a lack of a meaningful quantity of spillovers between markets (i.e. intertemporal spillover effects hold much more importance compared to cross-spillover effects into other markets).

Computing the Corrected Test Statistics

In practical applications in computing the corrected test statistics, one difficulty is created by $v = \Pr(w > |\varepsilon_t| | \theta = 0)$ not being directly observable, since it depends on the condition that $\theta = 0$. Because the non-censored returns ε_t are not fully observed, it is *not* possible to compute v directly from empirical data. The proposed procedure is based on approximating v through the simulation of a relationship between the standard deviations of ε_t and r_t for the case where $\theta = 0$.

This involves performing a series of simulations using the model (5.17) to (5.18) for $w = \ln(1.1)$, $n = 480$ and $\sigma_\varepsilon^{(j)}$, $j = 1, 2, \dots, 50$, changing from 0.01 by 0.01 until 0.76. For each $\sigma_\varepsilon^{(j)}$, 100 simulations of censored returns have been performed, with the computed average standard deviations denoted as $\hat{\sigma}_r^{(j)}$. This makes it possible to approximate v in association with standard deviations of the censored returns. Table 5.11 shows the estimated values of v for some particular standard deviations.

Table 5.11: Simulated two-sided probabilities of reaching the truncation point (ν), ($n = 480$, censoring range 10%, $\theta = 0$)

ν	$\hat{\sigma}_r$
0.0096	0.035
0.0208	0.040
0.0449	0.045
0.0789	0.050
0.1230	0.055
0.1843	0.060
0.2571	0.065
0.3450	0.070
0.4524	0.075
0.5679	0.080
0.6935	0.085
0.8349	0.090

Notes: $\nu = \Pr(w > |\varepsilon_t| | \theta = 0)$ for Test II and Test III, and $\nu = \Pr(w > \varepsilon_t | \theta = 0) = \Pr(-w < \varepsilon_t | \theta = 0)$ for Test I. ν is approximated through the simulation of a relationship between the standard deviations of ε_t and r_t from the system of equations (5.17) - (5.19), for the case where $\theta = 0$. $w = \ln(1.1)$, $n = 480$ and $\sigma_\varepsilon^{(j)}$, (representing the standard deviation of ε_t) for $j = 1, 2, \dots, 50$, is changed from 0.01 by 0.01 until 0.76. For each $\sigma_\varepsilon^{(j)}$, 100 simulations of censored returns have been performed, where $\hat{\sigma}_r^{(j)}$ denotes the corresponding computed average standard deviation.

Hence, a suggested way of computing the corrected test values is as follows;

- (i) Compute standard deviations of observed returns.
- (ii) Estimate ν for the appropriate standard deviation of observed returns from Table 5.11, approximating, if necessary.
- (iii) Run the regressions (5.19), (5.21) and/or (5.23) and, using ν , compute the corrected Student- t statistics for CTEST I, II and/or III. Note that the mean of the observed returns has to be equal to zero. If it is not, adjust the returns for the mean.

Additionally, the estimated values of v can be used for computation of a simple predictability test for returns. For $\theta = 0$, that is where returns are not predictable, the expected value of frequency of barriers hits observed in the sample is equal to v . Hence, the straightforward Z test for proportions is valid in large samples as the test for the hypothesis that $\theta = 0$, i.e.,

$$Z = \frac{\frac{n^h}{n} - v}{\sqrt{\frac{v(1-v)}{n}}} \quad (5.28)$$

The statistic Z has an asymptotic the standard normal distribution under the null hypothesis.

5.4.4 Testing predictability on the Warsaw Stock Exchange

With the use of the above tests, in this section, we perform a preliminary analysis of *ex-ante* predictability of returns of shares for the six companies trading on the WSE. These include Tonsil (TON), Prochnik (PRO), Exbud (EXB), Kable (KAB), Swarzędz, (SWA) and Wolczanka (WOL). The data used is as described in section 5.2 and 5.3 and ranges from April 1991 to mid-May 1995. We do not use direct quantitative information concerning identification of the disequilibrium trading sessions. Instead, as previously, we have assumed that if returns were closer than 0.05% to its upper or lower boundary (that is, if the published price was equal or higher than 1.095 times the previous session price, or 0.905 or lower than the previous session price), the upper (lower) boundary was hit. This 0.05% tolerance limit allows to account for rounding errors of published prices.¹⁹

Table 5.12 shows some descriptive statistics (as in Table 5.2), the probability of a hit for $\theta = 0$ (computed through interpolation from a more detailed version of Table 5.11), standard deviations of the observed series of logarithms of returns and that of non-censored returns for $\theta = 0$ (that is, the simulated value of σ_ϵ) and the results of the computed Tests I and II in their uncorrected and corrected versions. For Test I, the parameters explaining the upper and lower hits (that is, β_1 and β_2 respectively) are tested separately. Also, the Z test for $\theta = 0$,

¹⁹ Again, in a few instances missing observations are discarded and we also disregard the fact that in some cases transactions were suspended (this is allowed if, for a given security, demand exceeds supply by more than fivefold or *vice versa*) and we censor to its upper or lower limit those returns which were allowed to go beyond that limit due to its occasional suspension.

based on the differences between the observed and theoretical frequencies of hits, has been computed.

Table 5.12: Testing predictability of returns on Warsaw Stock Exchange, April 1991-May 1995.

		TON	PRO	KAB	EXB	SWA	WOL
No. of observations		471	476	476	476	467	464
Frequency of hits		0.25	0.24	0.29	0.22	0.26	0.20
ν		0.31	0.20	0.25	0.16	0.17	0.16
std. devs.	observed	0.068	0.061	0.064	0.058	0.059	0.058
	non-trun.	0.089	0.078	0.079	0.065	0.069	0.065
Test I	uncorrected	-5.00	-3.41	-2.74	-3.27	-4.04	-3.10
lower	corrected	-5.10	-3.44	-2.83	-3.34	-4.13	-3.21
Test I	uncorrected	4.30	4.86	5.97	5.54	4.66	3.00
upper	corrected	4.07	4.71	5.73	5.74	4.53	2.94
Test II	uncorrected	6.61	5.83	5.99	6.00	6.14	2.78
	corrected	6.37	5.85	5.93	6.24	6.08	2.90
Z test		-4.13	3.59	5.01	6.70	6.12	4.51

Notes: See notes to Table 5.11 for the computation of ν . The non-truncated standard deviation refers to σ_ε (i.e. for $\theta = 0$) obtained from the simulation experiment on computing the corrected tests. The corrected versions of the tests uses the formula given in (5.27), the uncorrected uses equation (5.25), and both are computed for Test I and II in regressions (5.19) and (5.21), respectively. The Z-test is according to equation (5.28) which is asymptotically normally distributed under the null of non-predictability of returns, i.e. $\theta = 0$.

The descriptive statistics show a relative homogeneity of the data set; the empirical frequencies of hits are of a similar order and standard deviations of the series are not far away from each other. The most volatile series seems to be that of returns from *Tonsil*, with the highest frequency of hits and the highest standard deviation. All the computed tests clearly indicate the predictability of returns and strongly suggest rejection of the null hypothesis that $\theta = 0$. There is, generally, a correspondence between the high (low) frequency of hits and the corresponding values of ν . This would suggest that the unknown values of θ might be

approximately equal to each other for all the series investigated. In other words, according to this analysis, the intertemporal spillover effects on these markets can perhaps be considered to be of a similar magnitude during the period of the exchange analysed and any cross-spillover effects occurring were generally not large enough to warrant the non-predictability of returns when a barrier was hit.

5.5 Concluding Comments

In this chapter, we have firstly undertaken a time series analysis of return series on the WSE and then investigated the issue of predictability of these series on a market facing constraints on the return generating process.

Overall, the data series investigated over the given time period exhibit similar characteristics. On average, the frequency of hits was approximately 25%, and this was found to be declining over time. A simulation analysis assuming no spillover effects suggests that a random series experiencing approximately the same empirical frequency of hits significantly contributes to the observed autocorrelation in returns in addition to the return series being informationally inefficient. Given the different number of weekly trading days over the sample period, an analysis of calendar effects reveals that the whole sample period can be treated homogeneously. In addition, a non-stationary analysis using simulated modified critical values, necessary because of the significantly different distribution of returns on the WSE compared to the normal distribution, shows that all the return series can be treated as stationary.

The results from section 5.4 on the predictability of returns on the WSE show that the proposed approach to modelling the predictability of returns for stock markets with disequilibrium trading might be of some practical importance. It reveals that, contrary to the widespread opinion among the practitioners, the question of returns predictability on such markets is non-trivial and that the predictability should be tested. It is possible, although computer-intensive, to evaluate probabilities of reaching a disequilibrium state under the null hypothesis of non-predictability and then using these probabilities to correct the computed t -statistics in order to improve on the power of the tests. Nevertheless, although empirical results have provided evidence of the predictability of returns on the WSE and we have previously shown that this *may not* always be the case despite the existence of the barriers, the results should be regarded as preliminary. Future research should concentrate on the analysis of the *ex-post* rather than *ex-ante* predictability. Also, modifications to the data generating

process should be made in order to allow for the heavy-tailed distributions of the non-censored returns. This would make feasible to analyse various speculative processes (which have not been considered) on stock exchanges with disequilibrium trading.

Appendix 5

5.1 Modified Critical Values for Censored Random Walk (GAUSS)

```
/* Critical Values for Censored Random Walk; Freq. of Hits ~ 25% */
```

```
new;
library coint pgraph auto arima;

#include c:\gauss\src\autoreg.ext;
#include c:\gauss\src\unit.src;
autoset;
arimaset;

et=hsec;
n=500;          @ No. of observations@
niter=50000;    @ No. of iterations (in thousands) @
ini=10;
drift=0.2;
sf=0.75;        @ truncation scaling factor @
trlimit=exp(0.1);

output file=c:\kal1\trunc\cvalue.out reset;
/*rndseed 1964463488;*/

format/rd 12,4;
lp=zeros(niter,1);

i=1;

do until i>niter;

    e=rndn(n+10,1).*sf+drift;
    yf=zeros(n+10,1);
    y=zeros(n+10,1);
    zup=zeros(n,1);
    zlo=zeros(n,1);
    z=zeros(n,1);
    y[1,1]=ini;
    yf[1,1]=ini;
    yrw=recserar(e[.,1],ini,ones(1,1));
    t=2;
    do until t>n;

        yf[t,1]=yf[t-1,1]+e[t,1];
        if abs(yf[t,1]-yf[t-1,1])<trlimit;
            y[t,1]=yf[t,1];
        elseif e[t,1]<0;
```

```

    y[t,1]=y[t-1,1]-trlimit; zlo[t,1]=1; z[t,1]=-1;
    else;
    y[t,1]=y[t-1,1]+trlimit; zup[t,1]=1; z[t,1]=1;
    endif;

    t=t+1;
    endo;

    y=y[10+1:n+10,];
    {al,tdf,crdf}=adf(y,-1,0);
    lp[i,1]=tdf;

    i=i+1;
    endo;

    lp=sortc(lp,1);

    ? "Critical values of Dickey-Fuller test for I(1) censored process";
    a99p=lp[niter*.99,1];
    a975p=lp[niter*.975,1];
    a95p=lp[niter*.95,1];
    a90p=lp[niter*.90,1];
    a10p=lp[niter*.10,1];
    a05p=lp[niter*.05,1];
    a025p=lp[niter*.025,1];
    a01p=lp[niter*.01,1];
    ? " Number of observations: " n ;
    ? " Number of iterations: " niter ;
    ? " 99% critical value: " a99p;
    ? " 97,5% critical value: " a975p;
    ? " 95% critical value: " a95p;
    ? " 90% critical value: " a90p;
    ? " 10% critical value: " a10p;
    ? " 5% critical value: " a05p;
    ? " 2,5% critical value: " a025p;
    ? " 1% critical value: " a01p;

    et=hsec-et;
    "Time in seconds" et/100;
    end;

