MASTER’S THESIS

MODELS AND STATISTICS OF INVENTORY INVESTMENTS CONSIDERING FINANCIAL CONSTRAINTS - SOUTHEAST EUROPE CROSS-COUNTRY EVIDENCE

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Author’s STATEMENT

I, Sanda Poljaković, hereby certify to be the author of this Master’s thesis that was written under the mentorship of Prof. Marija Bogataj and in compliance with the Act of Authors’ and Related Rights – Para. 1, Article 21. I herewith agree this thesis to be published on the website pages of the Faculty of Economics.

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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1. Research Problem</td>
<td>1</td>
</tr>
<tr>
<td>1.2. Research Purpose</td>
<td>2</td>
</tr>
<tr>
<td>1.3. Research Methodology</td>
<td>2</td>
</tr>
<tr>
<td>1.4. Research Structure</td>
<td>3</td>
</tr>
<tr>
<td>2. THE ROLE OF INVENTORIES IN THE CONTEXT OF LOGISTICS</td>
<td>4</td>
</tr>
<tr>
<td>2.1. Introducing Logistics and Supply Chain Management</td>
<td>4</td>
</tr>
<tr>
<td>2.1.1. Defining Logistics</td>
<td>5</td>
</tr>
<tr>
<td>2.1.2. The Concept of Integrated Logistics and Supply Chain Management</td>
<td>6</td>
</tr>
<tr>
<td>2.2. Logistics Activities</td>
<td>11</td>
</tr>
<tr>
<td>2.3. Logistics Costs</td>
<td>13</td>
</tr>
<tr>
<td>2.4. Defining Inventories</td>
<td>17</td>
</tr>
<tr>
<td>2.4.1. Types of Inventories</td>
<td>18</td>
</tr>
<tr>
<td>2.4.2. Reasons for Holding Inventories</td>
<td>19</td>
</tr>
<tr>
<td>2.4.3. Inventory Costs</td>
<td>23</td>
</tr>
<tr>
<td>2.4.3.1. Purchasing/Production Costs</td>
<td>23</td>
</tr>
<tr>
<td>2.4.3.2. Ordering/Setup Costs</td>
<td>24</td>
</tr>
<tr>
<td>2.4.3.3. Holding (Carrying)/Shortage Costs</td>
<td>25</td>
</tr>
<tr>
<td>2.5. Accounting for Inventories</td>
<td>27</td>
</tr>
<tr>
<td>2.6. Inventory Optimization Models for Optimal Inventory Control</td>
<td>31</td>
</tr>
<tr>
<td>2.6.1. Net Present Value Approach versus Cost Approach for Optimal</td>
<td>41</td>
</tr>
<tr>
<td>Inventory Policy Determination</td>
<td></td>
</tr>
<tr>
<td>3. THE ROLE OF INVENTORIES IN THE CONTEXT OF MACROECONOMICS</td>
<td>46</td>
</tr>
<tr>
<td>3.1. Introducing the Theoretical Framework of the Macroeconomic</td>
<td>46</td>
</tr>
<tr>
<td>Importance of Inventories</td>
<td></td>
</tr>
<tr>
<td>3.2. Types of Business Investments from Macroeconomic Perspective</td>
<td>47</td>
</tr>
<tr>
<td>3.2.1. Business Fixed Investment</td>
<td>47</td>
</tr>
<tr>
<td>3.2.2. Inventory Investment</td>
<td>49</td>
</tr>
<tr>
<td>3.3. The Relationship between Inventory Investments and Business</td>
<td>50</td>
</tr>
<tr>
<td>Fluctuations</td>
<td></td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 2-1: The integrated logistics framework  
Figure 2-2: Supply chain framework  
Figure 2-3: Optimal lot size  
Figure 2-4: Inventory with infinite replenishment rate and no shortages – EOQ model  
Figure 2-5: Discrete and continuous cash flows in EOQ  
Figure 2-6: Inventory with finite replenishment rate and no shortages – EPL model  
Figure 2-7: Discrete and continuous cash flows in EPL  
Figure 2-8: Comparison of AC and NPV approach  
Figure 4-1: Cyclical and trend component of GDP in Bulgaria, 1970-2004  
Figure 4-2: A simple inventory investment model, Albania, 1970-2004  
Figure 4-3: A simple inventory investment model, Romania, 1970-2004  
Figure 4-4: Inventory accelerator model for the SEE countries, 1970-2004  
Figure 6-1: The effect of cash flow and asymmetric information on investment in Povel and Raith’s model

LIST OF TABLES

Table 4-1: List of SEE countries included in the analysis with observation periods  
Table 4-2: Real output growth rates, cyclical real output growth rates and their relative volatility over the business cycle in the SEE and selected EU countries, 1970-2004  
Table 4-3: Periods and rates of real GDP contractions in the SEE countries, 1970-2004 (HP-filtered)  
Table 4-4: Total investments as a share of GDP in the SEE countries 1970-2004  
Table 4-5: Inventory investment as a share of GDP in the SEE and selected EU countries, 1970-2004
Table 4-6: Decline of inventory investment as a percentage of the decline in output during recessions, 1970-2004

Table 4-7: Simple inventory investment models for the SEE countries in two sub-periods, mil 1990 USD, 1970-2004

Table 4-8: Relationship between inventory investment and the change in GDP – $\beta$ parameters, SEE, 1970-2004

Table A-1: Summary statistics for the sample of SEE manufacturing firms split by size, age, and trade credit usage, 1999-2004, mil 1990 USD

Table A-2: Summary statistics for the sample of SEE manufacturing firms split by finance constraint characteristics, 1999-2004, mil 1990 USD

Table A-3: Summary statistics for the sample of SEE manufacturing firms split by country of origin, 1999-2004, mil 1990 USD

Table A-4: Summary statistics for the sample of SEE manufacturing firms split by industry sector, 1999-2004, mil 1990 USD

Table A-5: Regression results for the full sample of firms using all cash flow versus non-negative and negative cash flow observations

Table A-6: Regression results with sample split by size using all cash flow versus non-negative and negative cash flow observations

Table A-7: Regression results with sample split by age using all cash flow versus non-negative and negative cash flow observations

Table A-8: Regression results with sample split by trade credit usage using all cash flow versus non-negative and negative cash flow observations

Table A-9: List of the most relevant crises in the SEE, 1970-2004

LIST OF ABBREVIATIONS

AC: Average Cost
AS: Annuity Stream
EOQ: Economic Order Quantity
EPL: Economic Production Lot
JIT: Just In Time
LIFO: Last In - First Out
NPV: Net Present Value
PO: Purchase Order
R&D: Research and Development
S&R: Service and Repair
SCM: Supply Chain Management
SEE: Southeast Europe
SKU: Stock-Keeping Unit
UNNAMAD: United Nation’s National Accounts Main Aggregates Database
WACC: Weighted Average Cost of Capital
WIP: Work In Process
1. INTRODUCTION

1.1. RESEARCH PROBLEM

In the previous five decades, there has been a dramatic revival of research on the close relationship between inventory investment and economic downturns. The argument that inventory investment is important for the business cycle is based on the close relationship between changes in inventory investments and GDP during recessions (Hornstein, 1998). Yet, financing constraints firms face when making investment decisions, as a starting point of inventory disinvestment, came to the interest in the last decade.

There is a number of research papers devoted to the issue of the influence finance constraints play on inventory investment like Blinder and Maccini (1991), Lovell (1994), Gertler and Gilchrist (1994), Kashyap et al. (1994), Carpenter et al. (1994), Guariglia and Mateut (2006) and a number of others, each of them employing different financial variables and econometric approaches and emphasizing a different channel through which financing constraints operate. Lovell (1994) points to the potential influence of financing constraints on inventory investment as a major unanswered question. However, none of these or related researches concern this issue in Southeast Europe (SEE), although this region is well known of oft downturns and poor macroeconomic performance. According to the analysis done, that is presented in brief in the subsequent sections, in the twenty-four year period (1970-2004), there were 18 recessions addressed to SEE, making them a very frequent event that happens every three to five years. Table (A1-9) in Appendix shows the main reasons for the crisis that happened in the region in the past. Another important characteristic that dominates this region is the underdeveloped financial market and financial instability in all of the seven SEE countries, which in a combination with high illiquidity presents a strong limitation for the development of the business sector.¹ The majority of firms is constrained due to these and is required to rely on internal finance sources as well as trade credits under unfeasible conditions in order to finance their working capital.

These stylized facts were assumptions to start from in order to show what the inventory investment behavior in the SEE is on a macroeconomic level, and what is the sensitivity of inventory investment on a firm-level due to finance constraints firms’ in SEE face. Some results are later in the work compared with the indicators in EU countries to show whether there are significant differences in inventory investment behavior pattern between the two as regards to their level of economic development.

¹ Albania, Bosnia and Herzegovina, Bulgaria, Croatia, FYR Macedonia, Romania, Serbia and Montenegro
1.2. RESEARCH PURPOSE

Capital requirement of a firm depends on its available internal funds. A firm is financially constrained if it requires outside capital but faces imperfections in the capital market. Thus, a firm’s financial constraint depends on both the extent of capital market imperfections and the firm’s level of internal funds (Povel and Raith, 2002). The cost of raising any given amount depends on the extent of capital market imperfections that results from a state of the overall economy, the financial market development, or from asymmetric information between a firm and its investors. According to Povel and Raith (2002), with more asymmetric information investment tends to decrease, and becomes more sensitive to changes in internal funds.

While modern literature on inventories often excludes financial effects and rather talks about capacity constraints either in physical or financial sense, the connection between internal finance and inventory investment “may help resolve an empirical puzzle about inventory behavior” (Carpenter et al., 1994). The connection between these two issues is even more significant since inventory disinvestment can account for much of the movement in output during recessions and corporate profits, and therefore internal finance flows, are also extremely procyclical ad tend to lead the cycle.

This research tends to link these two stylized facts by examining whether fluctuations of internal finance are an important cause of changes in inventories, and what the inventory investments’ sensitivity towards internal finance is with regard to different categories of finance constraint in the SEE. Hence, a link between macroeconomic and microeconomic point of view is made to get a clear picture of general inventory investments performance in the SEE countries.

This research is the first to cover the topic of inventory investments behavior in SEE, and first to include both macroeconomic and firm-level analysis on this topic.

1.3. RESEARCH METHODOLOGY

In order to reach the ultimate purpose of the work and show the behavior of inventory investments in SEE, constraints that bias the decisions firms make regarding inventory investment, and account for unique macroeconomic characteristics of the SEE region which influence the direction of these decisions, different methods have been used during the work.

In the introduction, a review of the relevant literature and theoretical findings is presented in the field of logistics and SCM, in order to determine a broader view of inventory investments, as well as a loser scope concerning related macroeconomic and financial characteristics of inventory investments, econometrical and statistical procedures. Nevertheless, some important
mathematical models describing the impact of constraints on objective function, which is to minimize the costs or to maximize the net present value (NPV) of value chains, have been studied. These results, which participate to macroeconomic indicators, especially to GDP, can be understood as a feedback of inventory and other investment policies.

The next method used is the evaluation of the macroeconomic performance of the SEE region in the context of inventory investment behavior between 1970 and 2004 using statistical procedures with the help of the SPSS v13.0 software and the United Nation’s National Accounts Main Aggregates Database (UNNAMAD), as a source of secondary data used in the analysis. The macroeconomic, empirical analysis is done primarily to get a complete picture of the field of research in order to make more conclusions that are competent and secondly to follow the suggestions in related literature which opines inventory investments as a topic that requires a strong connection between macroeconomics and firm-level economics.

The third method used is an econometrical model specification in order to show the relationship between inventory investments in SEE and finance constraints firms face when making these decisions. Arellano-Bond Generalized Method of Moments regression procedure is used for the purpose of model estimation. The source of secondary data was the AMADEUS database. Financial statements were collected for 106 SEE manufacturing firms from six different industries. For the purpose of the analysis, STATA v9.1 software was used with “xtabond” syntax command to conduct the regression procedure.