```

CHAPTER 6

THE PREDICTABILITY OF CONDITIONAL SECOND MOMENTS OF RETURNS ON THE WARSAW STOCK EXCHANGE¹

Summary

A common finding for developed stock markets is that negative shocks entering the market lead to a larger return volatility than positive shocks of a similar magnitude. The following chapter considers two emerging Eastern European Markets, namely the Warsaw Stock Exchange and the Budapest Stock Exchange, where the first point of investigation is whether an analogous asymmetric characteristic is reflected in emerging markets. The second point of investigation is whether the findings differ depending on the institutional microstructure of the exchange being examined given that the Warsaw Stock Exchange operates a quantity constrained system. Hence, econometric techniques are modified accordingly and a 'Double-Censored Tobit GARCH' model is developed. This chapter finds that no asymmetry exists on either emerging market but further investigation reveals that it does exist for a stock return series on a developed market also operating a quantity constrained system. Possible reasons for these findings are proposed.

¹ This chapter represents an extended version of Shields (1997a, 1997b).

6.1 Introduction

Over recent years, there has been a growth in interest in the modelling of time-varying stock return volatility. This interest in the econometric time series modelling of conditional second order moments of stock returns, or equivalently time varying variances and covariances is due to the increasing importance played by risk and uncertainty in investment decisions. A common finding is that stock returns are heteroskedastic such that the volatilities of these series display periods of calm and extreme activity. There are numerous alternative parametric specifications aiming to model such heteroskedastic behaviour, however, the methodology considered in this research is the ARCH methodology due to the pioneering work of Engle (1981, 1982). His attempts can be seen as the first to parsimoniously condition the second moments of stock returns as time varying. Since this seminal work, Engle's ARCH models have become one of the most widely used means of modelling changing conditional variances. Underlying the ARCH models is the distinction between the *conditional* and *unconditional* second order moments, where, whilst the unconditional second order moments may not be time invariant, the conditional variances and covariances usually have a significant dependence on the past. The methodology presumes that forecasts of the variance of stock returns at some future point can be further improved by the use of recent information, and moreover, volatility clustering implies that large shocks of either sign will increase the probability of future volatility. Hence, it can be appreciated that the understanding of this temporal dependence is vital, at the least, for investment decisions and dynamic asset pricing relationships.

The ability of ARCH type models to capture the volatility clustering phenomena has led to an immense number of empirical implementations and Bollerslev, Chou and Kroner (1992) have cited a phenomenal number of papers (more than 300) which have applied ARCH, extensions of the ARCH models, for e.g. GARCH, and other related models. Despite this, there are severe limitations to the ARCH/GARCH formulation. For instance, Black (1976) observed that changes in stock prices tended to be negatively correlated with changes in stock return volatility - often referred to as the leverage effect². In other words, volatility tends to increase when prices are decreasing and to decrease when prices are rising. Hence, there is an asymmetry in volatility which the ARCH/GARCH models do not capture since they assume

² A possible but only partial explanation for this phenomenon is provided by fixed costs such as financial and operating leverage. For instance, a firm with outstanding debt and equity usually becomes more leveraged when the value of the firm falls. Typically, equity returns volatility increases if the returns on the firm as a whole is constant.

that only the magnitude and *not* the sign of past returns determines the characteristics of the conditional variance.

Following Black's observation, there has been more recent research, concentrating on the finding that the effect of good and bad news on return volatility is asymmetric rather than symmetric. A common finding for developed stock markets (for example, see Christie (1982), French, Schwert, and Stambaugh (1987), Nelson (1991), and Schwert (1990)), is that negative shocks to the market lead to larger return volatility than positive shocks of a similar magnitude. However, similar research for emerging markets is, as yet, non-existent. In this chapter, two Eastern European emerging stock markets of similar starting dates are investigated, namely, the Warsaw Stock Exchange (WSE), and the Budapest Stock Exchange (BSE). The first point of investigation is to attempt to model the second order moments of stock returns from both emerging markets, using the ARCH framework, whilst also examining whether the above analogous asymmetric characteristic is reflected on emerging markets. As has been encountered in the previous chapters, a complicating feature in this analysis is that the institutional microstructure of the WSE differs from that of the BSE. The WSE operates an order driven system with quantity constraints, where there is a 10% limit imposed on the movement of prices from one day's trading to the next, whereas the BSE operates the conventional market driven system. Thus, there is an implicit second point of investigation examining whether the findings differ depending on the exchange being investigated. In order to investigate this further, a similar analysis is carried out on the developed French Stock Exchange, which also operates a quantity constrained system. Therefore, this research has important implications regarding the behavioural tendency of the investors on emerging markets as well as the institutional microstructure of exchanges.

The chapter is organised as follows; section 6.2 justifies the use of the GARCH modelling framework in the context of the thesis and secondly, goes on to outline various symmetric and asymmetric models of stock volatility, and the estimation procedure assuming that returns follow a Gaussian or normal distribution. Section 6.3 proposes 'double-censored tobit' (DCT) models of conditional volatility, based on the models already outlined in section 6.2, but adjusted so as to be appropriate to the WSE. The modified estimation and testing procedures are discussed. Also described are Monte Carlo experiments carried out in order to evaluate the performance of misspecification tests assuming an underlying double-truncated Gaussian distribution of stock returns. In section 6.4, the four data series to be used, i.e. a typical stock return series and the market index from each exchange, are described, and the results from estimating the models of conditional volatility are presented. In section 6.5, a modified

partially non-parametric model is presented and the estimates are compared with the other models. Section 6.6 presents the results of estimating the same models of conditional volatility for a typical share from the French Stock Exchange and for its market index. Finally, in section 6.7, we discuss possible implications from the findings and conclude.

6.2 Model Specification and Estimation

The popular GARCH framework concerns the modelling of second moments incorporating the possible non-homogeneity of the series of stock returns. A simple interpretation to the predictability of the variance of returns is that it can be seen as an indication of the risk-neutrality of agents. In other words, the more predictable is the variance of stock returns, the less likely will all information be exhausted in its forecast and the more risk neutral agents will be. Agents, therefore, in this case are less concerned about not using all information in forming forecasts in maximising returns, or in minimising the variance of changes in the share price. The variance of a share is usually seen as a positive indicator of the risk of holding a share, so that the larger is the variance of a share, the more risky it is. Therefore, a risk averse investor *ceteris paribus* will prefer holding a share with a lower variance, and will exhaust all information to minimise risk and evaluate all the predictable elements affecting the variance of returns. Consequently, the variance of returns is expected to be minimal, with the change in returns from one period to the next being unpredictable. Hence, large variances in share prices as reported in Shiller (1981), De Bondt and Thaler (1985, 1987) suggest that agents are either risk neutral or not maximising individuals, especially when an ARCH/GARCH process can capture the variance. Nevertheless, note that this explanation is still only a tentative one.³

In the following part of this section, the better known predictable volatility models in the ARCH family are outlined. This begins with the symmetric GARCH model (Bollerslev (1986)) and the GARCH-in-Mean model (Engle, Lilien and Robins (1987)). These are followed by the asymmetric volatility models, namely, the Exponential GARCH or E-GARCH models (Nelson (1991)), the Generalised Quadratic ARCH or GQARCH models (Sentena (1992)), and the GJR model of Glosten, Jagannathan and Runkle (1993). The second part of the section describes the estimation procedure that would be relevant to the Budapest

³ For instance, if the variance of share returns do exhibit a GARCH property, and share prices do exhibit a random walk, then it could be the case that the GARCH effects observed could be arising through natural consequences of measurement. This case is simply noted rather than considered here.

Stock Exchange and the market index (WIG) of the WSE. Misspecification tests based on Engle and Ng (1993) are also presented.

6.2.1 Models of Predictable Volatility

Define r_t to be the rate of return on a stock or a market portfolio of stocks from time $t-1$ to t . Further, let the information available to investors at time $t-1$, at the time of making the investment decision, be denoted as I_{t-1} . Then, assuming that investors make their investment decisions using all available information, then the expected return and volatility relevant to the investors decisions are the conditional expected value of r_t given I_{t-1} , denoted $M_t = E(r_t | I_{t-1})$, and the conditional variance of r_t , given I_{t-1} , denoted $h_t = Var(r_t | I_{t-1})$. Using these definitions, the unexpected return at time t is given by $\varepsilon_t \equiv r_t - M_t$, and following Engle and Ng (1993), ε_t is treated as a collective measure of news at time t . Thus, a positive value of ε_t (or an unexpected increase in returns) indicates the arrival of good news, whilst a negative value of ε_t (or an unexpected decrease in returns) indicates the arrival of bad news. The absolute size of ε_t implies that the news is important in that it produces a significant change in price.

Following Mandelbrot's (1963) observation of volatility clustering in asset returns and that "large changes tend to be followed by large changes of either sign - and small changes by small changes ...", as noted above, Engle (1982) attempted to capture this feature in his ARCH model. Common characteristics for stock return volatility possibly justifying the use of Engle's ARCH modelling framework, in the main, include the leptokurticity of stock returns and more predominantly a volatility clustering of the stock returns. Leptokurtic asset returns are reflected in their distribution where the tails tend to be thick⁴ and the volatility clustering phenomenon over time can be observed by plotting stock returns across time - at least both these features were noted in the earlier descriptive chapter.

In Engle's original ARCH(q) model, the conditional variance is assumed to be a linear function of the past q squared innovations. For instance,

$$h_t = \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 \quad (6.1)$$

where $\alpha_1, \dots, \alpha_p$ and ω are constant parameters. If v_t is defined as $\varepsilon_t^2 - h_t$, then equation (6.1) can be written as,

$$\varepsilon_t^2 = \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + v_t \quad (6.2)$$

This model is equivalent to an AR(q) model for the squared innovations, ε_t^2 , since $E_{t-1}(v_t) = 0$. If the sum of the autoregressive parameters is less than one, then the unconditional variance will be

$$\text{Var}(\varepsilon_t) \equiv \sigma^2 = \omega / (1 - (\alpha_1 + \dots + \alpha_q)) \quad (6.3)$$

and the process is covariance stationary.⁵

The error terms in the ARCH model, although are serially uncorrelated are not necessarily independent through time. When $\alpha > 0$, the errors are related through their second moments. As already mentioned above, a regular observation in the empirical finance literature has been that large changes tend to be followed by large changes, or either sign, and small changes tend to be followed by small changes of unpredictable sign. This phenomenon is often referred to *clustering* or *pooling*. The ARCH methodology provides a framework to unambiguously deal with this effect by using past squared forecast errors to predict future variances. In addition, if $\omega < 1$ and ε_t is conditionally normal, the ARCH model has the attractive feature appropriate for when considering financial time series data, that for an ARCH(1) model say, the unconditional kurtosis or fourth moment of ε_t will exceed $3\sigma^4$. This allows the unconditional distribution of ε_t to have thicker tails relative to the normal distribution (a common characteristic of most distributions of financial time series) without violating the normality assumption and therefore be symmetric in distribution.