Based on the analysis of the theoretical and empirical findings a synthesis of results is drawn up in the conclusion, which gives a complete picture of inventory investments in SEE. At the end, a comparative analysis between the SEE countries and of selected EU countries is given.

1.4. RESEARCH STRUCTURE

Following the introduction of the problem, purpose, goals, and methods used in the work (Chapter 1), the chapters are organized in the following order.

Chapter (2) summarizes the role of inventories in the context of logistics. In the first part of the chapter, basic terms and concepts are defined such as the logistics, integrated logistics, SCM, logistics costs and activities in order to get an insight in the significance of logistics, and make boundaries and position inventories in logistics systems. In the second part of the chapter, inventories are defined and discussed as an object of logistics more in close. Topics discussed include the types of inventories, purpose of inventories, costs related to inventories and its financial and accounting considerations. The last part of Chapter (2) describes some important mathematical models, describing inventory management policies where the objective functions are minimal costs.
or maximal net present value of activities in the value chain. These models can include different kinds of constraints, as regard to the investment policies.

Chapter (3) discusses the role of inventories in the context of macroeconomics. A theoretical framework of the macroeconomic importance of inventories is made defining the inventory investment as one of the two types of business investment, showing the relationship between business fluctuations and inventory investments, accounting for few most important inventory investment models, and introducing inventory investment constraints.

Chapter (4) follows the framework from the previous chapter and presents the results from the macroeconomic analysis of the SEE region in the period 1970-2004. This empirical research focuses on the macroeconomic performance of the region with regard to inventory investments in relationship to GDP, business fluctuations and other GDP components. A comparison between SEE and selected EU countries is given. Empirical tests of few inventory investment models are also given.

Chapter (5) gives a theoretical framework of inventory investment and finance constraints that bias these investment decisions. This chapter is intended to be the introduction for the Chapter (6) which is an empirical research of inventory investments and finance constraints in SEE. The first part of Chapter (6) is a brief description of recent empirical literature related to the model selected to be the direction for the analysis. Then, a model is specified that is to be estimated using sophisticated econometric procedure.

In the conclusion, a review and synthesis of results from Chapter (4) and Chapter (6) is given with some concluding remarks.

2. THE ROLE OF INVENTORIES IN THE CONTEXT OF LOGISTICS

2.1. INTRODUCING LOGISTICS AND SUPPLY CHAIN MANAGEMENT

All organizations move materials. Manufacturers build factories that collect raw materials from suppliers and deliver finished goods to customers; retail shops have regular deliveries from wholesalers; a television news service collects reports from around the world and delivers them to viewers; most of us live in towns and cities and eat food brought in from the country; when someone orders a book from a website, a courier delivers it to the door (Waters, 2003). Each organization acts as a customer, when it buys materials from it on suppliers, and as a supplier, when it delivers its products to its own customers. Most products move through a series of organizations as they travel between suppliers and customers. Through those movements, if they are rational, a value is added constantly to those products.
For example, a book starts its journey from a single seeding from which a gardener grows a young tree that is planted by a forester. When it is mature it is felled by a logger, chipped, put into special grounding machines where it is pulped. After it has been processed, a raw paper is made of it, which is rolled up into large rolls that can be cut into smaller rolls and sheets of paper. This rolls or sheets of paper are transported first to a packer and the wholesaler. A printer house buys this paper, engraves the text, and binds it into a book. Nevertheless, the book manufacturer needs also other materials in order to make a book such is the material for binding, print ink and others each of which has to make its own journey in order to get to the printing house assembly line. After they are made, these books are packed and moved to a wholesaler or distributors who sell them to bookstores, hypermarkets or other retailers that resell it to the final customer. Along these journeys, materials may move through raw materials suppliers, manufacturers, finishing operators, logistics centers, warehouses, third party operators, transport companies, importers/ exporters, wholesalers, retailers, and final customers and even beyond them in the case of recycling and other activities of reverse logistics. A whole range of other intermediaries and operations could be also included in these chains of good movements along their journey. This is a principle of the supply chain that consists of the series of activities and organizations that materials move through on their journey from initial suppliers to final customers (Waters, 2003) and reverse.

2.1.1. DEFINING LOGISTICS

In his doctoral dissertation, Pretorius (2002) tries to find the earliest examples of a massive logistics exercise and states “since the earliest times logistics has been associated with supplying masses of people with their needs”. He finds one associated with a military force in Exodus 16, where the Lord supplied Israel with quails and manna in the desert. Pretorius’s (2002) opinion is that even though it was not called logistics, it had to be a huge logistical exercise to set up camp, provide water, firewood for cooking and heating and to provide waste services for 603,550 men to be able to go forth to war in Israel, excluding the Levites. Thus, it seems to be one of the first written examples where logistics is associated with a military force. Further in his work, the author names some of the first examples where the role of logistics has been described with regard to its importance to the ultimate success of a military campaign such are Sun Tzu Wu in the Art of War (500 BC), Alexander the Great, the Romans, Napoleon and Hitler. Pretorius (2002) cites Gourdin (2001) that “both Napoleon and Hitler failed with their attempts to invade Russia because their supply lines were too long and could easily be disrupted, in their case partially at least by the harsh reality of the winter weather”.

There is a lack of a general view on what the ancient root of the term “logistics” is. From one view, logistics is derived from the Latin word “logisticus” meaning “of calculation” (Wassenhove, 2003). The second view suggests a different one and explains the term with the Greek world “logistikos” which means “expert in
calculation”, “to reason logically” (Rodrigues et al., 2005), and “skilled in calculating” (Wassenhove, 2003). Another possible etymological source for it is “logos”, another Greek word standing for “to comprehend by using ones mind”. There are some other words that might be the root for the word as well such are the Greek word “logizesthai” meaning “to deliberate”, “to conclude” or “to calculate” (Wassenhove, 2003) or French from 1879 “l’art logistique” meaning “art of quartering troops” [URL: http://www.etymonline.com]. Consequently, the word logistics is a polysemic one (Wassenhove, 2003). In the nineteenth century, the military referred to it as the art of combining all means of transport, supplying, and sheltering of troops. Today it refers to the set of operations required for goods to be made available on markets or to specific destinations. Lambert et al. (1998) state that logistics was first studied in the early 1900s with the distribution of farm products.

Most definitions of logistics seems to contradict one another, and when the meanings of definitions are analyzed, the confusion becomes even more. Even though a large number of definitions for logistics in some form or another exist, the concept of logistics is still a very confusing one.

The most widely accepted logistics definition is the one proposed by Canadian Association of Logistics Management that states that logistics is “the process of planning, implementing, and controlling the efficient, cost effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of meeting customer requirements”.

2.1.2. THE CONCEPT OF INTEGRATED LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Many authors along the time have developed different definitions about logistics, according to “fashionable topics or periodic problems” (Klen et al., 1998). According to the author, the object of logistics is nowadays seen as an integrated or embedded flow of material and information that has to be managed as one entity from the raw material to the final consumer, i.e. along the whole value-chain, also evoking the concept of SCM.

Integrated logistics focuses on overall performance instead of on the performance of individuals, considering that “the time is too short to allow the existence of multiple coordinating organizational levels and inventories” (Christopher, 1994).

Christopher (1994) states that, in the integrated logistics:

• The focus is on the overall performance rather than on the performance of individual components, with material and information flows being managed as one entity. Integration is an important concept in the new framework and the material and information flows are seen as an integrator of several dimensions as presented in Bogataj M. and Bogataj L. (2004): “On the compact presentation
of the lead times perturbations in distribution networks”. According to the authors, the final goal is to achieve the maximal net present value (NPV) of all activities in the supply chain.

- There is no time for having multiple coordinating organizational levels, inventories, slack on other types of waste as used for coordinating material flow in the classical framework. Instead, controlling the material and information flows is integrated in the supply chain structure.
- Managing the structural premises for the material flow is more important than only optimizing the material flow to match the structural premises, which means that important role is hidden in constraints given by structure. Therefore only joint optimization like described in Bogataj M. and Bogataj L. (1989, 1990, 1992, and 2004) is ought to be effective.
- Integration of processes, departments, functions, organizations, disciplines, systems, etc., is strongly necessary, which means that managing relations and partnerships are therefore fundamental. To optimize such systems, models that support the decisions have to be developed. In this case, good knowledge of algebra and systems theory is needed.

Integration has been one of the dominant themes in the development of logistics management. This development began around 40 years ago with the integration at a local level of transport and warehousing operations into physical distribution systems. Today, many businesses are endeavoring to integrate supply networks that traverse the globe, comprise several tiers of supplier and distributor, and use different transport modes and carriers. The process of integration has transformed the way that companies manage the movement, storage, and handling of their products. Traditionally, these activities were regarded as basic operations subservient to the needs of other functions. Their integration into a logistical system has greatly enhanced their status and given them a new strategic importance (McKinnon, 2001).

Klen et al. (1998) conceptualize the integrated logistics as illustrated on Figure (2-1) below. Logistics is seen as the competency that links an enterprise with its customers and suppliers. Information flows from the customer through the enterprise in form of sales activity, forecasts, and orders. The information is refined into specific manufacturing and purchasing plans. As products and materials are procured, a value-added inventory flow is initiated that ultimately results in ownership transfer of finished products to customers. Thus, the process is viewed in terms of two interrelated efforts: inventory flow and information flow. The last one identifies specific location within a logistical system that has requirements. Information also integrates the three operating areas. The primary objective of developing and specifying requirements is to plan and execute integrated logistical operations. Without accurate information, the effort involved in the logistical system can be wasted (Klen et al., 1998).
Viewing internal operations in isolation is useful to elaborate the fundamental importance of integrating all functions and work involved in logistics. While such integration is fundamental to success, it is not sufficient to guarantee that an enterprise will achieve its performance goals. To be fully effective in today's competitive environment, enterprises must expand their integrated behavior to incorporate customers and suppliers. This extension, through external integration, is referred to as SCM and will be explained in the next. It is recognized that for the real benefits of the logistics concept to be realized, there is a need to extend the logic of the logistics upstream to suppliers and downstream to final customers. This is the concept of Supply Chain Management (SCM) (Klen et al., 1998).

The scope of SCM covers the control and management of material and information flow through a supply chain, from supplier through manufacturing and distribution chains to the end-user. This concept suggests a holistic approach to material and information flow management. Partnership and trust aspects are introduced as important elements in this kind of supplier relations. SCM aims at maximizing NPV through enhanced competitiveness in the final market, what is achieved by a lower cost to serve it in the shortest time possible. If the supply chain as a whole is efficiently coordinated, i.e. minimizing total channel inventory, eliminating bottlenecks, compressing time frames and abolishing quality problems, that goals will be attained (Klen et al., 1998).

The term SCM has risen to prominence in the past ten years (Cooper et al., 1997). Supply chain management extends the concept of functional integration (i.e., the integration of traditional business functions, departments, and processes) beyond a firm to all the firms in the supply chain (Cooper and Ellram, 1993; Ellram and Cooper, 1990) and, thus, individual members of a supply chain help each other improve the competitiveness of the supply chain, which should improve competitiveness for all supply chain members (Bowersox and Closs, 1996; Cavinato, 1992; Cooper and Ellram, 1993; Lee and Billington, 1992; in Min and Mentzer, 2004). Christopher (1994) proposed that the real competition is not company against company, but rather supply chain against
supply chain. As stated and cited by Min and Mentzer (2004), different authors regard a supply chain as a set of firms involved in the upstream and downstream flows of products, services, information, and/or finances. As an example, Mentzer et al. (2001) described a supply chain as being "a set of three or more organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer." Thus, the nature of a supply chain is comprehensive so that membership is not limited to a supplier, a manufacturer, and a distributor, but opens to any firm that performs various flow-related services (Mentzer et al. 2001).

Examples of different SCM conceptualizations include (Min and Mentzer, 2004):

1. Nothing more than a different name for integrated logistics (Tyndall et al., 1998);
2. A management process (La Londe, 1997);
3. A form of vertical integration of firms (Cooper and Ellram, 1993);
4. A management philosophy (Ellram and Cooper, 1990);

Figure (2-2) illustrates an overall supply chain focusing on the integrated management of all logistical operations from original supplier procurement to final customer acceptance.

Figure 2-2: Supply Chain Framework

![Supply Chain Framework Diagram](source)

Source: Bowersox and Closs, 1996; Klen et al., 1998

Successful integrated logistics management ties all logistics activities together in a system which simultaneously works to minimize total distribution costs and maintain desired customer service levels (Kenderdine and Larson, 1988; Daugherty et al., 1996) and includes "planning, allocating, and controlling the financial and human resources committed to manufacturing support and

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purchasing operations as well as physical distribution” (Bowersox et al., 1986; in Daugherty et al., 1996).

Supply chain management requires both internal functional integration and external integration. Internally, SCM involves working to achieve a seamless integration of logistics with other functional areas. The business philosophy also requires that trading partners and service companies “jointly plan, execute, and co-ordinate logistical performance” (Bowersox, 1991; Daugherty et al., 1996) as an external integration. Both types of integration are necessary in order to improve channel-wide performance (Daugherty et al., 1996).

As Kenderdine and Larson (1988) noted, “the present competitive environment requires integrated logistics management throughout the entire channel system”. It becomes imperative that all the trading partners of a particular channel be linked together in a manner that allows efficient distribution (Daugherty et al., 1996). According to Christopher (1994) logistics managers face “the challenge of integrating and coordinating the flow of materials from a multitude of suppliers, often offshore, and similarly managing the distribution of the finished product by way of multiple intermediaries” (Daugherty et al., 1996).

Integrated logistics has been credited with achieving cost reductions while increasing efficiency and productivity (Gustin et al., 1995; Lambert et al., 1978) as well as with “reductions in inventory, shorter lead times, customer service enhancements, and improved forecasting and scheduling” (Muller, 1991; in Daugherty et al., 1996). However, most of the evidence is anecdotal or company-specific. Relatively few empirical studies have been undertaken examining the relationship between integrated logistics and performance (Larson, 1994).

In the research conducted in 1996, by surveying 127 logistics executives, Daugherty et al. (1996) tried to find a relationship between integrated logistics implementation and logistics performance. Over 21 percent of the respondents said the concept has been recognized and adopted, but not successfully implemented. Thus, nearly 50 percent of the respondent firms can be considered non-integrated. In more than 42 percent of respondents, the integration was in progress in that time. Only 9 percent of all respondents of that time had successfully adopted and implemented integrated logistics.

Significant improvements in the form of cost reductions and service improvements are generally believed to be associated with integration (Lambert et al., 1978).

Integrated logistics has generally been considered an evolving concept (Daugherty et al., 1996). Although a number of researchers have examined the issues over the years3, no longitudinal studies were identified which would allow

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3 Gustin et al., 1995; Gustin, 1984; Burbridge, 1988; Williamson et al., 1990;
for direct comparison and assessment of growing (or declining) acceptance and trend patterns (Daugherty et al., 1996). However, based on the current research and the authors’ discussions with logistics executives, it appears that top management in most companies has recognized the need to increase internal and external integration to remain competitive.

However, the degree of success in achieving a satisfactory level of integration has been less than expected for many firms (Daugherty et al., 1996). Previous research has indicated that confusion may exist regarding interpretation of the “integrated concept” (Daugherty et al., 1996). Integrated logistics may be associated with organizational structure, with information systems, some combination of the two, or be perceived as a more comprehensive business philosophy (Gustin, 1984).

Daugherty et al (1996) showed that logistics executives at integrated firms compared to non-integrated firms (on a seven-point scale with 1=not at all successful and 7=extremely successful) reported significantly better performance with respect to improved customer service (5.72/5.08), productivity improvements (5.55/4.61), reduced costs (5.52/4.57), improved strategic focus (5.52/4.45), cycle time reductions (5.38/4.37), and quality improvements (5.33/4.94) thus showing that integrated logistics can provide the support needed to facilitate enhanced performance with integrated firms reporting significantly greater success in improving performance in all of the areas examined. Integrated firms showed also a “better competitive position” (5.56) compared to non-integrated firms (4.98). Thus, Daugherty et al. (1996) found a strong support for the linkage between implementation of integrated logistics and logistical performance.

2.2. LOGISTICS ACTIVITIES

Logistics is the function that is responsible for the movement of goods and materials on their journey between the suppliers and customers. Waters (2003) proposes the following activities that are by his opinion normally included in logistics:

1. Procurement and purchasing – finding suitable suppliers, negotiating the terms and conditions, sending a purchase order, organizing delivery, arranging insurance and payments, and other activities which will get the desired materials on time into the organization;

2. Inward transport or traffic – moving materials from suppliers to the organization’s receiving area by selecting a transport mode, finding the best transport operator, designing a route, making sure that all safety and legal requirements are met, getting deliveries on time, rationalizing the costs, and other;

3. Receiving – checking the delivered materials against the order, acknowledging receipts, unloading delivery vehicles, inspecting materials
for damage, sorting, informing the subjects in the chain about the status of inventories and other;
4. Warehousing and stores – moving the materials into the storage, taking care of them until they are needed as quickly as needed at the right condition, treatment, packaging, and other;
5. Stock control – setting the inventory policies about what to store, how much to invest, customer service, service levels, order sizes, order timing, and other;
6. Order picking – locating, identifying, checking, and removing materials from racks, consolidating them into a single load, wrapping and moving them to a departure area for loading onto delivery vehicles;
7. Materials handling – moving materials from one operation within the organization to next by making these journeys shorter (effective) and efficient as possible, using appropriate equipment, with little damage, and using special packaging and handling when needed;
8. Outward transport – taking materials from the departure area and delivering them to customers;
9. Physical distribution management – delivering finished goods to customers, including outward transport;
10. Recycling, returns, and waste disposal – collecting and bringing back the damaged, problematic, faulty, wrong, or excess products back to the factory. These products are brought back for the purpose of recycling, reusing, or safe disposal. These activities are also called reverse logistics or reverse distribution;
11. Location – finding the appropriate location for all the operations concerning the infrastructure, size of the factory, number of facilities, and other capacity and location problems;
12. Communication – linking all the parts of the supply chain, passing information about products, demand, materials to be moved, timing, stock levels, availability, costs, problems, service levels, and other;

Depending on the circumstances, an author’s point of view or categorization criteria, many other activities can be included under the term logistics. Such activities might be sales forecasting, production scheduling, customer service management, overseas liaison, third party operations, and so on. According to Waters (2003) the important point is not to draw arbitrary boundaries between functions, but to recognize that they must all work together to get an efficient flow of materials.

Logistics is present in every organization in a great number of different forms. The activities can be arranged in many ways within an organization, and there is no single best arrangement. In small organizations, one person might be enough to look after everything. On other hand, a larger organization might have a whole logistics division with thousands of people.
When devising a logistics strategy, managers aim at achieving a suitable compromise between three main objectives (Ghiani et al., 2004):

**Capital reduction.** The first objective is to reduce as much as possible the level of investment in the logistics system (which depends on owned equipment and inventories). This can be accomplished in a number of ways, for example, by choosing public warehouses instead of privately owned warehouses, and by using common carriers instead of privately owned vehicles. Of course, capital reduction usually comes at the expense of higher operating costs.

**Cost reduction.** The second objective is to minimize the total cost associated with transportation and storage. For example, one can operate privately owned warehouses and vehicles (if sales volume is large enough).

**Service level improvement.** The level of logistics service greatly influences customer satisfaction, which in turn has a major impact on revenues. Thus, improving the logistics service level may increase revenues, especially in markets with homogeneous low-price products where competition is not based on product features. The level of logistics service is often expressed through the order-cycle time, defined as the elapsed time between the instant a purchase order (or a service request) is issued and the time goods are received by the customer (or service is provided to the user).

### 2.3. LOGISTICS COSTS

Logistics is essential for every organization and its vital importance. Waters (2003, p.19) explains this in the simplest way by the following statement – “Without logistics, no materials move, no operations can be done, no products are delivered, and no customers are served”. As every coin has two sides, logistics is also expensive. The year 2004 saw logistics costs for the US reach $1.015 trillion dollars. On average 15 percent of all US products’ sales price is accounted for by logistics (Voss, 1994).

These two attributes often go hand in hand. However, according to Mentzer et al. (2004), the logistics contribution to firm competitive advantage is significant in both efficiency (cost leadership) and effectiveness (customer service). Since there are some general disagreements on what activities to include under logistics from systematic point of view, its costs are very difficult to separate from other operating costs, thus it is difficult to put a figure to these as there is also a good deal of uncertainty in this area. As a result, very few organizations can put a precise figure on their logistics expenditure, and many have almost no idea of the costs (Waters, 2003). As it is both essential and expensive, it affects just about every measure of performance such as customer satisfaction, the perceived value of the product, operating costs, profit and others. To evaluate the risk and lead time uncertainties net present value approach is more appropriate than cost approach (see Bogataj M. and Bogataj L., 2004).
Heskett et al. (1973) presented the first published research for logistical cost estimation. The authors developed a methodology for estimating total logistics cost and applied it to the US. Their methodology considers total logistics cost as the sum of four types of commercial activities: transportation, inventory, warehousing, and order processing (Rodrigues et al., 2005). According to Rodrigues et al. (2005), when estimating the overall annual logistics cost for 2004 in US, the Council of Supply Chain Management Professionals (CSCMP) used the same basic model but with smaller variations, using inventory carrying cost, transportation cost, and administrative cost (with warehousing costs being a part of inventory carrying costs). Rodrigues et al. (2005) argues that the challenge in measuring global logistics costs as contrasted to the US is the data unavailability or it is available to varying degrees but only in more developed countries. The first study to estimate global logistic expenditure was published by Bowersox (1992) (Rodrigues et al., 2005). Bowersox (1992) presented an estimation of global logistics costs based on four components: total GDP, government sector product, industrial sector product, and total trade ratio. In later studies the Artificial Neural Network Model (ANN) was introduced, and 27 variables were included in the estimation (Bowersox et al., 2004; in Rodrigues et al., 2005). In the conservative estimate, by using 2000 data for 24 countries which represent 75 percent of world GDP in 2002, Rodrigues et al. (2005) got the global requirement for logistics expenditures estimated as US$ 5.1 trillion in 1997, US$ 6.4 trillion in 2000, US$ 6.7 trillion in 2002. This represents a 32 percent increase from 1997, and a 5 percent increase from 2000. The 2002 estimate represents 13.8 percent of the world GDP.

A recent survey of “over 200” European companies found that logistics costs represent, on average, 7.7 percent of sales revenue (Management Consulting Firm A.T. Kearney Report, 2000; in McKinnon, 2001) and in some sectors, this proportion can be two or three times higher. According to McKinnon (2001, p. 164), “...by improving the productivity of logistics operations it is possible to cut this cost and translate some of the savings into lower prices” which could make whole supply chains become more competitive. Over the past 20 years, the largest saving in logistics costs has accrued from a reduction in inventory levels (relative to sales). This has been achieved by the move to just-in-time/quick response replenishment, the centralization of inventory, the application of new IT systems, and the development of SCM. There have also been substantial improvements in the efficiency of freight transport operations, resulting mainly from the upgrading of transport infrastructure, liberalization of freight markets, and improved vehicle design. Warehousing costs per unit have also declined in real terms because of scale economies, increased mechanization, and the diffusion of new computer-based warehouse management. The combined effect of these trends has been to reduce the proportion of revenue spent on logistics by European firms by an average of 46 percent between 1987 and 1999 (A.T.