⁴ For reference to empirical literature on modelling stock returns from fat-tailed distributions, see Mandelbrot (1963), Fama (1963, 1965), Clark (1973), and Blattberg and Gonedes (1974).

⁵ Covariance stationarity represents the condition where, in addition to the first two moments of ε_t not being constant, $\text{Cov}(\varepsilon_t, \varepsilon_s) = 0$ for $t \neq s$. Note that the ARCH(q) model may also be represented as a *time-varying parameter* MA(∞) model for ε_t . For a discussion of this interpretation of ARCH models, see Tsay (1987), Bera, Higgins and Lee (1993) and Bera and Lee (1993).

However, in empirical applications, a long lag length and an increased number of parameters is often required therefore leading to Bollerslev's (1986) proposition of a generalised version of this model, i.e. a 'GARCH' model. A GARCH (p,q) model can be represented as:

$$\begin{aligned} h_t &= \omega + \sum_{i=1}^p \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^q \beta_j h_{t-j} \\ &= \omega + A(L)\varepsilon_{t-1}^2 + B(L)h_{t-1} \end{aligned} \quad (6.4)$$

where $\alpha_1, \dots, \alpha_p, \beta_1, \dots, \beta_q, \omega$ are all constant parameters, and L denotes the lag operator. In this case, the conditional variance is a function of both past innovations and of lagged values of itself, and for the conditional variance to be well defined, all the coefficients in the corresponding infinite order ARCH model must be non-negative. Further, the GARCH model has finite variance if $A(L)+B(L)<1$.⁶ Engle and Bollerslev (1986) have found that low order (or augmentation of) GARCH(p,q) processes on the whole have properties similar to higher order ARCH, but obviously have significant less parameters to estimate, and Bollerslev (1985) shows evidence suggesting that a lower order GARCH model fits as well or even better than an ARCH model with linearly declining weights. A further weakness of the ARCH model is that a misspecification in the variance equation will lead to biased estimates for the parameters and estimates for the conditional variance and the mean will no longer be valid. Nelson (1992) shows that GARCH models are not so sensitive to misspecification, and even if the conditional variance in a linear GARCH model is misspecified, the parameter estimates are consistent. The usual parameterisation for the GARCH model has been the GARCH(1,1) which implies an infinitely long memory with respect to past innovations; see Bollerslev et al. (1992).

The unconditional variance for a GARCH(1,1) model can be given by,

$$Var(\varepsilon_t) \equiv \sigma_t^2 = \omega / (1 - \alpha - \beta) \quad (6.5)$$

for $(\alpha+\beta)<1$, (where α and β represent parameters for $p,q=1$). One important consequence emerging for this specification is that shocks to the volatility decay at a constant rate, where the speed of decay is measured by the estimate of $(\alpha+\beta)$. The closer this is to one, the higher

⁶ See Bollerslev (1985) for the proof.

is the persistence of shocks to current volatility. If $(\alpha+\beta)=1$, then shocks to volatility are permanent and the unconditional variance is not determined by the model. This process is known as “Integrated GARCH” or IGARCH (see Engle and Bollerslev (1986)). If the GARCH(p,q) model is rearranged, as in Engle and Bollerslev (1986), to give,

$$\varepsilon_t^2 = \omega + (\alpha(L) + \beta(L))\varepsilon_{t-1}^2 - \beta(L)v_{t-1} + v_t \quad (6.6)$$

in which ε_t can be written as an ARMA(m,p) process, $m=\max\{p,q\}$ with serially uncorrelated innovations v_t , where $v_t = \varepsilon_t^2 - h_t$. Therefore, if $(\alpha(L)+\beta(L))$ is close to one, its autocorrelation function will decline fairly slowly showing a relatively slowly evolving conditional variance, and if it equals one, (i.e. the autoregressive polynomial in equation 6.6 has a unit root) a shock to the conditional variance is persistent in the sense that it remains important for future forecasts for all horizons.⁷

With regard to the GARCH-in-Mean GARCH-M model, the process reflects the suggestion made by finance theory that assets with higher perceived risk would, on average, provide a higher return, and therefore, the mean return would be related to the variances of the return. Engle, Lilien and Robins introduced the GARCH-M regression which simply includes a variance term in the return equation. However, there are important limitations to the ‘symmetric’ GARCH models, whereby ‘symmetry’ refers to the assumption that only the magnitude and not the positivity or negativity of unanticipated excess returns determines the variance of returns given information at time t .

Nelson (1991), to overcome this limitation proposed an E-GARCH model which improves the GARCH model in at least two ways; firstly, the E-GARCH model allows good and bad news to have a different impact on volatility; secondly, the model allows more important news to have a larger impact on volatility.

Under the E-GARCH (1,1), the (log of) conditional variance is given by⁸:

$$\ln(h_t) = \omega + \alpha \left[\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} - \sqrt{\frac{2}{\pi}} \right] + \beta \ln(h_{t-1}) + \frac{\delta \varepsilon_{t-1}}{\sqrt{h_{t-1}}} \quad (6.7)$$

⁷ Nelson (1990) shows that the IGARCH model is strictly stationary and ergodic if $\beta > 0$. This is true since it is still possible for ε_t to come from a strictly stationary process in the sense that the unconditional density of ε_t is the same for all t . Nelson (*ibid.*) also shows that the IGARCH model collapses to zero if $\beta = 0$.

where ω, α, β , and δ are constant parameters. Since δ is usually negative, then *ceteris paribus*, good news will generate less volatility than bad news. Nelson (1991) developed the EGARCH from the Logarithmic GARCH suggested by Geweke (1986) and Pantula (1986), and the EGARCH model implies that a deviation of $|\varepsilon_{t-1}|$ from its expected value causes the conditional variance to be larger than otherwise - an effect similar to the GARCH specification. An attractive feature of the EGARCH model, however, is that, since it describes the logarithm of the conditional variance, the variance itself will be positive regardless of whether the coefficients are positive. This avoids the problem of negative coefficients often faced with the standard ARCH/GARCH specification. Moreover, rather than revealing the persistence of shocks to variance, the $\ln(h_t)$ in the EGARCH, is strictly stationary and ergodic.

The Quadratic GARCH or Asymmetric AGARCH was developed independently by Sentena (1991) and Engle (1990), respectively. Sentena's GQ-ARCH in its simplest form can be written as:

$$h_t = \omega + \alpha (\varepsilon_{t-1} + \tau)^2 + \beta h_{t-1} \quad (6.8)$$

where τ, ω, α , and β are constant parameters. The advantage of this parameterisation relative to the EGARCH model is that it is still within the parametric ARCH framework of Engle (1982). The model can be interpreted as a second order Taylor approximation to the unknown conditional variance function, or the quadratic projection of the squared series on the information set. In this case, the asymmetric effect is captured by the parameter τ , whereby if $\tau < 0$, the conditional variance will be higher when ε_{t-1} is negative, and analogously, the conditional variance will be smaller when ε_{t-1} is positive.⁹

The Threshold ARCH (TARCH) model was independently developed by Glosten, Jagannathan and Runkle (GJR) (1993) and Zakoian (1990). The GJR model¹⁰ parameterises the conditional variance as:

⁸ Formulas for the higher moments are given in Nelson (1991).

⁹ As in the GARCH framework when the sum of the α 's and β 's is equal to one, then the model is referred to as the Integrated (G)QARCH, and the parameters of the (G)QARCH are constrained to be non-negative.

¹⁰ This model is closely related to the threshold ARCH and TARCH model of Zakoian (1994) and Rabemananjara and Zakoian (1993).

$$h_t = \gamma + \beta h_{t-1} + \alpha \varepsilon_{t-1}^2 + \delta S_t^- \varepsilon_{t-1}^2 \quad (6.9)$$

where S_t^- is a dummy variable which takes the value of unity if $\varepsilon_t < 0$ and zero otherwise. The Threshold GARCH model basically parameterises the conditional variance as in the following equation 6.10, where $S_t^+ = 1$ if $\varepsilon_t > 0$, $S_t^+ = 0$ otherwise.

$$h_t = \gamma + \beta h_{t-1} + \alpha \varepsilon_{t-1}^2 + \delta S_t^- \varepsilon_{t-1}^2 + \lambda S_t^+ \varepsilon_{t-1}^2 \quad (6.10)$$

Both models capture the asymmetry in the impact of news on volatility, i.e. the $S_t^- \varepsilon_{t-1}^2$ variable causes the conditional variance to be higher when ε_{t-1} is negative. Moreover, Rabemananjara and Zakoian (1993) argue that the asymmetry may be inverted between large and small values of ε_{t-1} ; for instance, small positive values may have a higher impact on volatility than small negative ones of equal magnitude, while the converse is true for larger values. Threshold GARCH models provide a means of capturing such effects, whilst at the same time maintaining the classical GARCH framework.¹¹

Each of the above specifications models predictable volatility and captures the asymmetry in the impact of news on volatility in different ways and so will have differing implications for predictable volatility and market risk premiums.

6.2.2 Model Estimation

GARCH models are typically estimated using maximum likelihood methods where the log likelihood for a sample of T observations (conditional on initial values) is proportional to:

$$L(\varphi) = \sum_{t=1}^T \left(-\ln |h_t| - \frac{\varepsilon_t^2}{h_t} \right) \quad (6.11)$$

which assumes conditional normality of the forecast errors. However, this assumption is often fairly restrictive, and in common findings, especially for financial time series data is that empirical conditional distributions often are more peaked and with fatter tails relative to that generated by a normal distribution. However, as shown by Weiss (1984,1986), Bollerslev and Wooldridge (1992) and Jagannathan and Runkle (1989), maximisation of the Gaussian log likelihood function can still provide consistent estimates of the parameters of the family of

¹¹ Zakoian (1994) derives the conditions for the strict stationarity of the TGARCH(1,1).

GARCH models, provided that the first and second moments of the standardised disturbances can be specified (see Hamilton 1993, p.663). Bollerslev and Wooldrige (1992) also demonstrate that the asymptotic results carry over to finite samples. This method of estimation is referred to as Quasi Maximum Likelihood Estimation.¹²

A second issue concerning the estimation of GARCH models is the common imposition of inequality constraints on the parameters (excluding the E-GARCH model) to keep the conditional variance non-negative, since significant violations of these constraints may be evidence of sampling error or of misspecification. However, Nelson and Cao (1992) show that not only may difficulties occur in estimation if these constraints are imposed, they rule out any random oscillatory behaviour in the conditional variance process. Hence, in this paper, the estimations carried out do not impose non-negativity conditions.¹³

6.2.3 Misspecification Tests

Engle and Ng (1993) propose three diagnostic tests for models of conditional volatility. These tests basically examine whether it is possible to predict the squared normalised disturbances term by some variables observed in the past, which are not included in the volatility model being used. If these variables can predict the squared normalised residual then the variance model being used is misspecified.