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4 Bowersox and Calantone, 1998; Bowersox, Closs, and Stank, 1999

The supply chain costs represent 60 to 80 percent of a typical chemical manufacturer’s costs, so a 10 percent cost reduction can bring a 40 to 50 percent improvement in before tax profit. Supply chain management is becoming a leading strategic concern in the industry, with more than 90 percent of chemical companies planning initiatives. One of their primary goals is to develop closer trading partnership, which possibly will lead to a greater integration across the supply chain. The opinion of Kernel consultants is that “many supply chains will become so well integrated that they will function as organisms” (Management Consulting Firm A. T. Kearney Report, July 1997; in Cottrill, 1997, p. 36).

Logistics efficiency creates lean supply chain and therefore need less investments in inventories at the same service level. Rodrigues et al. (2005) have found out that although logistics efficiency has increased in developed countries, this is not true in the balance of the whole world. They give a possible explanation lying in globalization which “has created greater operational pressures in developed markets” and that decreases in logistics efficiency in developing nations are potentially due to the fact that their current logistics infrastructure is not adequate to support this higher average output growth rate in 1990s which was 2.4 percent in developed countries, and 4.1 percent in developing ones, according to UNCTAD (2004). Therefore, there is the open question: are the investments in inventory per GDP in SEE higher than in EU in average because of less efficient supply chains in this part of world?

High logistics costs are not easily handled by developing nations. Rodrigues et al. (2005) name also other possible explanation; such are the characteristics of products transported in each country and state that “transportation cost efficiencies are substantially affected by the value and density (combination of weight and value) of products moved” and while in developed nations, the majority of freight activity is related to products with high value and low density, in developing nations the majority is related to products with low value and high density. According to Rodrigues et al. (2005), “these results highlight the necessity for logistics infrastructure investment and efficiency improvements throughout developing nations”.

The ex-socialist countries of Southeast and Central Europe show substantial differences in logistics practice compared to developed European countries (Csikán, 1996). The most important differences follow from:

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\(^5\) McKinnon, 2001
• The starting position of the various countries (e.g. some countries had a substantial private sector, others not; some countries had a large foreign debt, while others not);
• Policies followed in the transition (most importantly, whether shock therapy or a gradualist approach was applied);
• History and culture. There are also some very important common elements;
• Structural and operational problems inherited from the previous regimes are in many respects similar;
• They have similar tasks in modernization, privatization, and restructuring;
• All are heavily affected by the collapse of eastern European integration;
• All wish to join the European Union in the shortest time possible.

The continued growth in global markets and foreign sourcing has placed increasing demands on the logistics function (Cooper and Ellram, 1993). Consequently, it has led to more complex supply chains and has involved more transportation and distribution managers in international logistics. Lack of specific knowledge of customs and infrastructure of destination countries forces firms to acquire the expertise of third-party logistics vendors.

The KPMG Peat Marwick’s third annual logistics benchmarking study shows that cost control, followed by information technology and inventory management are the major logistics concerns in respondent companies.

The evolution and the radical shift of inventory management during the last thirty years that has pioneered by Japanese “Just-in-Case” inventory philosophy (safety stocks), followed by the “Just-in-Time” philosophy (zero inventory), nowadays, according to Oliver (1999) has a great chance to evolve to a new concept of “Just-About-Zero” suggesting a new acronym - JAZ.

Inventory cuts are often achieved by using sophisticated software planning tools and aided by advanced logistics techniques such as “merge-in-transit”, where a logistics supplier merges parts from two or more suppliers, often to complete a product without warehousing such is in the case of Xerox company which cut its inventory holding period by 12 days while increasing customers served by 10 percent (Oliver, 1999). IBM for example uses FedEx not just for shipping replacement parts but for inventoring the parts as well (Oliver, 1999).

Oliver (1999) suggests an interesting view when defining inventory in a strategic sense as “the physical manifestation of the lack of information between demand and supply.” His opinion is that by improving the information flow – from point of purchase to the first-level raw material supplier – can be seen as the primary manner in which inventories can be pushed toward zero but this information has to be extremely detailed. However, uncertainties of demand and nonzero lead-time do not allow zero inventory level.
Chapter (2.6) presents in detail the inventory level optimization models in dynamic inventory systems describing some important mathematical models and inventory management policies where the objective functions are minimal costs or maximal NPV of activities in the value chain.

A supply chain is dynamic and involves the constant flow of information, product, and funds between different stages (Chopra and Meindl, 2004). Since supply chains are actually networks, the objective of every supply chain is to maximize the overall value generated. The value which supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer’s request.

Mostly, the value of the supply chain is correlated with supply chain profitability, the revenue generated from the customer and the overall cost across the supply chain. Supply chain profitability is the total profit to be shared across all supply chain stages. Supply chain success should be measured in terms of supply chain profitability and not in terms of the profits at individual stages (Chopra and Meindl, 2004). In such complex structure of costs and incomes of dynamic inventory systems NPV approach, for inventory systems control is the most appropriate one (see Chapter 2.6.1.).

In order to improve supply chain performance in terms of responsiveness and efficiency, a company has to examine the four drivers of supply chain performance (Chopra and Meindl, 2004). These drivers are facilities, inventory, transportation, and information. Facilities are the places in the supply chain network where product is stored, assembled, or fabricated. The two major types of facilities are production sites and storage sites. Inventory is all raw materials, work in process and finished goods within a supply chain. Inventory is an important supply chain driver because changing inventory policies can dramatically alter the supply chain’s efficiency and responsiveness. With a large inventory at location A, the likelihood is high that the retailer can immediately satisfy customer demand at location A. A large inventory however will increase retailer’s holding cost, thereby making supply chain less efficient when being more effective. Reducing inventory will make him more efficient but will hurt its responsiveness. Transportation entails moving inventory from point to point in the supply chain and can take the form of many combinations of modes and routes. Information consists of data and analysis concerning facilities, inventory, transportation, and customers throughout the supply chain.

2.4. DEFINING INVENTORIES

All organizations keep inventory. Inventories are stockpiles of items (raw materials, components, semi-finished and finished goods) waiting to be processed, transported or used at a point of the supply chain (Ghiani et al., 2004). Inventory exists in the supply chain because of the mismatch between supply and demand (at the same location). Every management mistake ends up
An important role that inventory plays in the supply chain is to increase the amount of demand that can be satisfied by having product ready and available when the customer wants it. Another significant role is to reduce cost by exploiting any economies of scale that may exist during both production and distribution. Inventory is a major source of cost in supply chain and it has a huge impact on responsiveness (Chopra and Meindl, 2004).

2.4.1. TYPES OF INVENTORIES

In general, there are three main types of inventories:

1. Raw materials: Used to produce partial products or completed goods. They are made up of goods that will be used in the production e.g., nuts, bolts, flour, sugar;

2. Work-in-process (WIP): Items are considered WIP during the time raw material is being converted into partial product, subassemblies, and finished product. WIP occurs from such things as work delays, long movement times between operations, and queuing bottlenecks. They consist of materials entered into the production process but not completed, e.g., subassemblies. While changing location (transportation) inventories are supposed to be work in process. WIP are further divided on available inventories and inventories in process, both having different impact on GDP and NPV;

3. Finished product: This is the product ready for current customer sales. It can also be used to buffer manufacturing from predictable or unpredictable market demand and seasonal changes. In other words, a manufacturing company can make up a supply of toys during the year for predictably higher sales during the holiday season.

Other categories of inventory should be considered rather from a functional standpoint (Muller, 2003):

- Consumables: Light bulbs, hand towels, computer and photocopying paper, brochures, tape, envelopes, cleaning materials, lubricants, fertilizer, paint, packing materials, and so on are used in many operations. These are often treated like raw materials.
- Service, repair, replacement, and spare items (S&R Items): These are after-market items used to “keep things going.” As long as a machine or device of some type is being used (in the market) and will need service and repair in the future, it will never be obsolete. S&R Items should not be treated like finished goods for purposes of forecasting the quantity level of your normal stock. Quantity levels of S&R Items will be based on considerations such as preventive maintenance schedules, predicted failure rates, and dates of various items of equipment.
- Buffer/Safety stock: This type of inventory can serve various purposes, such as compensating for demand and supply uncertainties, holding it to “decouple” and
separate different parts of your operation so that they can function independently from one another.

- **Anticipation Stock**: This is inventory produced in anticipation of an upcoming season such as fancy chocolates made up in advance of Mother’s Day or Valentine’s Day. Failure to sell in the anticipated period could be disastrous because you may be left with considerable amounts of stock past its perceived shelf life.

- **Transit Inventory**: This is inventory on route from one place to another. It could be argued that product moving within a facility is transit inventory. However, the common meaning of the concept concerns items moving within the distribution channel toward you and outside of your facility or en route from your facility to the customer. Transit stock highlights the need to understand not only how inventory physically moves through your system, but also how and when it shows up in your records. If, for example, 500 widgets appeared as part of existing stock while they were still en route to you, your record count would include them while your shelf count would be 500 widgets short. Generally, there is a mismatch between a paper life of a product and its real life (Muller, 2003). The relationship between an item’s real life and its paper life within the system, the item’s physical movement through the facility while noting what is happening to its paper life during that same time should be tracked.

The types of inventory depend on the specifics of the industry and business thus inventory found in distribution environments (mainly finished goods for resale) are fundamentally different from those found in manufacturing environments (raw materials and work in progress) (Muller, 2003). In the worlds of distribution, retailing, and replacement parts, an organization deals with finished goods (Muller, 2003). In the manufacturing world, an organization deals with raw materials and subassemblies. Considerations of what to buy, when to buy it, in what quantities, and so on are dramatically different in these two worlds. In distribution, you are concerned with having the right item, in the right quantity. Issues relating to having the item at the right time and place are often dealt with by simply increasing safety stock on-hand. That is not a good solution because it leads to wasted money and space. However, traditional formulae used in computing inventory requirements in a distribution environment focus on item and quantity rather than place and time. In manufacturing, you are concerned with having the right item, in the right quantity, at the right time, in the right place (Muller, 2003). For better presentation and control inventory systems has to be considered as distributed parameter systems where lead time and other time delays are clearly presented and locations are analyzed in components of state vectors.

### 2.4.2. REASONS FOR HOLDING INVENTORIES

The main purpose of stocks is to act as a buffer between supply and demand. They allow operations to continue smoothly and avoid disruptions. To be more specific, inventories (Waters, 2003):
• Act as a buffer between different stages of the supply chain;
• Allow for demands that are larger than expected, or at unexpected times;
• Allow for deliveries that are delayed or too small;
• Take advantage of price discounts on large orders;
• Allow the purchase of items when the price is low and expected to rise;
• Allow the purchase of items that are going out of production or are difficult to find;
• Allow for seasonal operations;
• Make full loads and reduce transport costs;
• Give cover for emergencies;
• Can be profitable when inflation is high.

Some of the most important reasons for obtaining and holding inventory are (Muller, 2003):
• Predictability: In order to engage in capacity planning and production scheduling, it has to be controlled how much raw material, parts, and subassemblies is processed at a given time. Inventory acts as buffers for what different processes need in particular periods.
• Fluctuations in demand: A supply of inventory on hand is a protection: it is impossible always to know how much of a particular good is needed at any given time, but customers or production demands still have to be satisfied on time. If it would be possible to see how customers are acting in the supply chain, surprises in fluctuations in demand would be held to a minimum.
• Unreliability of supply: Inventory protects from unreliable suppliers or when an item is scarce and it is difficult to ensure a steady supply. Whenever possible, unreliable suppliers should be rehabilitated through discussions or they should be replaced. Rehabilitation can be accomplished through master purchase orders with timed product releases, price or term penalties for nonperformance, better verbal and electronic communications between the parties, etc. This will result in a lowering of on-hand inventory needs.
• Price protection: Buying quantities of inventory at appropriate times helps avoid the impact of cost inflation. Note that contracting to assure a price does not require actually taking delivery at the time of purchase. Many suppliers prefer to deliver periodically rather than to ship an entire year’s supply of a particular stock keeping unit (SKU) at one time.
• Quantity discounts: Often bulk discounts are available if you buy in large rather than in small quantities.
• Lower ordering costs: If a larger quantity of an item is bought less frequently, the ordering costs are less than buying smaller quantities repeatedly. However, the costs of holding the item for a longer period will be greater. In order to hold down ordering costs and to lock in favorable pricing, many organizations issue blanket purchase orders coupled with periodic release and receiving dates of the SKUs called for.

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6 SKU generally stands for a specific identifying numeric or alpha-numeric identifier for a specific item
There are three basic decisions to make regarding the creation and holding of inventory (Hugos, 2003):

1. Cycle Inventory. This is the amount of inventory needed to satisfy demand for the product in the period between purchases of the product. Cycle inventory exists because producing or purchasing in large lots allows a stage of the supply chain to exploit economies of scale and lower costs. The presence of fixed costs associated with setup the production, ordering and transportation, quantity discounts in product pricing, and short-term discounts or trade promotions encourages different stages of a supply chain to exploit economies of scale by ordering in large lots. Cycle inventory is the average inventory in the supply chain due to either production or purchases in lot sizes that are larger than those demanded by the customer are. A supply chain where stages produce or purchase in larger lots will have more cycle inventory than a supply chain where stages purchase in smaller lots. The larger the cycle inventory, the longer the lag time between when a product is produced and when it is sold. A lower level of cycle inventory is always desirable because large time lags leave a firm vulnerable to demand changes in the marketplace. A lower cycle inventory is also desirable because it decreases the working capital requirement for a firm. Cycle inventory is primarily held to take advantage of economies of scale and reduce cost within the supply chain. Increasing the lot size or cycle inventory often decreases the cost incurred by different stages of a supply chain. When deciding about a lot size to be purchased, following costs must be considered: average price per unit purchased (material cost), fixed ordering costs per lot, and holding costs per unit per year. The average price paid per unit purchased is a key cost in lot sizing decision. The price paid per unit is referred to as the material cost. In most situations, increasing the lot size decreases the material cost. The fixed ordering cost includes all costs that do not vary with the size of the order but are incurred each time an order is placed. These costs include fixed administrative costs when placing an order, trucking costs, labor costs, etc. Given the fixed ordering costs per lot or batch, by increasing a lot size these costs can be reduced per unit purchased. Holding cost is the cost of carrying one unit in inventory for a specified period. It is a combination of the cost of capital, the cost of physically storing the inventory, and the cost that results from the product becoming obsolete. The total holding cost increases with an increase in lot size and cycle inventory. The primary role of cycle inventory is to allow different stages in the supply chain to purchase product in lot sizes that minimize the sum of material, ordering, and holding cost. Thus, in a case of deterministic demand, a trade-off that minimizes the total cost when making a lot size decision should be made. The optimal lot size is one that minimizes the total costs. The optimal lot size is referred to as the Economic Order Quantity (EOQ). Total ordering and holding costs are relatively stable around the EOQ. Aggregating across multiple products in a single order allows for a reduction in lot size for individual products thus reducing cyclical inventory because fixed ordering costs and transportation costs are spread across multiple products.
For commodity products where price is set by the market, manufacturers can use lot size based quantity discounts to achieve coordination in the supply chain and decrease supply chain costs. However, this lot size based discounts increase cycle inventory in the supply chain. Trade promotions lead to a significant increase in lot size and cycle inventory because of forward buying by the retailer. This generally results in reduced supply chain profits unless the trade promotion reduces demand fluctuations. In order to reduce lot size and the cycle inventory in the supply chain without increasing cost, fixed ordering costs and transportation costs incurred per order should be reduced (Chopra and Meindl, 2004).

2. Safety stock - Inventory that is held as a buffer against uncertainty. If demand forecasting could be done with perfect accuracy, then the only inventory that would be needed would be cycle inventory. Nevertheless, since every forecast has some degree of uncertainty in it, we cover that uncertainty to a greater or lesser degree by holding additional inventory in case demand is suddenly greater than anticipated. The trade-off here is to weight the costs of carrying extra inventory against the costs of losing sales or making backlogs due to insufficient inventory. On one hand, raising the level of safety inventory increases product availability and thus the margin captured from customer purchases. On the other hand raising the level of safety stocks increases holding costs. This issue is particularly important in industries where product life cycles are short and demand is very volatile. Given the product variety and high demand uncertainty in nowadays supply chains, a significant fraction of the inventory carried is safety inventory. As product variety has grown, product life cycles have shrunk, especially in the case of high-tech industries. Thus, it is more likely that a product that is attractive today will be obsolete tomorrow, which increases the cost to enterprises of carrying too much inventory. Thus, a key to the success of any supply chain is to figure out ways to decrease the level of safety inventory carried without hurting the level of product availability under the optimal level (Chopra and Meindl, 2004).

The appropriate level of safety stock is determined by the following two factors (Chopra and Meindl, 2004):
1. The uncertainty of both demand and supply,
2. The desired level of product availability.

As the uncertainty of supply and demand grows the required level of safety stock increases. As the desired level of product availability increases, the required level of safety inventory also increases.

3. Seasonal Inventory - this is inventory that is built up in anticipation of predictable increases in demand that occur at certain times of the year – anticipation of future demand. For example, it is predictable that demand for anti-freeze will increase in the winter. If a company that makes anti-freeze has a fixed production rate that is expensive to change, then it will try to manufacture
product at a steady rate all year long and build up inventory during periods of low demand to cover for periods of high demand that will exceed its production rate. The alternative to building up seasonal inventory is to invest in flexible manufacturing facilities that can quickly change their rate of production of different products to respond to increases in demand. In this case, the trade-off is between the cost of carrying seasonal inventory and the cost of having more flexible production capabilities (Hugos, 2003).

2.4.3. INVENTORY COSTS

Inventories are frequently found in such places as warehouses, yards, shop floors, transportation equipment, and on retail store shelves. Having inventories on hand can make significant costs. Even though many strides have been taken to reduce inventories through just-in-time, time compression, quick response, and collaborative practices applied throughout the supply chain, the annual investment in inventories in the US by manufacturers, retailers, and merchant wholesalers, whose sales represent about 99 percent of GDP, is about 12 percent of the US GDP (Waters, 2003).

Inventory brings with it a number of relevant costs. These costs can include (Waters, 2003):

1. Costs of goods;
2. Costs of space;
3. Costs of labor to receive, check quality, put away, retrieve, select, pack, ship, and account for;
4. Costs of deterioration, damage, and obsolescence;
5. Theft;

Good inventory management relies largely on cost-minimization strategies. The basic costs associated with inventory are (Barfield et al., 2003):

1. Purchasing/production costs;
2. Ordering/setup costs;
3. Holding (carrying)/shortage costs;

2.4.3.1. PURCHASING/PRODUCTION COSTS

Purchasing costs are those associated with the acquisition of goods. They typically include fixed costs (independent of the amount ordered) and variable costs (dependent of the amount acquired).

Purchasing/production costs may include (Ghiani et al., 2004):

- A (fixed) reorder cost (the cost of issuing and processing an order through the purchasing and accounting departments if the goods are bought, or the cost for setting up the production process if the goods are manufactured by the firm);
- A purchasing cost or a (variable) manufacturing cost, depending on whether the goods are bought from a supplier or manufactured by the firm;
• A transportation cost, if not included in the price of the purchased goods; for the sake of simplicity, we assume in the remainder of this chapter that fixed transportation costs are included in the reorder cost, while variable transportation costs are included in the purchasing cost;
• The cost of handling the goods at the receiving point;

The purchasing cost for inventory is the quoted purchase price minus any discounts allowed, plus shipping charges. For a manufacturer, production cost refers to the costs associated with purchasing direct material, paying for direct labor, incurring traceable overhead, and absorbing allocated fixed manufacturing overhead. Of these production costs, fixed manufacturing overhead is the least susceptible to cost minimization in the short run (Barfield et al., 2003). An exception is that management is able to somewhat control the fixed component of unit product cost through capacity utilization measures within the context of product demand in the short run. Most efforts to minimize fixed manufacturing overhead costs involve long-run measures. Purchasing/production cost is the amount to be recorded in the appropriate inventory account (raw material inventory, work-in-process inventory, finished goods inventory, or merchandise inventory) (Barfield et al., 2003).

The two fundamental approaches to producing inventory are push systems and pull systems. In a traditional approach, production is conducted in anticipation of customer orders. In this approach, known as a push system, work centers may buy or produce inventory not currently needed because of lead-time or economic order or production quantity requirements. This excess inventory is stored until it is needed by other work centers. To reduce the cost of carrying inventory until needed at some point in the future, many companies have begun to implement pull systems of production control. In these systems, parts are delivered or produced only as they are needed by the work center for which they are intended. Although some minimal storage must exist by necessity, work centers do not produce to compensate for lead times or to meet some economic production run model (Barfield et al., 2003).

2.4.3.2. ORDERING/SETUP COSTS
Incremental, variable costs associated with preparing, receiving, and paying for an order are called ordering costs and include the cost of forms and a variety of clerical costs (Barfield et al., 2003). Ordering costs are traditionally expensed as incurred by retailers and wholesalers, although under an activity-based costing system these costs can be traced to the ordered items as an additional direct cost. Retailers incur ordering costs for their entire merchandise inventory. In manufacturing companies, ordering costs are incurred for raw material purchases (Barfield et al., 2003). If the company intends to produce rather than order a part, direct and indirect setup costs (instead of ordering costs) are created as equipment is readied for each new production run. Setup necessitates costs for changing dies or drill heads, recalibrating machinery, and resetting
tolerance limits for quality control equipment. For decision analysis purposes, only the direct or incremental setup costs are relevant (Barfield et al., 2003).

Components of order cost include (Chopra and Meindl, 2004):

1. Buyer time;
2. Transportation cost;
3. Receiving cost;
4. Other costs;

Buyer time is the incremental time of the buyer placing the extra order and the cost should be included only if the buyer is utilized fully. The incremental cost of getting an idle buyer to place an order is zero and does not add to the order cost. A fixed transportation cost is often incurred regardless of the size of the order. Some receiving costs are incurred regardless of the size of the order. These include any administration work such as purchase order matching and any effort associated with updating inventory records. For all order costs it is important to determine that all costs included are the incremental change in real cost for an additional order. The order cost is often a step function: it is zero when the resource is not fully utilized and at that point, the order cost is the cost of the additional resource required (Chopra and Meindl, 2004).

2.4.3.3. HOLDING (CARRYING)/SHORTAGE COSTS

Inventory carrying costs are the variable costs of carrying one inventory unit in stock for one year. Inventory holding costs are incurred when materials are stored for a period. Holding costs include the following (Ghiani et al., 2004):

- A warehousing cost for storage, handling, insurance, losses from obsolescence and damage. If the company runs its own warehouses, such costs include space and equipment costs, personnel wages, insurance on inventories, maintenance costs, energy costs and state taxes. Otherwise, warehousing costs amount to the fee paid for storing the goods in third-party warehouses (rent);
- An opportunity (or capital) cost representing the return on investment the firm would have realized if money had been invested in a more profitable economic activity (e.g. on the stock market) instead of inventory. This cost is generally estimated based on a standard banking interest rate. Inventory is one of the many investments made by an organization and should be expected to earn a satisfactory rate of return. Some Japanese managers have referred to inventory as a liability. One can readily understand that perspective considering that carrying costs, which can be estimated using information from various budgets, special studies, or other analytical techniques, “can easily add 20 percent to 25 percent per year to the initial cost of inventory.” Although carrying inventory in excess of need generates costs, a fully depleted inventory can also generate costs.