The sign bias test, the negative size bias test and the positive size bias test are respectively:

$$v_t^2 = a + bS_{t-1}^- + \beta' Z_{0t}^* + e_t \quad (6.12)$$

$$v_t^2 = a + bS_{t-1}^- \varepsilon_{t-1} + \beta' Z_{0t}^* + e_t \quad (6.13)$$

$$v_t^2 = a + bS_{t-1}^+ \varepsilon_{t-1} + \beta' Z_{0t}^* + e_t \quad (6.14)$$

¹² Asymptotically valid inferences regarding QML estimates, say, $\hat{\varphi}$, may be based upon robust versions of the standard test statistics. Under fairly weak regularity conditions, an asymptotic robust covariance matrix for the parameter estimates is consistently estimated by $A(\hat{\varphi})^{-1} B(\hat{\varphi}) A(\hat{\varphi})^{-1}$, where

$A(\hat{\varphi})$ and $B(\hat{\varphi})$ denote the hessian and the outer product of the gradients respectively, evaluated at $\hat{\varphi}$.

¹³ Although note that if GARCH (1,1) paramterisations are used in the estimations, then this requirement in any case is unnecessary.

where v is the normalised residual $\frac{\varepsilon_t}{\sqrt{h_t}}$; a and b are constant parameters; β is a constant parameter vector; e_t is the residual; S_{t-1}^- is a dummy variable that takes the value of one when $\varepsilon_{t-1} < 0$ and zero otherwise; S_{t-1}^+ is $(1 - S_{t-1}^-)$; and Z_{0t}^* is a vector of additional explanatory variables. The t -ratio for b in the 1st equation is defined as the sign bias test statistic (SBTS) which examines the impact of positive and negative return shocks on volatility which were not predicted. The t -ratio for b in the second equation is the negative size bias test (NSBT) which examines the effect of large and small negative return shocks on volatility which were not predicted. The t -ratio for b in the third equation is the positive size bias test (PSBT) which focuses on the effect of large and small positive return shocks on volatility which were not predicted by the model. A 2-stage OLS method of estimation is used for these three tests.

6.3 Modified Models of Predictable Volatility

As mentioned in the introduction, an order driven system with quantity constraints operates on the WSE. Given that r_t represents the return on a particular stock at time t (or the difference between the log of prices as before, i.e. $p_t - p_{t-1}$), then this relationship can be expressed as a Double Censored Tobit model as in equation (5.15) in Chapter 5, in a returns form such that:

$$\begin{aligned}
 r_t^* &= x_t(\beta) + \varepsilon_t & \varepsilon_t &\sim i.i.d.n(0, \sigma^2) \\
 r_t &= r_t^* & \text{if } r_t^L < r_t^* < r_t^U \\
 r_t &= r_t^L & \text{if } r_t^* \leq r_t^L \\
 r_t &= r_t^U & \text{if } r_t^* \geq r_t^U
 \end{aligned} \tag{6.15}$$

where r_t^* is the return generating process at time t ; r_t^U represents the upper limit imposed on the price change; and r_t^L represents the lower limit, and β is a vector of parameters.

The direct effects of the price limits are a reduction in their variation and artificial serial correlation. Furthermore, since the distribution of returns is no longer Gaussian or Normal, this suggests that even if the above GARCH models could be modified to form, in the simplest case, a “DCT-GARCH” model, the standard econometric framework for estimation is no longer applicable. Similarly, neither is the QMLE framework appropriate in this case

since a simulation of the above distribution would reveal one which fails, even remotely, to resemble a Gaussian distribution.¹⁴

Therefore, the log-likelihood for the Double Censored Tobit-GARCH (1,1) needs to be derived, which would be estimated using maximum likelihood methods. We propose such a log-likelihood function as follows,

$$\begin{aligned}
L = & \sum_{r_t^L \geq r_t^U} \ln [\phi (\frac{-1}{\sqrt{h_t}} (r_t^U - \mathbf{X}_t \beta))] \\
& + \sum_{r_t^L \leq r_t^L} \ln [\phi (\frac{1}{\sqrt{h_t}} (r_t^L - \mathbf{X}_t \beta))] \\
& + \sum_{r_t^L < r_t^L < r_t^U} \ln [\frac{1}{\sqrt{h_t}} \psi (\frac{1}{\sqrt{h_t}} (r_t - \mathbf{X}_t \beta))] .
\end{aligned} \tag{6.16}$$

The first term corresponds to the observations at the upper limit r_t^U , the second to the observations at the lower limit r_t^L , and the third term refers to the non-limit observations. ϕ represents the cumulative normal density function; ψ denotes the standard normal density function and $\mathbf{X}_t \beta = \mathbf{x}_t(\beta)$. This is similar to the log-likelihood function applied by Rosett and Nelson (1975) and Nakamura and Nakamura (1983) among others, although in these studies, the conditional variance was replaced by a constant unconditional variance.

However, there is a potential problem in using this log-likelihood function once the variance is conditioned to be time-varying of the form of a GARCH process. We have seen that the conditional variance in the standard GARCH model (see expression (6.4)) is a function of the information set consisting of past values of the conditional variance and also of past values of the squares of the residuals from the data generating process. If we consider the return-generating process in expression (6.15), in which returns are censored beyond a limit, we observe that the residuals refer to the process when the returns are in equilibrium (i.e. neither limit is hit). It is herein where the problem lies. In the situation where neither upper nor lower limit is hit, past values of the residuals, ε_t , are observed and the log-likelihood in (6.16) collapses to the standard log-likelihood relating to a Gaussian distribution. If, however, if either one of the limits are hit, then the value of ε_t , which is observed, is the *censored* value, which will be equal to the value of the positive (negative) limit if the upper

¹⁴ Figures 5.4a-b in Chapter 5 graph the empirical distributions of returns traded on the WSE compared to a simulated normal distribution.

(lower) limit is hit, and we therefore *do not* observe the uncensored value.¹⁵ However, the log-likelihood in (6.16) with the conditional variance modelled according to a GARCH process is only valid for the *uncensored* (or equilibrium) values of ε_t .

Given that the uncensored values of ε_t are unobserved, we can put forward one possible resolution to this problem for estimation purposes. In the cases where the limits are not hit, then, as discussed, the past value of ε_t (ε_{t-1}) used to determine the conditional variance at time t (h_t), is the observed uncensored value. In the case where the limits are hit, then the best estimate of the uncensored residual, ε_{t-1} , can be assumed to be h_{t-1} (the previous value of the conditional variance). In other words,

$$h_t = \omega + \alpha E(\varepsilon_{t-1}^2) + \beta h_{t-1}$$

where,

$$E(\varepsilon_{t-1}^2) = \varepsilon_{t-1}^2 \quad \text{if } r_t^L < r_t^* < r_t^U, \quad \text{and}$$

$$E(\varepsilon_{t-1}^2) = h_{t-1} \quad \text{if } r_t^* \leq r_t^L \quad \text{or} \quad r_t^* \geq r_t^U.$$

In this analysis, however, this approach is left for further work outside this thesis, and hence the log-likelihood expression in (6.16) is assumed to be only an approximation in which censored series of residuals are used to model the conditional variance.

6.3.1 Misspecification Tests

Another cause of concern is the use of the diagnostic statistics previously described in Section 1, since the performance of the test (i.e. SBT, NSBT and PSBT) may be sensitive to the underlying distribution of returns. In order to examine this, Monte Carlo experiments were carried out to investigate the size and power of the SBT, NSBT and PSBT's. The Monte Carlo experiment for checking the size of the tests is based on a DCT-GARCH (1,1) data generating process and is according to the system of equations in (5.15) (Chapter 5) but allowing for the variance of the residuals to be conditional, i.e.,

¹⁵ I am grateful to Stephen Hall for pointing this out and for the suggestion of the possible solution that follows.

$$p_t = \begin{cases} \mu + p_{t-1} + \varepsilon_t & \text{if } |p_t - p_{t-1}| < w \\ p_{t-1} + w & \text{if } p_t - p_{t-1} \geq w \\ p_{t-1} - w & \text{if } p_t - p_{t-1} \leq -w \end{cases} \quad (6.17)$$

$$h_t = \omega + \beta h_{t-1} + \alpha \varepsilon_{t-1}^2 \quad (6.17a)$$

$$\varepsilon_t = \sqrt{h_t} \cdot v_t$$

where w is the censoring limit as before set at 10%, and $v_t \sim \text{iid } N(0,1)$, ω , α , and β are constant parameters. As in the analysis in Chapter 5, both μ (drift term) and the variance of ε_t are such that they approximate the frequency of hits of the empirical series to be investigated. As in Engle and Ng's (1993) paper, the parameter values considered signify high, medium and low persistence where Model H represents high persistence and $(\omega, \beta, \alpha) = (0.01, 0.9, 0.09)$; Model M represents medium persistence and $(\omega, \beta, \alpha) = (0.05, 0.9, 0.05)$; and Model L represents low persistence where $(\omega, \beta, \alpha) = (0.2, 0.75, 0.05)$. For a sample size of 500, 10000 replications were carried out, replacing any non-converged replications. For each replication a DCT-GARCH (1,1) was estimated and the SBT, NSBT and the PSBT are conducted. Tables 6.1, 6.2 and 6.3 report the actual rejection frequencies based on the asymptotic 1%, 5% and 10% critical values for models H, M and L, respectively. These are compared to the actual rejection frequencies when the data generating process is, instead, a GARCH (1,1) process¹⁶ and a GARCH (1,1) model is estimated under the same conditions.

¹⁶ For the GARCH (1,1) model, the simulated return at time t is assumed to be entirely unpredictable, and thus equal to ε_t .

Table 6.1: The Simulation Size of the Misspecification Tests; Model H

Model H	DCT - GARCH (1,1)			GARCH (1,1)		
	Actual Rejection Frequencies			Actual Rejection Frequencies		
	(%)			(%)		
	1%	5%	10%	1%	5%	10%
SBT	0.64	4.00	9.42	1.06	4.51	10.10
NSBT	1.36	6.00	10.78	1.20	5.52	9.81
PSBT	1.20	5.40	10.40	0.92	4.80	9.83

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. The DCT-GARCH (1,1) corresponds to the system of equations in (6.17)-(6.17a) where model H represents high persistence.

Table 6.2: The Simulation Size of the Misspecification Tests; Model M

Model M	DCT - GARCH (1,1)			GARCH (1,1)		
	Actual Rejection Frequencies			Actual Rejection Frequencies		
	(%)			(%)		
	1%	5%	10%	1%	5%	10%
SBT	0.60	3.20	8.68	0.94	5.19	8.91
NSBT	0.94	4.90	10.22	1.18	5.42	10.43
PSBT	1.12	5.46	10.20	0.80	4.81	10.25

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. The DCT-GARCH (1,1) corresponds to the system of equations in (6.17)-(6.17a) where model M represents medium persistence.