Holding cost is usually estimated as a percentage of the cost of a production (Chopra and Meindl, 2004). It is estimated as the sum of the following major components:
1. Cost of capital;
2. Obsolescence or spoilage cost;
3. Handling cost;
4. Occupancy cost;
5. Miscellaneous cost;

Cost of capital is the most important component of holding cost (Chopra and Meindl, 2004). The appropriate approach is to evaluate the Weighted Average Cost of Capital (WACC). This cost takes into account the return demanded on the firm’s equity and the amount the firm must pay on its debt. These are weighted by the amount of debt and equity financing that the firm has. The WACC is the appropriate cost of capital for a firm that could grow its business using the funds released by reducing inventories. The obsolescence cost estimates the rate at which the value of the product stored drops either because the market value of that product drops or because the product quality deteriorates. Handling cost should only include receiving and storage costs that vary with the quantity of product received. Quantity-independent handling costs are often included in the order cost. Quantity-dependent costs are generally small and often the real does not change if quantity varies within a range. Occupancy cost should reflect the incremental change in space cost due to changing cycle inventory. As long as a marginal change in cycle inventory does not change the space requirements, the occupancy cost should be considered zero. If the firm is being charged based on the actual number of units held in storage, we have the direct occupancy cost. Firms often lease or purchase a fixed amount of space. Miscellaneous costs are other, relatively small costs like theft, security, damage, tax, and additional insurance charges that may be incurred (Chopra and Meindl, 2004).

Obsolescence costs arise when stocked items lose some of their value over time. This happens, for example, when food inventories deteriorate, clothing items in stock go out of fashion, or newspapers are unsold. The value of an item at the end of its lifetime is usually referred to as its salvage value (Ghiani et al., 2004).

Shortage costs are paid when customer orders are not met. Shortage costs depend heavily on customer behavior and are difficult to evaluate accurately. They can be classified as follows (Chopra and Meindl, 2004):
• Lost sales costs. A lost sale is likely to occur if the unavailable items can be easily obtained from a competitor. Lost sales costs include the profit that would have made on the sale, and the negative effect that the shortage could have on future sales.
• Back order costs. When goods are difficult to replace, a shortage often results in a delayed sale. Apart from the negative effect on future sales, a back order could result in a penalty.

The cost of having a stockout is not easily determinable, but some of the costs involved might include lost customer goodwill, lost contribution margin from not
being able to make a sale, additional ordering, and shipping charges incurred from special orders, and possibly lost customers. This cost can be easily considered through the differences of net present value of value chain. For a manufacturer, another important stockout cost is incurred for production adjustments arising from not having inventory available. If a necessary raw material is not on hand, the production process must be rescheduled or stopped, which in turn may cause additional setup costs before production resumes (Barfield et al., 2003). In such a complex structure of costs and incomes of dynamic inventory systems net present value approach for inventory systems control is the most appropriate one, which is shown in the subsequent section.

2.5. ACCOUNTING FOR INVENTORIES

Since inventories require investments, their financial aspects are of a high importance. It is important to understand and appreciate that “inventory information in financial statements are useful in the business operation as it influences the ability as well as the possibility of a right item in the right quantity in the right place at the right time” (Muller, 2003, p. 19). That is what the business is all about. If this function is not maintained or managed properly, there is neither core competence nor business per se.

Inventory is typically counted among a company's current assets because it can be sold within one year. This information is used to calculate financial ratios that help assess the financial health of the company. Inventory shows up on the income statement in the form of cost of goods sold and it reflects the cost of inventory sold, and flowing out of a business. The value of goods that are not sold is represented by the ending inventory amount on the balance sheet (Muller, 2003).

Among the most important, there are three ratios that are useful when assessing inventory (Muller, 2003). Muller (2003) explains them in brief as follows:

1. **Current Ratio.** The current ratio assesses the organization’s overall liquidity and indicates a company’s ability to meet its short-term obligations. In other words, it measures whether or not a company will be able to pay its bills. Technically speaking, the current ratio indicates how many dollars of assets we have for each dollar of liabilities that we owe.

The current ratio is calculated as follows:

\[
\text{Current Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}}
\]

Standards for the current ratio vary from industry to industry. Companies in the service industry that carry little or no inventory typically have current ratios ranging from 1.1 to 1.3 — that is, 1.10 USD to 1.30 USD in current assets for each dollar of current liabilities. Companies that carry inventory have higher
current ratios. Manufacturing companies are included in this latter group and often have current ratios ranging from 1.6 to 2.0; not only do they have inventory in the form of finished goods ready for sale, but they also carry inventory of goods that are not yet ready for sale. The longer it takes a company to manufacture the inventory and the more inventory it must keep on hand, the higher the current ratio. A low current ratio may signal that a company has liquidity problems or has trouble meeting its short- and long-term obligations. In other words, the organization might be suffering from a lack of cash flow to cover operating and other expenses. As a result, accounts payable may be building at a faster rate than receivables. Note, however, that this is only an indicator and must be used in conjunction with other factors to determine the overall financial health of an organization. In fact, some companies can sustain lower-than-average current ratios because they move their inventory quickly and/or are quick to collect from their customers and therefore have good cash flow. A high current ratio is not necessarily desirable. It might indicate that the company is holding high-risk inventory or may be doing a bad job of managing its assets. For example, fashion retailers may have costly inventory, but they might also have significant trouble getting rid of the inventory—if the wrong clothing line was selected for example. This makes it a high-risk company, forcing creditors to require a bigger financial cushion. Further, if a high current ratio is a result of a very large cash account, it may be an indication that the company is not reinvesting its cash appropriately. Even if the current ratio looks fine, other factors must be taken into consideration, as liquidity problems might still exist. Since ratios look at quantity, not quality, it is important to look at what the current assets consist of to determine if they are made up of slow-moving inventory.

In order to assess inventory’s impact on liquidity, another test of liquidity should be taken into account—the Quick Ratio (or Acid Test).

2. Quick Ratio or Acid Test. The quick ratio compares the organization’s most liquid current assets to its current liabilities. The quick ratio is calculated as follows:

\[
\text{Quick Ratio} = \frac{(\text{Current Assets} - \text{Inventories})}{\text{Current Liabilities}}
\]

An industry that sells on credit has a quick ratio of at least 0.8. In other words, the company has at least 80¢ in liquid assets (likely in the form of accounts receivable) for every $1 of liabilities. Industries that have significant cash sales (such as grocery stores) tend to be even lower. As with the current ratio, a low quick ratio is an indicator of cash flow problems, while a high ratio may indicate poor asset management as cash may be properly reinvested or accounts receivable levels are out of control. An organization’s ability to promptly collect its accounts receivable has a significant impact on this ratio. The quicker the collection the more liquidity it has.
3. **Inventory Turnover Ratio.** The inventory turnover ratio measures, on average, how many times inventory is replaced over a period. In its simplest sense, an inventory turn occurs every time an item is received, is used or sold, and then is replaced. If an SKU came in twice during the year, was used/sold, and then replenished, that would be two turns per year. If this happened once per month, it would be twelve turns per year, and so forth. Inventory turnover is an important measure since the ability to move inventory quickly directly affect the company’s liquidity. Inventory turnover is calculated as follows:

\[
\text{Inventory Turnover Ratio} = \frac{\text{Cost of Goods Sold}}{\text{Average Inventory}}
\]

Essentially, when a product is sold, it is subtracted from inventory and transferred to cost of goods sold. Therefore, this ratio indicates how quickly inventory is moving for accounting purposes. It does not necessarily reflect how many times actual physical items were handled within the facility itself. This is true because the cost of goods sold number may include items you sold but never physically handled. For example, items that we purchase and then have drop-shipped directly at our customer’s site are not ever handled within our facility.

A more accurate measure of how many times actual physical inventory turned within the site would be:

\[
\text{Actual Physical Inventory Turnover Ratio} = \frac{\text{Cost of Goods Sold from Inventory Only}}{\text{Average Inventory}}
\]

If the inventory has increased or decreased significantly during the year, the average inventory for the year may be skewed and not accurately reflect your turnover ratio going forward. In addition, if the company uses the LIFO (Last In – First Out) method of accounting, the ratio may be inflated because LIFO may undervalue the inventory. Unlike the current ratio and quick ratio, the inventory turnover ratio does not adhere to a standard range. Organizations with highly perishable products can have inventory turns of 30 times a year or more. Companies that retain large amounts of inventory or that require a long time to build their inventory might have turns of only two or three times a year. In general, the overall trend in business today is to reduce carrying costs by limiting the amount of inventory in stock at any given time. As a result, both individual inventory turnovers and industry averages in this area have increased in recent years. It is important to understand, however, that many factors can cause a low inventory turnover ratio. The company may be holding the wrong type of inventory, its quality may be lacking, or it may have sales/marketing issues.

The problem for many organizations is that cash flow does not always keep up with our needs. Often organizations raise operating capital by borrowing against (Muller, 2003):
• Their accounts receivable, and
• The book value of the inventory they are carrying

Accounts receivables are the amounts due from customers resulting from normal sales activities. Depending on the industry, banks will generally lend up to 75 percent of the value of accounts receivable due in ninety days or less. Bankers will also lend against the book value of inventory. The willingness to lend against this asset is not as straightforward as with accounts receivable. The more complex nature of these transactions comes from the fact that in accordance with accepted accounting practices, inventories should be valued at the lower of cost or fair market value. Therefore, dead stock should logically be valued at a fair market value of zero dollars no matter what it originally cost. In spite of generally accepted accounting practices and even though parts of inventory have no real market value (and should be valued at zero dollars), bankers will often loan organization 50 to 60 percent of the value of the inventory as that value is shown on the books. Therefore, companies will sometimes continue to carry dead stock to retain this artificial value on the books (Muller, 2003). Most stock keepers will not have any direct control over this area.

Every day that an item remains on the stock, it costs money in the form of a carrying cost (K Factor) (Muller, 2003). If this concept were taken to its ultimate extreme, it would make sense to only buy items exactly when they are needed. Multiple smaller quantity purchases of the same item certainly hold down carrying costs. However, it hurts the cost of replenishment - the expenses associated with buying things. However, the cost of purchasing product exceeds the actual price paid for it. As it is already noted, expenses related to purchasing include the salaries of the purchasing staff, rent, and other overhead expenses attributable to the purchasing department. In fact, the more often a purchase is made, the greater the internal costs are (Muller, 2003). For example, if million widgets were purchased all the same time, purchasing, or replenishment cost (R factor) would be the cost per purchase order (PO). Order size versus frequency of purchase shifts the cost burden from the K Factor to the R factor and vice versa. In other words:
• If smaller quantities are bought more often, purchasing costs go up - the R factor increases.
• If larger quantities are bought less often, there is a higher inventory level for a longer period, so the carrying costs go up - the K factor increases.

In a perfect world, the K factor and the R factor would be equal. Although this is difficult to achieve, an organization attempting to have the correct amount of product at the overall lowest cost will strive for that balance.

The goal or mission of SCM can be defined using Mr. Goldratt’s words as “Increase throughput while simultaneously reducing both inventory and operating expense” (Hugos, 2003, p. 9). The steady fall in stock clearly suggests
improving inventory management, but there may well be other factors, such as the changing structure of industry, the move towards services, international competition, economic cycles, inflation, changing GDP, currency value and increasing mobility. Inventories clearly respond to such external influences. For example, in the case of business cycle, it might start with industry being over-optimistic about the future, expecting sales to rise and increasing production to meet this higher demand. Inventories build up as sales lag behind production, and at some point, industry loses confidence and cuts back on production to use the excess stocks (Waters, 2003). This causes a decline in the economy, which only picks up again when stocks are lower and production is not meeting current demand. Because it is relatively easy to change inventory levels – much easier than, say, adjusting production levels – they tend to fluctuate more than the business cycle itself (Waters, 2003). This is the point where inventories enter the sphere of macroeconomics.

2.6. INVENTORY OPTIMIZATION MODELS FOR OPTIMAL INVENTORY CONTROL

As noted in the precedent sections, inventories are of a high practical and economic importance in everyday business, making the subject of inventory control a major consideration in many situations. Questions must be constantly answered as to when and how much raw material should be ordered, when a production order should be released to the plant, what level of safety stock should be maintained at a retail outlet, or how in-process inventory is to be maintained in a production process. These questions are amenable to quantitative analysis through the subject of inventory management and theory [URL: http://www.me.utexas.edu/~jensen/ORMM/omie/computation/unit/invent_add/inventory.html].

The basic function of inventory is to insulate the supply of goods from demand changes. Since costs are associated with inventories, they need to be dealt with in an effective, efficient, and economic manner. The simple question that inventory theory attempts to answer is “How much stock to hold?” Two fundamental questions that are derived from the previous one which have to be addressed by inventory optimization models for optimal inventory control are:

1. How much to replenish?
2. When to replenish?

The ultimate purpose of inventory management is optimization of the inventory policy for the whole production-distribution system - to minimize total operating inventory costs while maximizing profits and maintaining a high level of customer service. This means that the objective of optimal inventory control is to make a balance between the conflicting goals. Optimization in its broadest sense is “balancing multiple factors to obtain the best overall result,” as stated by William H. Drumm, president and CEO of Establish Inc./Herbert W. Davis and Company, a supply chain strategy consultancy. As Laderman and Littauer
(1953) have noted “The inventory problem can be stated very simply: it is to
decide how much material to stock in preparation for an uncertain future. Both
understocking and overstocking are costly, else there is no problem.”

One important fact that has to be considered when solving inventory
optimization problems is that inventory policy has to be taken in high
convergence with other activities, which are both part of company’s policy and
the whole supply chain. According to Bogataj and Bogataj (2004) inventories are
limited by the capacity of each processing node of the chain and transportation
capability of input and output flows”. Activities that are directly correlated with
inventory control include production planning, scheduling, transportation,
location, capacity adjustments, etc. As Bogataj and Bogataj (2004) state, that
“optimizing the entire process is not the same as optimizing each link
separately.” All the variables that are important to supply chain costs and net
present value (NPV) of all activities in it has to be taken into account (Bogataj
and Bogataj, 2004). Bogataj and Bogataj (2004) note that “the flows of items in
supply chains influence transportation costs and costs of activities in logistics
nodes of global economy and consequently the net present value (NPV) of all
activities that have to be performed in such logistics networks.” Optimal
inventory levels across the whole supply chain, which result from optimal
inventory policies, reduce the need for additional inventory investments in each
node, which may result from a lack of integrated approach in inventory control
across the whole supply chain. This is the point where microeconomic and
macroeconomic aspects of inventory behavior converge. On one hand, lean
production and lean distribution require less inventory investments both on firm
and aggregate economy level, and on the other hand increased added value at
constant investment rate which leads towards a higher GDP on a macro level.
Thus, the ultimate goal of the supply chain is to achieve the maximal NPV of all
activities in the supply chain (see Chapter 3.6.1).

Optimization involves “a mathematical model representing a description of a set
of operations or logistics/SCM problems that an organization wants to optimize”
as Jeff Schutt, a senior principal of Menlo Worldwide Logistics (Austin, Texas)
explains [URL: http://www.inboundlogistics.com/articles/features/0105_
feature01.shtml]. The optimization model works to minimize or maximize an
objective function. The objective function ”represents the objective of what you’re
trying to optimize” Schutt states. A company’s objective function, for example,
might be to meet customer orders at the lowest possible cost subject to certain
constraints, such as not exceeding production line capacity on any given day.
However, the two most significant objective functions are to minimize total costs
or maximize profits, net present value, or “net utility” as defined by Arrow et al
(1951).

Objective function of an organization is a subject to constraints of some sort
such are capacity limited by capital, production limited by capacity, etc. Two
main types of constraints addressed in the majority of inventory related
literature are capacity constraints and capital constraints. A great number of authors have done a research regarding capacitated inventory problems (see Grubbström and Wang, 2000). Consequently, a mathematical model of the optimization problem has to address several issues:

1. Decision variables that define the problem;
2. Constraints that limit the decision choices;
3. Objective functions.

There are two steps when searching for an optimal solution. The first is to find a feasible solution – any set of values that satisfies all the constraints, and the second to search for an optimal solution – a feasible solution that has the best possible objective function value.

There are a number of inventory optimization models in the form of mathematical applications that can be classified regarding a number of criteria or decision variables, according to Ghianni et al. (2004). These criteria for inventory systems classification determine the constraints, which will have an impact on the objective function, which is either to maximize total profit or minimize total inventory costs:

1. **Deterministic versus stochastic models.** In a deterministic model, where demands, prices, and lead times are assumed to be known in advance, the focus is on balancing different categories of costs (e.g. the fixed costs of ordering and the costs of holding inventory). In a stochastic model, where some data are uncertain, it is impossible to always satisfy all the demand. As a result, a constraint on customer service level (stating, for example, that a customer is satisfied with a given probability) is usually imposed.

2. **Fast-moving items versus slow-moving items.** Fast-moving items are those manufactured and sold regularly, and include most products on the market. The main issue when managing a fast-moving item inventory is to determine when stocking points have to be replenished and how much to order. On the other hand, slow-moving items, which are often spare parts of complex machineries, have a very low demand (e.g. a few units every 10 or 20 years). As a rule, manufacturing a spare part several years after the machinery is constructed is very expensive compared to producing it along with the machinery. Hence, the main issue is to determine the number of items that have to be produced and stored at the beginning of the planning horizon.

3. **Number of stocking points.** Optimal inventory policies can often be derived analytically for single stocking point models, while multiple stocking point situations are usually much harder to deal with.

---

4. **Number of commodities.** When holding a multicommodity inventory, joint costs and constraints usually come into play. These inventory systems are known as multi-item systems. For the multi-item system, two or more items are stored and use a number of common resources. However, constraints arise on the limited resources, which have an impact on the objective function. In inventory theory, the single-product problem is extensively studied. Chikán (1990) has given an overview of 336 inventory models, of which 276 models deal with some variant of the single-product problem. In practice, organizations keep thousands of products at stock at several locations. The best knows single-item model is the economic order quantity (EOQ) presented in the next section.

5. **Instantaneous resupply versus noninstantaneous resupply.** A stocking point can be replenished almost instantaneously (e.g. because of a truck delivery) or noninstantaneously (e.g. at a constant rate through a manufacturing process).

Research in the area of inventory theory focuses often either on deterministic or stochastic models. The approach to each of the models is somewhat different in that an optimal solution of each model requires different tools, for example, for deterministic problem heuristics and complexity, results are important, and for stochastic problem heuristics and bounds on average costs are of interest in order to get optimal strategies or sub-classes of strategies. For solving deterministic problems techniques as Linear Programming and Branch and Bound are most often used and for stochastic problem stochastic Dynamic Programming and Markovian Decision Processes are important.

From a practical point of view, both types of models are too restrictive. Deterministic models lack the notion of uncertainty in demand, in supply or within the system itself. Stochastic models, on the other hand, are often complicated and therefore difficult to comprehend. Moreover, incorporating deterministic variables complicates the model even more. For instance, in a production context often a large part of the required output is already known for the coming periods. Dealing with real world problems a combination of deterministic and stochastic models is needed. In practice, one settles for deterministic models and incorporates uncertainty by, for example, creating safety stocks.

According to the above criteria and the combination of the alternatives, different inventory systems arise where each requires a different approach in solving the inventory problem. Two basic deterministic models will be presented in the following paragraphs – EOQ and EPL model.

**Deterministic inventory model with infinite replenishment rate and no shortages – EOQ.** The best-known mathematical optimization problem in inventory theory is the economic order quantity (EOQ, hereafter), “square-root” rule, or “Wilson lot-size” formula originally developed by F. W. Harris in 1913.
The model tries to determine the point at which the combination of order costs\(^8\) and inventory holding costs are the least, the optimal lot size. The result is the most cost effective quantity to produce/order. This relationship is presented in Figure (2-3) below:

**Figure 2-3: Optimal lot size**

![Optimal lot size graph](image)

*Source: Lovell (2003)*

EOQ is a deterministic inventory model that addresses infinite inventory replenishment, without shortages. A firm orders its products in lots (or batches) of size \(q\) in meeting annual sales \(D\). The saw-tooth movement of the inventory stock, \(I\), that presents the cycle is given below on Figure (2-4):

The cycle begins at time \(t=0\) with a first batch ordered. The batch is ordered all at one time causing the inventory to shoot from zero to \(q\) instantaneously. The goods ordered in each batch are placed in inventory and gradually sold off at a continuous demand rate \(D\). The basic assumption is that the goods are withdrawn in a continuous fashion, rather than in discrete units, so it is shown as the inventory level declining as a straight line. After a batch is sold off and inventory reduced to zero, another lot is ordered and the cycle repeats.

Two types of costs must be balanced in deciding how big a batch \(q\) to order:

1. Ordering cost, \(A\)
2. Holding cost, \(H\).

---

\(^8\) Order cost in the case of procurement, and setup cost in the case of production
The optimal lot size minimizes the sum of these two types of cost. Let $D$ equal annual sales and $q$ the size of a batch. Then there will be $D/q$ setups a year. If $A$ is the cost of a ordering, then total setup costs for the year will be $AD/q$. Assuming sales take place at a roughly uniform rate throughout the year, inventory will range from zero to $q$ with an average level of $q/2$. If the cost of carrying a unit of output in inventory for a year is $H$, then yearly inventory cost will be $Hq/2$. For this model, a single decision variable is the lot size or the replenishment, $q$. All other quantities are a function of $q$. The inventory cost is a strictly convex function of $q$, so there is a unique global minimum with respect to $q$. For determination of the optimum lot size $q^*$ we write the expression for the cost rate for operating the inventory:

$$z_f = \frac{AD}{q} + \frac{Hq}{2}$$  \hspace{1cm} (2-1)

If we set derivative of (2-1) with respect to $q$, we have a necessary condition for a maximum:

$$\frac{dz_f}{dq} = -\frac{AD}{q^2} + \frac{H}{2} = 0$$  \hspace{1cm} (2-2)

Solving (2-2) for the optimum lot size, $q^*$:
\[ q' = \sqrt{\frac{2AD}{H}} \]  

(2-3)

Since \( z_I \) is a convex function of \( q \):

\[
q^* = \begin{cases} 
q_{min} & \text{if } q'<q_{min} \\
q_{min} \leq q' \leq q_{max} \\ 
q_{max} & \text{if } q'>q_{max}
\end{cases}
\]  

(2-4)

To test convexity, we take the second derivative of (2-1):

\[
\frac{d^2 z_I}{dq^2} = \frac{2AD}{q^3} > 0
\]  

(2-5)

Since the second derivative is positive for positive parameters, the inventory cost function is convex and the solution for \( q^* \) is a global minimum. To construct a mathematical model describing the economic costs or profits associated with the inventory system, the cash flows are shown below on Figure (2-5).

This figure is a mixed representation of discrete as well as continuous cash flows. The arrows represent amounts paid or received at points in time. The areas represent continuous cash flows given by rates. Amounts appearing above the zero axes are revenues, \( Rq \), while amounts below are expenditures or costs.

If \( C \) denotes product costs, then the profit rate, \( z_p \), is equal to:

\[ z_p = (R - C)D - z_I \]  

(2-6)

When \( q^* \) is between the minimum and maximum lot sizes, the inventory measures with the optimum lot size are found by substituting \( q^* \) into the instance formula:

\[
z_I^* = \frac{AD}{q^*} + \frac{Hq^*}{2} = \sqrt{\frac{ADH}{2}} + \sqrt{\frac{ADH}{2}} = \sqrt{2ADH}
\]  

(2-7)

By substituting \( z_I^* \) into \( z_p \) we get the optimum total profit, \( z_p^* \):

\[ z_p^* = (R - C)D - \sqrt{2ADH} \]  

(2-8)

Since the demand is assumed deterministic, using the determined optimal order size, it is easy to determine the optimal order interval (cycle time), \( \tau^* \), as:
At the optimum, the holding cost is equal to the setup cost. It can be seen that the optimal inventory cost is a concave function of product flow through the inventory, indicating that there is an economy of scale associated with the flow through inventory. The optimal lot size increases with increasing setup cost and flow rate and decreases with increasing holding cost.