Table 6.3: The Simulation Size of the Misspecification Tests; Model L

Model L	DCT - GARCH (1,1)			GARCH (1,1)		
	Actual Rejection Frequencies (%)			Actual Rejection Frequencies (%)		
	1%	5%	10%	1%	5%	10%
SBT	0.20	2.04	6.58	1.15	5.20	10.00
NSBT	1.90	6.90	12.22	0.90	4.80	9.37
PSBT	1.84	6.74	12.66	0.94	5.10	9.86

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. The DCT-GARCH (1,1) corresponds to the system of equations in (6.17)-(6.17a) where model L represents low persistence.

The tables of results show that the SBT seems to be performing reasonably given the asymptotic critical values, however, in contrast to the simple GARCH (1,1) case, the NSBT and PSBT for the DCT - GARCH (1,1) seem to be rejecting the null too often when it is in fact true. This is probably due to the comparatively larger number of observations in the tails of the distribution. Moreover, as the degree of persistence decreases, the performance of the size of tests decreases also for the DCT - GARCH(1,1).

The Monte Carlo experiment for checking the power of these tests is based on a DCT- GJR (1,1) model as in the system of equations in (6.17) and with the conditional variance being defined as follows,

$$h_t = 0.005 + 0.7h_{t-1} + 0.28[|\varepsilon_{t-1}| - 0.23\varepsilon_{t-1}]^2 \quad (6.18)$$

$$\varepsilon_t = \sqrt{h_t} v_t$$

where $v_t = iidN(0,1)$. Again, 10000 replications are carried out on a sample size of 500, replacing any non-converged replications. For each replication a DCT - GARCH (1,1) is estimated and Table 6.4 reports the actual rejection frequencies based on the 5% asymptotic critical values.

Table 6.4: The Simulated Power of the Misspecification Tests

	DCT - GJR model Actual Rejection Frequencies (%)
SBT	5.22
NSBT	6.44
PSBT	7.92

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. The DCT-GJR (1,1) corresponds to the system of equations in (6.17) but with the conditional variance being specified according to (6.18).

The results suggest that the power of the tests give cause for concern at this sample size, although this is consistent with Engle and Ng's findings. They suggest a possible reason for this weakness, in that it may be due to collinearity between the misspecification indicators, especially with respect to the SBT and NSBT.

In any case, it is clear that the asymptotic critical values are not appropriate either when assessing the significance of the parameters of the DCT - GARCH models, or when drawing inference from the misspecification tests. Hence, simulated critical values evaluated at the 1%, 5% and 10% levels, for a sample size of 500 with 50000 replications, for a DCT distribution, were used on reference to the DCT models.¹⁷

6.4 Estimation and Hypothesis Testing

This section describes the data series to be used for the empirical analysis for the series from the two emerging markets, and any manipulations which took place prior to estimation. The results from the estimations are then reviewed.

Four data series were chosen, two from the WSE and two from the BSE. One of these from each exchange was the market index; the WIG for the WSE and the BUX for the BSE. The WIG index consists of 500 observations starting from the beginning of operations of the WSE, i.e. 16th April 1991 to May 1995. The BUX consists of 1089 observations starting from

¹⁷ The procedure for simulating the critical values was described and the critical values reported in section 5.3, Chapter 5.

the 1st January 1990 through August 1995. The two series of stock returns chosen from the WSE and BSE are Tonsil and Ibusz respectively¹⁸, which were selected on the grounds of the length of the series, since each has been trading since the start of operations in each exchange. Tonsil as described in section 5.2 (Chapter 5), consists of 447 observations ranging from April 1991 to May 1995, and Ibusz, a typical series on the BSE, has 995 observations spanning June 1990 to August 1995. Each series is transformed to represent returns as the difference between the log of the prices in time t and the log of prices in time $t-1$.

Before modelling the conditional variance however, Pagan and Schwert (1990) point out that, although it is well researched, the mean return exhibits little predictability from the past. There are qualifications to this conclusion. For instance, there may be the existence of a moving average error term induced by non-synchronous data and calendar effects. In this paper, the unpredictable element of stock returns is obtained by a similar procedure to Pagan and Schwert (1990). The raw return data is basically regressed on a constant and r_t, \dots, r_{t-6} ¹⁹. Then the residuals from this regression represent the unpredictable stock return data (referred to as 'pre-whitened' series).²⁰

Kurtosis, skewness and some summary statistics are presented for each of the pre-whitened series in Table 6.5 as well as the Ljung-Box Q statistic on the squared return data to detect the presence of ARCH effects.

¹⁸ Tonsil manufactures electrical components, and Ibusz is a tourism company.

¹⁹ Calendar effects should also be removed but significant effects were not found during a previous analysis in each of the four series. Furthermore, since the error terms will be heteroskedastic they need to be adjusted, and this is done using the method of White (1980).

²⁰ Note that, in this analysis, we follow the practice in the existing literature. However, in order to pre-whiten series in the presence of censoring, a preferable method would be to add, as additional explanatory variables, the lags of returns into the return equation of the DCT-GARCH model. Hence, the estimation would all be carried out in a single stage rather than in two separate stages.

Table 6.5: Summary Statistics for the Pre-whitened Return Series on the WSE and BSE.

	WIG	Tonsil	BUX	Ibusz
Number of observations	500	477	1089	995
Mean	0.00	0.00	0.00	0.00
Variance	14.03	54.57	1.30	28.54
Skewness	0.25 (0.01)	-0.51 (0.00)	-0.66 (0.00)	-1.31 (0.00)
Kurtosis	1.30 (0.00)	2.03 (0.00)	10.31 (0.00)	12.00 (0.00)
Ljung-Box (12) for squares	133.85 (0.00)	46.35 (0.00)	361.83 (0.00)	54.39 (0.00)

Note: Marginal significance levels are displayed as (.)

The estimation procedure adopted from here on is as follows. Firstly, using the relevant econometric estimation procedures, the symmetric GARCH and GARCH-M models, and the DCT-GARCH and DCT-GARCH-M models are estimated. The quasi-maximum likelihood algorithms used are the Simplex algorithm to find the initial values and then the Broyden, Fletcher, Goldfarb and Shanno (BFGS) algorithm.²¹ In all cases the convergence criterion adopted is 0.00001. If, from the misspecification tests any asymmetry is detected, then the three models of asymmetry are subsequently estimated. Tables 6.6 presents the parameter estimates and misspecification test statistics for the GARCH (1,1) and GARCH (1,1)-M models for the WIG and BUX indices, and Table 6.7 presents the statistics for the GARCH (1,1) and GARCH (1,1)-M models for Ibusz, and the DCT-GARCH (1,1) and DCT-GARCH (1,1) for Tonsil. Each of the parameters is as specified in sections 6.2 and 6.3, and λ represents the coefficient on the variance term in the GARCH-M model.

²¹ See Press et al. (1988) for details.

Table 6.6: Estimates of the Symmetric Volatility Models for the WIG and BUX

Parameter	WIG Index		BUX Index	
	GARCH (1,1)	GARCH (1,1) - M	GARCH (1,1)	GARCH (1,1) - M
λ	-	0.0481 [0.595]	-	0.288 [2.178]
ω	1.033 [7.66]	0.938 [1.919]	0.296 [1.327]	0.323 [2.483]
α	0.442 [60.45]	0.574 [8.73]	0.276 [2.54]	0.299 [3.308]
β	0.556 [20.71]	0.413 [5.460]	0.482 [1.728]	0.441 [3.184]
Log Likelihood	-812.88	-812.75	-526.77	-524.45
Ljung-Box(12) of squares	6.603 (0.883)	7.065 (0.853)	10.403 (0.581)	10.362 (0.584)
SBT	0.078 [0.581]	0.081 [0.601]	0.228 [1.260]	0.214 [1.189]
NSBT	0.028 [0.304]	0.238 [0.255]	-0.122 [-1.284]	-0.060 [-0.692]
PSBT	0.128 [0.756]	0.146 [0.834]	-0.057 [-0.498]	-0.064 [-0.548]

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. [.] denote the robust t-ratios, (.) denote the marginal significance levels.

Table 6.7: Estimates of the Symmetric Volatility Models for Ibusz and Tonsil

Parameter	Ibusz		Tonsil	
	GARCH (1,1)	GARCH (1,1) - M	DCT-GARCH (1,1)	DCT-GARCH (1,1) -M
λ	-	0.404 [2.505]	-	-0.006 [-0.192]
ω	10.699 [13.59]	11.322 [5.499]	6.513 [5.930]	6.755 [6.791]
α	0.393 [2.123]	0.414 [1.966]	0.208 [6.899]	0.201 [8.627]
β	0.331 [3.635]	0.291 [4.386]	0.699 [31.879]	0.698 [35.899]
Log Likelihood	-2070.42	-2066.14	-1419.23	-1419.21
Ljung-Box (12) for squares	2.044 (0.999)	2.173 (0.999)	12.277	12.048
SBT	0.154 [0.502]	0.284 [0.920]	-0.150 [-1.681]	-0.141 [-1.576]
NSBT	-0.026 [-0.269]	-0.002 [-0.021]	0.143 [2.902]	0.140 [2.876]
PSBT	-0.022 [-0.149]	-0.016 [-0.100]	0.060 [0.734]	0.065 [0.749]

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. The DCT-GARCH corresponds to the system of equations in (6.17). [.] denote the robust t-ratios, (.) denote the marginal significance levels.

On initial examination of Tables 6.6 and 6.7, for the BUX index and Ibusz, it can be seen that on the basis of the log likelihood criterion the GARCH (1,1)-M model appears to be more appropriate than the GARCH (1,1) model. This finding is reinforced by the fact that the estimate of λ is found to be significant and positive in both cases. As such, the result tentatively supports the assertion made in finance theory, that investors require higher expected returns as compensation for holding riskier assets. With regard to the misspecification tests for the detection of asymmetry in the conditional volatility of returns, both the BUX and Ibusz fail to detect the presence of any of the asymmetries referred to.

By contrast, for the WIG and Tonsil, the coefficient λ is now found to be insignificant²², suggesting no such relationship between the mean and variance of returns. Therefore, the GARCH (1,1) and the DCT-GARCH (1,1) seem to be the more appropriate models for the WIG and Tonsil, respectively. On consideration of the discovery of particular asymmetries, the WIG, consistent with the BUX and Ibusz, shows no asymmetry in its GARCH model. However, for Tonsil, although the SBT and the PSBT are insignificant at the 5% level of significance, the NSBT is significant at the 5% level, suggesting that the DCT-GARCH (1,1)

²² Note that the critical values for deciding on the significance of coefficients differ, as mentioned in section 5.3, chapter 5, depending on whether the WIG or Tonsil is being investigated.

is misspecified. In other words, the model does not account for the size of negative returns having a different effect on the predicted volatility.

Table 6.8 therefore presents the estimates of the modified asymmetric volatility models for Tonsil.

Table 6.8: Estimates of the Asymmetric Volatility Models for Tonsil

Parameter	DCT-EGARCH (1,1)	DCT-GJR (1,1)	DCT-GQARCH (1,1)
δ	-0.109 [-0.540]	-0.079 [-0.761]	0.576 [0.503]
ω	3.167 [37.42]	4.82 [1.06]	4.07 [0.714]
α	0.295 [3.97]	0.240 [2.44]	0.190 [3.00]
β	0.199 [10.55]	0.740 [6.74]	0.760 [6.033]
Log Likelihood	-1423.95	-1417.91	-1418.11
Ljung-Box (12) for squares	19.49	10.16	9.74
SBT	-0.047 [-0.53]	-0.014 [-0.158]	-0.036 [-0.386]
NSBT	0.039 [0.609]	0.078 [1.23]	0.093 [1.468]
PSBT	0.002 [0.022]	-0.011 [-0.121]	0.017 [0.205]

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. The DCT-EGARCH, DCT-GJR and DCT-GQARCH correspond to the system of equations in (6.17) but with the conditional variance being specified according to formulations (6.7), (6.10) and (6.8), respectively. [.] denote the robust t-ratios.

From the above table, it can be seen that although the misspecification tests no longer detect any asymmetry, *none* of the models are in fact appropriate in capturing the asymmetry present. This is clearly evident since the coefficient δ - which is the asymmetry coefficient in each of the models - is consistently insignificant.

An alternative approach in characterising the impact of past return shocks on the return volatility is through the estimation of a partially non-parametric model. There are several approaches to accomplish this in the literature, the most prominent being those of Gouriéroux and Monfort (1992), Pagan and Schwert (1990) and Engle and Ng (1993). These approaches allow the data to directly reveal the impact of shocks on the conditional volatility of returns, thereby, enabling a deeper understanding or alternatively, a clearer picture of the relationship compared to the above symmetric and asymmetric models. Moreover, it would be possible to

identify the significance or importance of the asymmetries. The next section briefly outlines Engle and Ng's partially non-parametric model, and proceeds to modify and estimate it, analogous to the method outlined in section 6.3 (i.e. the DCT distribution of returns), so that it is appropriate for the censored returns of Tonsil.

6.5 A Modified Partially Non-Parametric Conditional Volatility Model.

Engle and Ng propose the following partially non-parametric model which treats the relationship between news and volatility non-parametrically, and the long memory component in the variance equation is given as a parametric component. The model uses linear splines with kinks at ε_{t-1} equal to 0, $\pm\sigma$, $\pm 2\sigma$, $\pm 3\sigma$, $\pm 4\sigma$, where σ represents the unconditional standard deviation of the dependent variable.

$$h_t = \omega + \beta h_{t-1} + \sum_{i=0}^{m+} \theta_i P_{it-1}(\varepsilon_{t-1} - i\sigma) + \sum_{i=0}^{m-} \delta_i N_{it-1}(\varepsilon_{t-1} + i\sigma) \quad (6.19)$$

where ω , β , θ_i ($i = 0, \dots, m+$), δ_i ($i = 0, \dots, m-$) are constant parameters; P_{it} ($i = 0, 1, 2, 3, 4$) is a dummy variable taking the value of one if $\varepsilon_t > i\sigma$ and zero otherwise; N_{it} ($i = 0, 1, 2, 3, 4$) is a dummy variable taking the value of one if $\varepsilon_t < -i\sigma$ and zero otherwise.

In this case, since the limits imposed on prices on the WSE constrain the variance of returns of the series, as an initial investigation, a modified partial non-parametric model is estimated for Tonsil where the kinks at ε_{t-1} are set equal to 0, $\pm 0.5\sigma$, $\pm\sigma$, $\pm 1.3\sigma$, and $\pm 1.5\sigma$. Maximum likelihood estimation assuming a DCT log likelihood function (expression (6.16)), and robust standard errors, reveal the following estimates of the model;

Table 6.9: Modified Partially Non-Parametric ARCH Model for Tonsil

ω	55.33 [0.232]
β	0.508 [0.003]
θ_0	0.058 [0.137]*
$\theta_{0.5}$	0.172 [0.101]*
θ_1	0.264 [0.073]
$\theta_{1.3}$	0.297 [0.062]
$\theta_{1.5}$	0.316 [0.057]
δ_0	-.0446 [0.016]
$\delta_{0.5}$	-0.455 [0.014]
δ_1	-0.461 [0.012]
$\delta_{1.3}$	-0.463 [0.011]
$\delta_{1.5}$	-0.464 [0.011]

Notes: The modified partially non-parametric ARCH model for Tonsil refers to the system of equations in (6.17) but with the conditional variance being specified according to (6.19). ‘*’ denotes insignificant coefficients and [.] denotes robust or heteroskedasticity consistent standard errors, (White (1990)).

From the above table, if the value of coefficients corresponding to the P terms are compared to their counterpart N terms, it appears that the negative ε_{t-1} ’s cause more volatility than positive ε_{t-1} ’s of equal absolute size. Moreover, for the given specifications of i and m , the rate of increase in volatility as we approach ε_{t-1} ’s with a larger absolute magnitude (i.e. larger shocks), is higher for the positive news than for negative news. This suggests that a sign or asymmetric effect as well as a size effect does differ for negative and positive news; i.e. the response to negative news is not dependent on the size of the news, although is larger than that for an equal magnitude of good news, whereas by contrast, the larger the amount of good news, the more volatility is produced. However, on changing the specification of i and m , it is found that the above results are most definitely not robust. On further analysis, it becomes evident that there is no clear or systematic way in which returns respond to shocks, and the modified non-parametric model is not monotonic.

6.6 Volatility Models for a Developed Exchange with Quantity Constraints

For the purposes of a simple comparative analysis, the above estimation procedure was carried out for two data series from the French Stock Exchange, the structure of which has provided the basis for the institutional set-up of the WSE. One of the series chosen was the market index, the CAC, ranging, similarly, from the beginning of January 1990, until the end of August 1996, i.e. a total of 1710 observations. The other series chosen, is a well established stock, L'Oreal, again taken from the same time period as the CAC Index.

The graphs in the Appendix show plots of the pre-whitened series of returns for both series. On inspection, the series do appear to display a clustering phenomenon associated with a GARCH process. On examination of the distribution of returns, however, they differ significantly from the distribution of returns on the WSE. This evidently reflects the significantly smaller degree of volatility of a developed market on the whole and a larger number of investors relative to emerging markets. Consequently, the limit on the change in price is very rarely imposed, and therefore, in terms of estimation, the QMLE method applies.²³ Table 6.10 provide summary statistics for both series, and the presence of ARCH effects on the squared returns is confirmed.

For both models, analogous to the above procedure strategy for the other series, the symmetric GARCH models were estimated and if any asymmetry were to be found, then the asymmetric GARCH models would need to be estimated. Tables 6.11 and 6.12 present the final outcomes.

²³ There is a 4-5% limit on the movement of returns on this exchange.

Table 6.10: Summary Statistics for the Pre-whitened Return Series on the French Stock Exchange

	CAC Index	L'Oreal
Number of observations	1710	1710
Mean	0.00	0.00
Variance	1.23	2.72
Skewness	-0.12 (0.03)	-0.08(0.19)
Kurtosis	3.05 (0.00)	1.40 (0.00)
Ljung-Box (12) for levels	5.52 (0.94)	5.03 (0.96)
Ljung-Box (12) for squares	170.26 (0.00)	344.23 (0.00)

Note: Marginal significance levels are displayed as (.).

Table 6.11: Estimates of the GARCH(1,1) Model for CAC Index and L'Oreal Returns

Parameter	CAC Index GARCH(1,1)	L'Oreal GARCH(1,1)
ω	0.106 [2.589]	0.106 [2.589]
α	0.071 [4.670]	0.071 [4.670]
β	0.841 [23.375]	0.841 [23.375]
Log Likelihood	-976.02	-976.02
Ljung-Box (12) for squares	4.497	4.497
SBT	-0.020 [-0.184]	-0.020 [-0.184]
NSBT	0.014 [0.169]	0.014 [0.169]
PSBT	-0.102 [-1.355]	-0.102 [-1.355]

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. [.] denote the robust t-ratios.

Table 6.12: Estimates of the Volatility Models for L'Oreal Returns

Parameter	GARCH (1,1)	EGARCH(1,1)
δ	-	1.28 [3.56]
ω	0.35 [40.2]	0.05 [4.00]
α	0.089 [20.5]	0.07 [4.01]
β	0.77 [190.03]	0.94 [65.28]
Log Likelihood	-1648.93	-1630.63
Ljung-Box (12) for squares	10.70	8.72
SBT	0.079 [1.015]	-0.048 [-0.605]
NSBT	-0.107 [-1.570]	-0.047 [-0.682]
PSBT	-0.153 [-2.620]	-0.038 [-0.590]

Notes: The SBT, NSBT and PSBT refer to the sign bias test, negative size bias test and the positive size bias test in equations (6.12), (6.13) and (6.14) respectively. [.] denote the robust t-ratios.

For the CAC Index, the most appropriate model proved to be the GARCH(1,1), where no significant asymmetry in the conditional volatility of returns was captured by the misspecification tests. However, for the L'Oreal stock series of returns, the simple GARCH(1,1) model was misspecified, and out of the three asymmetric volatility models, the EGARCH (1,1) appeared to be the most appropriate. Contrary to the traditional finding, it can be seen from the above table that the asymmetry parameter is significantly positive. This implies that a positive shock leads to a larger change in the conditional volatility of returns compared to an equal negative shock.

The final section of this chapter summarises, and attempts to provide some economic intuition underlying these results.

6.6 Concluding Comments

The aim of this chapter was to attempt to model the second moments of returns of series from the WSE, and in doing so, to investigate whether the common finding regarding the asymmetric impact of news on the volatility of returns also applied to the emerging markets in

Eastern Europe. Also under investigation was whether the eventual results were robust to the underlying microstructure of the stock exchange; i.e. the WSE operates an order driven system with quantity constraints and limits on the movement in prices, and the BSE operates the more conventional market driven system. The results from both these investigations would hence provide implications for investor behaviour as well as the microstructure of the stock exchange.

The above results show that, for the WIG Index, the BUX index and Ibusz - a share on the BSE, no asymmetry in the volatility of returns were found. They assumed similar structures (GARCH (1,1)), although investors on the BSE seem to require a higher compensation for any extra risk undertaken, (- this may be related to the fact that only a small percentage of companies traded on the WSE pay dividends). Tonsil, a share on the WSE, was the only share to exhibit any asymmetry. However, this may be due to the fact that the size of the misspecification test, through a Monte Carlo experiment, was found to be higher than 5% once the limits of the WSE has been accounted for. A disputing argument is that the power of the misspecification tests are low. Nevertheless, examination of the modified non-parametric news impact curve for Tonsil, did in fact reveal that it was not monotonic or robust and there appeared to be no clear effect regarding the magnitude of the news entering the market. This finding is confirmed by a similar analysis on six other stock return series traded on the WSE, which were chosen on grounds of the number of observations - although the results are not presented here. Likewise, the results for the BSE are also confirmed for four other main series traded on the Exchange.

One plausible explanation for these results is that the investors on the emerging markets have a comparatively lower level of understanding of its operation, relative to the investors of developed markets. Hence, non-rational investor behaviour is perhaps the more prominent feature on emerging markets. For example, for the WSE, despite the attempts of a 'promotion and information' program undertaken by the WSE in 1992 and 1993 to increase the awareness and understanding of investors, this was just one initial step in the right direction. For instance, surveys carried out on investor demographics in November 1993, by the Polish polling agency, 'Demoskop' - see Gordon and Rittenberg (1995), show that 28% of the investors are between the ages of 18 and 27, and that only 21% have high school education. They report from interviews with two WSE officials that, 'new investors.....very young.....university students;.....do not have a very thorough understanding of how the markets work;tend to be more aggressive;.....invest(ing)....because their friends are investing.' A recent CBOS survey conducted on small investors (Gazeta Wyboreza, 4

February, 1994) also provides evidence that a clear majority of investors lacked the required knowledge to explain the market forces underlying an abnormally high stock price.

A second possible reason for the finding is that the dissemination of information to investors is slow and therefore when investors finally receive the information, either some consider it too late to respond, or investors do respond, but with a time lag - and this is not detected by the analysis. For example, Gordon and Rittenberg report that in interviews with Polish exchange officials, it was acknowledged that the system was unprepared for the sudden increases in accounts, trading volume and turnover value. Although there are daily newspaper publications in Poland, again, significant information is still omitted.

An alternative or rather a complimentary theory is based on the experiences faced by Eastern European countries on their transition between command economies to the market economy system. Indeed, these countries are still transforming and a justifiable comment is that the economies, in particular, those of Poland and Hungary in this case, have encountered tremendous upheavals and turmoil. Hence, given that both stock exchanges were set up and are operating in the midst of the transition program, an arguable occurrence is that the investors of such countries relative to those of developed countries, are more 'immune' to the same degree of 'good' or 'bad' news entering the exchange. Thus, their reactions may be relatively more dampened.

Finally, with respect to the WSE, it may have been thought that the presence of regulations do not allow investors to fully react to new information, which implies a possible reason for a lack of asymmetry of response. But, the simultaneous examination of the BSE, also failing to reveal any asymmetry, suggests that emerging market investor behaviour or psychology is the dominant factor in explaining the findings; - these findings are robust to the underlying institutional microstructure of the stock exchanges of the forms encountered.

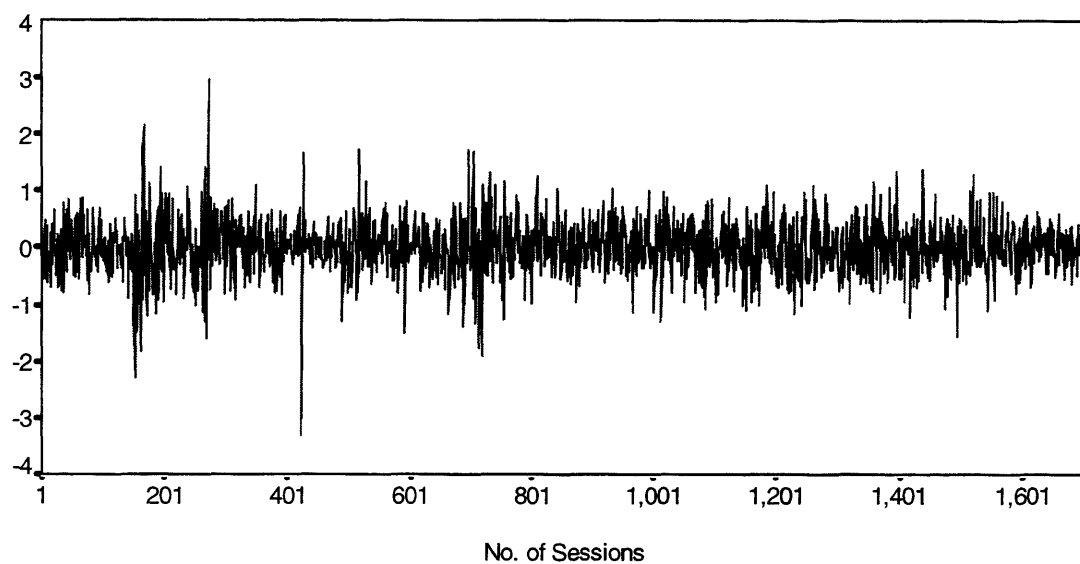
Further interesting research would be to examine whether these results hold for a different sample size and for when each of the markets is more developed. A simple attempt at the latter option was made by considering a 'developed' stock market, which has a institutional microstructure similar to the WSE. On consideration of the French CAC Index, no asymmetry is found, where for the stock L'Oreal, positive shocks lead to a larger volatility compared to a negative shock of the same magnitude. However, compared to the role of the limits on the WSE, on the French Stock Exchange, not only were the imposed limits on returns smaller, they were found to play a relatively insignificant role. This clearly reflects the maturity and stability of a developed market compared to an emerging market.

A number of complementary explanations related to investor behaviour and psychology, the nature of financing of firms on the stock exchange, the volume of trade and the institutional structure of the exchange can be proposed for these findings. As such, this analysis could be extended by examining early and more extensive data from developed markets, which would allow a better insight. Alternatively, a simulation study could be undertaken assuming rational investors facing differing stock exchange regimes, to investigate the effect of the institutional set-up of the exchanges on the volatility of returns. However, this is left to further research.

Appendix 6

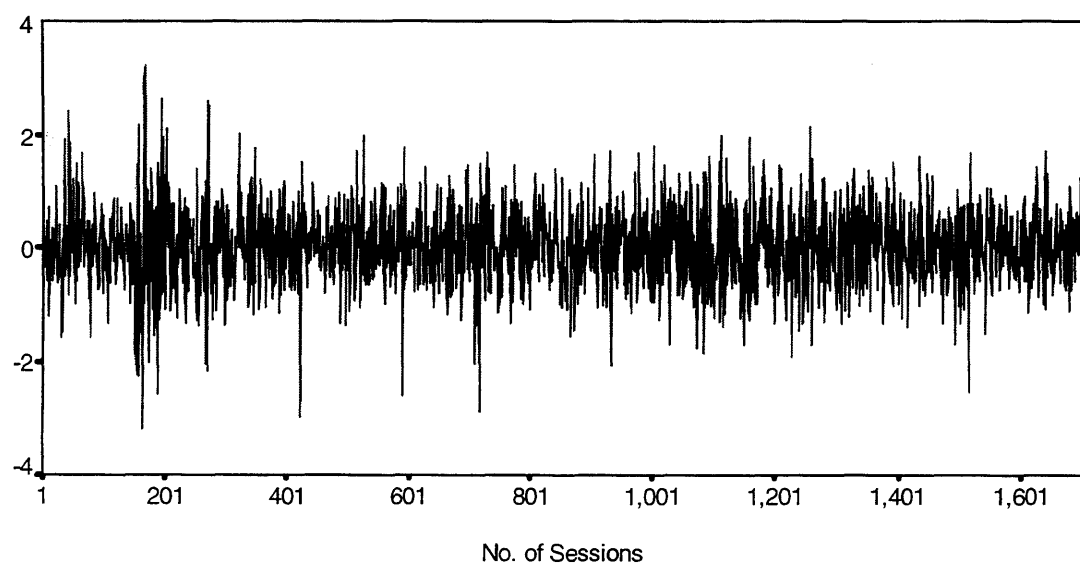
Prewhitened Series of CAC Index Returns

1/90 - 8/96

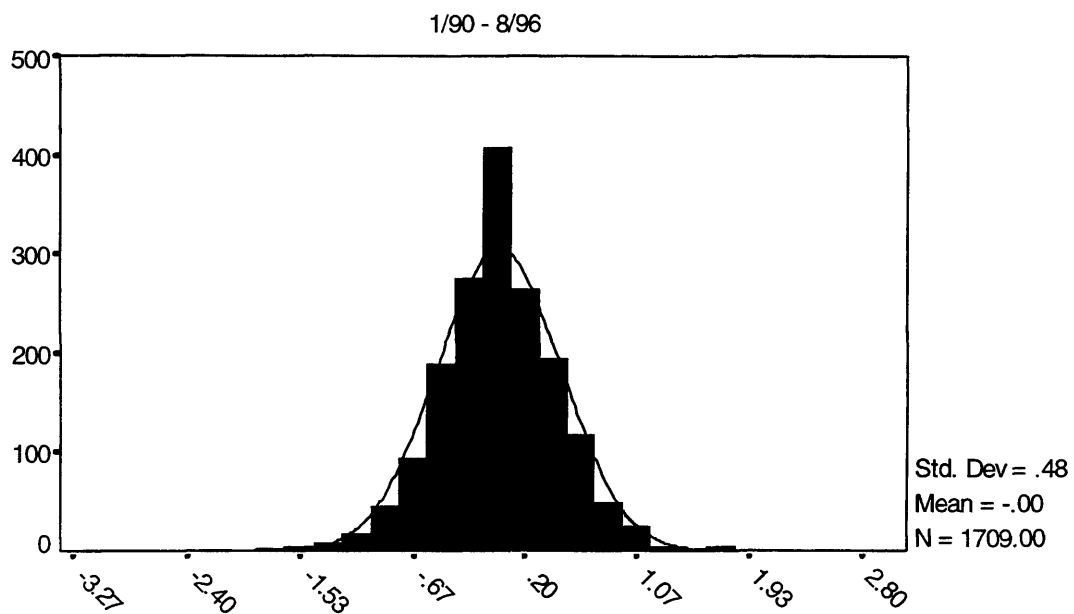


Prewhitened Series of L'Oreal Returns

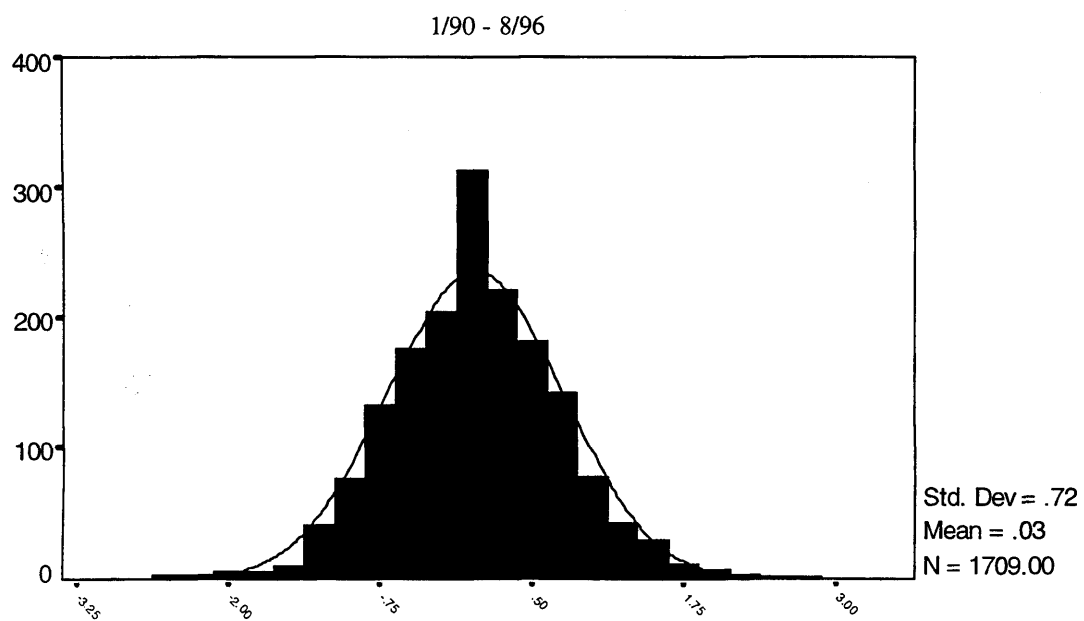
1/90 - 8/96



Distribution of Prewhitened Series of CAC Index Returns



Distribution of Prewhitened L'Oreal Stock Returns



CHAPTER 7

CONCLUSIONS

Summary

This chapter begins by summarising the work contained in this thesis. Our main findings are then reviewed and some suggestions for future research are made.

7.1 Summary of Thesis

This thesis has investigated the behaviour of asset returns on an Eastern European stock market, namely the Warsaw Stock Exchange, on which there exists a one-period censoring of asset returns moving beyond a pre-specified range of $\pm 10\%$. Our principal objective has been to incorporate this institutional feature, introduced to limit speculative behaviour and volatility on the market, into both a theoretical and econometric analysis. This is in addition to investigating the time series behaviour of an Eastern European emerging market. The analyses undertaken can be summarised as follows.

In chapter 2, we provide a background to the establishment and development of the current stock exchange in Poland. The emergence of market-based economies in Eastern Europe is described, highlighting the economic and political problems that led to the collapse of the central planning system operating in these countries. We note that the emergence of a market-based system also necessitates an efficient financial sector, and we therefore consider the emergence of the financial sector in Poland. Savings and investment facilities are described before and after the 1989 reforms in Poland. This leads to the description of the WSE and the BSE, both of which have been essential in privatisation process and the WSE, in particular, as an alternative source of funding.

Given that the WSE is an important emerging market on the domestic scene as well as on the world scale, in chapter 3, we provide a review of studies investigating the behaviour of stock returns on emerging stock markets. This review also highlights the characteristic features of emerging markets.

In chapter 4, we first show that the traditional 'economics of equilibrium' needs to be abandoned essentially because of the strong underlying assumption of market equilibrium no longer holds and we apply the disequilibrium framework introduced by Benassy (1982) to the market under consideration. The single markets setting is extended to a multi-market setting, incorporating cross and intertemporal spillover effects, and we note the appropriateness of such a framework to a market mechanism such as that existing on the WSE. Relying on ideas proposed by Benassy (1982) and Dreze (1975), we propose a more explicit model of traders' behaviour on a market experiencing quantity constraints from which we are able to make inferences about asset predictability in such a market. Secondly, we propose a model of a disequilibrium trading system such as that existing on the WSE and analyse the predictability on the hypothetical market.

In chapter 5, we firstly undertake a time series analysis of return series on the WSE paying particular attention to the limits censoring the movement of returns. In the second section, we propose an approach to model the predictability of returns for stock markets with disequilibrium trading. We present empirical test statistics based on the corrected Student- t statistic of a regression of returns of some information concerning the previous truncation. Finally, we apply the proposed predictability tests to six main time series of returns on the Warsaw Stock Exchange.

Finally, chapter 6 investigates the whether the finding for developed stock markets that negative shocks entering the market lead to a larger return volatility than positive shocks of a similar magnitude also applies to two emerging Eastern European markets. The Warsaw Stock Exchange and the Budapest Stock Exchange are considered where the first point of investigation is whether an analogous asymmetric characteristic is reflected in emerging markets. The second point of investigation is whether the findings differ depending on the institutional microstructure of the exchange being examined given that the Warsaw Stock Exchange operates a quantity constrained system. Hence, econometric techniques are modified accordingly and a 'Double-Censored Tobit GARCH' model is developed.

7.2 Main Results and Conclusions

In chapter 1, the overview of the emergence of market-based systems to replace the command-based systems in Eastern European economies highlighted the constantly and rapidly changing environment that the WSE was operating in. The previous complete breakdown of the political and economic structures of these economies has led to the emergence of a financial sector, the infrastructure of which has had to be established virtually from scratch. Hence, the importance of the WSE was noted, where, not only was it essential to the privatisation process, but it proved particularly important amongst households facing a lack of attractive alternative investment opportunities and for firms as an alternative source of finance in an economy with an under-developed banking system. As such, the majority of investment in the WSE up until 1995 was been from the domestic economy, and has shown extremely rapid growth its early years of establishment.

On reviewing the literature on emerging markets, we find that most of the studies have been carried out on stock markets established in the 1970s-early 80s, and only a few studies on Eastern European markets. Nevertheless, the lessons from the research findings are

valuable and are generally characteristic of Eastern European emerging markets. In summary, the empirical evidence has found that emerging markets were not well integrated with the world financial markets until the early 1980s and increasingly they are becoming more integrated. Despite the increasing integration (and hence more comparable costs of capital with the world markets), the general policy conclusion has been towards continuing to lower the barriers to foreign equity flows. The most important barriers have been found to be instability, underdeveloped stock markets and a *de facto* lack of openness, and policies towards providing investor protection, a solid regulatory and accounting framework, fewer restrictions on foreign ownership are at the least the first step in helping to remove the barriers. Stock returns are found to exhibit higher than average sample returns and in the short run have been found to be more predictable in emerging markets relative to industrial market although only weak evidence of return reversals has been found over the longer horizon. Predictability *per se* with ex-ante observable variables as an indication of integration has however found to be not altogether useful. Finally, the conventional views that equity and portfolio flows into emerging markets are inherently unstable or cause destabilising effects through the volatility of stock returns have so far been unfounded.

In chapter 3, we find that the traditional ‘economics of equilibrium’ forming the standard theory of prices, demand and transactions needs to be abandoned essentially because of the strong underlying assumption of market equilibrium no longer holds. Applying the disequilibrium framework introduced by Benassy (1982) to market under consideration, we find that notional demands existing in equilibrium theory are no longer relevant and instead, that effective demands and supplies which are functions of price *and* quantity signals are those which are expressed on markets in disequilibrium. The concept of a perceived rationing scheme was introduced which relates expected demand and supply to the transaction and we were therefore able to compare effective demand and supply to the demand and supply resulting if the market had cleared. We find that according to the Benassy (1982) framework in a multi-market setting, an investor’s effective demand (supply) is determined by maximising his utility function subject to the budget constraint and the perceived constraints on *other* markets. These perceived constraints are assumed to have the properties that (i) if an agent is on the long side of the market, his realised transaction is his perceived constraint; (ii) if the agent can fulfil his demand, because he is on the short side, for instance, then he may subjectively perceive more possibility for trade in the same direction; and (iii) the perceived constraints being a function of all other demands are assumed to be continuous. However, once the analysis incorporates cross and intertemporal spillover effects such as those would

exist on the WSE, we note the drawbacks of such a framework on application to the WSE. In particular, if the agent is specialised in one good, the question of agent i 's perceived transaction constraint involves observing the demands expressed by all the other agents. However, quite clearly, the problem is how the perceived constraints are generated (even though there is the unrealistic assumption that agents have the ability to perceive them correctly), since they drive the system to the new states. Moreover, since the agent ignores that perceived constraint for his particular good, but accommodates all the other perceived constraints on the other markets *as well* as the budget constraint, there may be a situation where the chosen effective demand may violate the perceived constraint. If this occurs, the trader is communicating to the market that he wants to buy (sell) more than he will perceive that he will be able to buy (sell). Therefore, after finding himself successfully overcoming all the perceived constraints, he may not be able to meet all his commitments.

Nevertheless, in an explicit model of an investor's effective demand for a single asset facing a binding quantity constraint in an intertemporal framework, we show that effective demand for the asset in time period one (expressed at time zero) is a function of the quantity constrained asset in time zero and of the part of demand expected not to be satisfied in period zero. Incorporating such spillover effects, being cross or intertemporal, we also conclude that in the case of a full cross-spillover effect, effective demand equals notional demand and the martingale hypothesis in prices can be maintained *despite* the presence of a binding transactional constraint on the market.

Furthermore, using a simulation model of a disequilibrium trading system such as that existing on the WSE, we show that, for a single asset, the imposition of upper and lower price limits again may not necessarily be a source for market predictability. In particular, if there is some kind of funds withdrawal process due to a quantity spillover in relation to other stocks or to non-market assets, the market might *not* be predictable.

In chapter 4, we find that on investigating six main time series from the WSE, the data series exhibit similar characteristics over the earlier years of the exchange, from April 1991 to May 1995. On average, the frequency of hits was approximately 25%, and this was found to be declining over time. A simulation analysis assuming no spillover effects suggests that a random series experiencing approximately the same empirical frequency of hits significantly contributes to the observed autocorrelation in returns *in addition* to the return series being informationally inefficient. Given the different number of weekly trading days over the sample period, an analysis of calendar effects reveals that the whole sample period can be treated homogeneously. Finally, a non-stationarity analysis using simulated modified critical

values, necessary because of the significantly different distribution of returns on the WSE, caused by the limits imposed on returns, compared to the normal distribution, shows that all the return series can be treated as stationary.

Even though emerging market stock returns are expected to be predictable, we propose an approach to modelling the predictability of returns for stock markets with disequilibrium trading which might be of some practical importance. We show that, contrary to the widespread opinion among the practitioners, the question of return predictability on such constrained markets is non-trivial and that the predictability should be tested. Although computer-intensive, it is possible to evaluate probabilities of reaching a disequilibrium state under the null hypothesis of non-predictability and then using these probabilities to correct the computed t -statistics in order to improve on the power of the tests. The empirical results provide evidence of the predictability of the returns of six main series on the WSE.

In chapter 5, although emerging markets are expected to be volatile in their early years as previously noted, we proposed an approach to model the conditional volatility of returns on a market imposing limits on the return generating process. We show that the common finding regarding the asymmetric impact of news on the volatility of returns on developed markets does not apply to the WSE or the BSE. This finding is therefore robust given the differences in the micro-institutional structures of both exchanges and given the frequency of hits of the limits by the return series on the WSE. One plausible explanation for these results is that the investors on the emerging markets have a comparatively lower level of understanding of its operation, relative to the investors of developed markets. Hence, the result is characteristic of inexperienced investors on emerging markets in the early years. Among the other evidence mentioned, this finding is backed up by a CBOS survey conducted on small investors (Gazeta Wyboreza, 4 February, 1994) which also provides evidence that a clear majority of investors lacked the required knowledge to explain the market forces underlying an abnormally high stock price.

A second possible reason for the finding is that the dissemination of information to investors is slow and therefore when investors finally receive the information, either some consider it too late to respond, or investors do respond, but with a time lag - and this is not detected by the analysis. Although there are daily newspaper publications in Poland, again, significant information was still omitted during the time horizon considered. Therefore, once again, quality of information provides a barrier to investment.

Finally, an alternative or rather a complimentary theory is based on the experiences faced by Eastern European countries on their transition between command economies to the

therefore this, in itself, is a reason for promoting much needed research in the area of emerging stock markets.

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