**Deterministic inventory model with finite replenishment rate and no shortages – EPL.** A first extension of this model is the economic production lot (EPL) model where the product is added to the inventory at a finite rate, rather than arrive instantaneously as in the previous model. EPL is a deterministic inventory model with finite inventory replenishment and no shortages. The model is illustrated below on Figure (2-6).

Rather than arrive instantaneously, the lot is assumed to arrive continuously at a rate \( P \). This situation arises when a production process feeds the inventory and the process operates at the rate \( P \). Of course, \( P \) must be greater than the demand rate \( D \). The maximum inventory level never reaches \( q \) because material is withdrawn at the same time it is being replenished.
Figure 2-6: Inventory with finite replenishment rate and no shortages – EPL model

Rate of increase is $P - D$

Rate of decrease is $D$


Replenishment takes place at the beginning of the cycle when the inventory grows at the rate $P-D$. At time $t'$ production stops. For the remainder of the cycle, inventory is withdrawn at a rate $D$, the demand rate, until it reaches zero at the end of the cycle. To construct a mathematical model describing the economic costs or profits associated with the inventory system, Figure (2-7) presents discrete as well as continuous cash flows.

Figure 2-7: Discrete and continuous cash flows in EPL

Since total inventory costs, $z_i$, are equal to:

$$z_i = \frac{AD}{q} + \left( \frac{P-D}{P} \right) \frac{Hq}{2}$$

, the optimum lot size in EPL model is:

$$q' = \sqrt{2AD\left( \frac{P}{P-D} \right)}$$

(2-11)

Considering (2-4), we get the optimal total inventory costs $z_i^*$, and optimal total profits, $z_p^*$ in EPL:

$$z_i^* = \frac{AD}{q^*} + \left( \frac{P-D}{P} \right) \frac{Hq^*}{2} = \sqrt{2ADH\left( \frac{P-D}{P} \right)}$$

(2-12)

$$z_p^* = (R-C)D - \sqrt{2ADH\left( \frac{P-D}{P} \right)}$$

(2-13)

The optimal lot size increases with increasing setup cost and flow rate and decreases with increasing holding cost. As $P$ approaches $D$ the optimal lot size approaches infinity and the inventory cost goes to zero.

Except these two most common deterministic inventory models, the model with infinite replenishment rate and no shortages allowed (EOQ), and the model with finite replenishment rate and no shortages allowed (EPL), there is a number of other alternative deterministic models such is the infinite replenishment rate model with shortages backordered, then finite replenishment rate model with shortages backordered, infinite replenishment order with shortages lost, and finite replenishment order with shortages lost.

The second category of inventory problems includes stochastic inventory models. These inventory problems with uncertain demand or lead times have quite a complex mathematical structure. Few most common inventory policies used by practitioners are the classical Newsboy Problem, where a one-shot reorder decision has to be made, then the reorder level method, the reorder cycle method, the $(s, S)$ method and the two-bin technique. Because of their complexity and specificity stochastic inventory, models will not be elaborated in detail.
2.6.1. NET PRESENT VALUE APPROACH VERSUS COST APPROACH FOR OPTIMAL INVENTORY POLICY DETERMINATION

Production management and business logistics are governed by objective function, which requires the maximal net present value (NPV) (Bogataj and Bogataj, 2004). As noted in preceding paragraphs, the purpose of optimization models is to minimize or maximize an objective function that a decision maker has set, depending on what the objective function in a particular case is. The two most relevant objective functions in inventory theory are to maximize net present value or to minimize costs. The first approach in inventory theory is known as net present value approach and the second as the average cost approach. While the net present value (NPV) approach is widely accepted as the right framework for studying production and inventory control systems, average cost (AC) models are more widely used (Laan, 2000; Laan et al., 2001).

Among the activities related to production control there are long-run capacity adjustments such as investments in plants and machinery, short- and medium-run capacity adjustments such as workforce reallocation, and short-run operational activities such as determining order quantities (Grubbström, 1980). Grubbström (1980) suggests that the economic consequences of any action taken by a firm, whenever possible, should be derived from the ultimate payment consequences for the firm. According to the author, such consequences are resulting in cash flows to be valued by present value measures. Grubbström (1980) economic theory provides evidence that payment flows should be evaluated by their net present value (NPV) or by some equivalent measure such as the corresponding annuity stream. According to Naim et al. (2005), a number of production planning studies have been undertaken with the aim of maximizing the NPV.

The net present value approach in inventory theory has a root in a theory of Arrow et al. (1951) who introduced the concept of “net utility” – “…the quantity that the policymaker seeks to maximize”. The authors have noted that in the case of profit-making enterprises this “net utility” is “conveniently approximated by profit: the difference between gross money revenue and money cost” (Arrow et al., 1951). Authors further state that the “net utility” to any policy maker (a holder of inventories) is, in general, a random variable that depends on certain conditions some of which he can control but others he cannot. Between those the policy maker can control are strategies and rules of action (such is the size of the order), and those that he cannot are represented by a joint probability distribution of non-controlled conditions (demand rate, lead-time, ordering costs, etc.). Authors conclude that a rational (inventory) policy consists in “fixing the controlled conditions so as to maximize the expected value of utility, given the probability distribution of non-controlled conditions” (Arrow et al., 1951).

Grubbström (1980) has shown that where the economic consequences of production planning decisions need to be known then the NPV should be applied
instead of the cost approach, which is rather used in practice. The author notes that in practice, inventory-holding costs are usually valued as an estimate of the costs laid down in the product up to current date, multiplied by an interest rate reflecting the cost of capital of the firm Grubbström (1980). However, as Grubbström (1980) states that “standard machine-hour costs and standard material costs, etc., can be no more than rough substitutes for a more correct valuation of the payments associated with production, although they might provide simple and quick estimates to be used for deciding upon different operative courses of actions.”

Grubbström (1980) notes that “a peace of material in stock or a semi-assembled product in a waiting line should be valued at its contribution to the present value (or annuity stream) which does not necessarily coincide with the price paid or the cost incurred to date.” Laan (2000) and Laan et al. (2001) give a comparison between the NPV and AC approaches and makes significant conclusions stating that for the well known EOQ model it can be verified that (under certain conditions) the AC approach gives near optimal results, but for multi-source systems the NPV approach is more appropriate one.

Laan (2000) notices that several authors (e.g. Hadley, 1964; Trippi and Lewin, 1974; Thompson, 1975; Hofmann, 1998; Haneveld and Teunter, 1998) have argued that for the EOQ model the average cost (AC) framework as an approximation to the superior net present value (NPV) framework leads to near optimal results under the following conditions:

1. Products are not moving too slow,
2. Interest rates are not too high,
3. The customer payment structure does not depend on the inventory policy.

Laan (2000) gives a short review of some key insights on this issue. He argues that the first two conditions have to guarantee that compounded interest does not affect the results. He states that the latter condition is crucial and was first put forward by Beranek (1966), whose concern was confirmed later by Grubbström (1980) and Kim et al. (1984). Grubbström and Thorstenson (1986) report that the NPV approach can differ significantly from the AC approach for a multilevel inventory system. The main objections against the average cost approach, as it is usually applied, as an approximation to the NPV approach is threefold (Laan, 2000):

1. The time value of money is not explicitly taken into account;
2. There is no distinction between out-of-pocket holding costs and opportunity costs due to inventory investment, while other sources of opportunity costs/yields (fixed ordering costs, product sales) are not taken into account at all;
3. Initial conditions are not taken into account.

Laan et al. (2001) argue that the NPV approach is often rather complicated and that an approximation may still be preferred. The authors state that several
authors have tried to deal with the above problems by showing that a certain transformation of the holding cost parameters in EOQ-type models gives near optimal results from an NPV perspective, but this, however, shifts the problem to finding the right transformation. Up to now, only ad hoc solutions have been given that are often very counter-intuitive (Beranek, 1966; Corbey et al., 1999; Luciano and Peccati, 1999). The authors conclude that until that time no general principle has been developed to solve the transformation problem.

Laan (2000) and Laan et al. (2001) note that finding the right holding cost transformation requires comparing a NPV analysis with an AC analysis and choosing the holding cost parameters in such a way that the results of both approaches (approximately) coincide.

Laan et al. (2001) make a comparison between the NPV approach and the AC approach that is presented in the following paragraphs. Net Present Value (NPV) is defined as the total discounted cash flow over an infinite horizon. For instance, when a cyclic cash flow $C$ that occurs at stochastic times $T_1, T_2, ...$ starting at time $T_1=0$ is considered, the NPV of this series of cash flows, discounted at rate $r$, equals:

$$NPV = E \left\{ \sum_{n=1}^{\infty} Ce^{-rT_n} \right\}$$

(2-14)

In addition to NPV the Annuity Stream (AS) is defined as:

$$AS = r \{NPV\}$$

(2-16)

The annuity stream is the transformation of a set of discrete and/or continuous cash flows to one continuous stream of cash flows, such that the latter has the same net present value as the original set of cash flows. The notion of an annuity stream is useful, since it can be directly compared with average costs.

If $T$ denotes the cycling time of a discrete cash flow $C$, with first occurrence time $T_1$, then the annuity stream is given by

$$AS = rC \sum_{n=0}^{\infty} e^{-r(T_1+nT)} = \frac{rCe^{-rT_1}}{1-e^{-rT}}$$

(2-17)

This can be written as the McLaurin expansion:

$$AS = \frac{rCe^{-rT_1}}{1-e^{-rT}} = \frac{C}{T} + C \left[ r \left( 1 - \frac{T_1}{T} \right) + O(r^2 \max\{T, T_1\}) \right],$$

(2-18)
So that we have the following linearization in $r$ of the annuity stream:

$$\overline{AS} = \frac{C}{T} + rC\left(1 - \frac{T_1}{T}\right)$$  \hspace{1cm} (2-19)

In most practical applications, $r$ is small and $0 \leq T_1 \leq T$, so that the above approximation is quite reasonable. The first term of (2-19), $C/T$, denotes the average cash flow per time unit, as it would follow from a standard AC calculation. The second term may be viewed as a first order correction term to account for the time value of money. Figure (2-8) shows the comparison between the average cash flow per time unit, $C/T$, the annuity stream, $\overline{AS}$, and its linearization, $\overline{AS}$ for $T = 4$, $C = 1$ and $r = 0.2$. Approximately, the AC approach underestimates the interest component of the annuity stream if $T_1 \leq T/2$ and overestimates otherwise. The results of both approaches are the same if $T_1 \approx T/2$.

Figure 2-8: Comparison of AC and NPV approach

The above only holds for discrete cash flows, but we can do a similar analysis for continuous cash flows. Suppose that a product is sold with continuous rate $\lambda$ for a price $p$, starting at time $T_1$. Then, its annuity stream is given by:

$$AS = rp\int_{T_1}^{\infty} e^{-rt} \, dt$$

$$= rp\int_{T_1}^{\infty} e^{-rt} \, dt$$

$$= p\lambda \left[1 - rT_1 + O(r^2T_1^2)\right]$$

$$\approx p\lambda \left[1 - rT_1\right]$$  \hspace{1cm} (2-20)

According to Laan (2000) and Laan et al. (2001), the way that the AC approach usually deals with the underestimation of the interest component for cash flows
related to variable production costs is to add a certain factor to the out-of-pocket holding cost parameter. This factor is usually taken as the interest rate $r$ times the value of the stocked item. This approach has a number of disadvantages. First, it assumes that the overestimation is proportional with average inventory although this does not need to be the case but in fact; size and timing of cash flows are dependent on cycle times rather than the existence of physical stocks. Second, it only deals with underestimation of the interest component and not with overestimation, since the value of a stocked item is usually taken to be positive. Third, this approach only considers the interest components of variable production costs, while interest components of all other cash flows (fixed costs, sales, etc.) are not taken into account. Finally, it is unclear what is meant by the value of a stocked item, since this depends on the type of decision that has to be made.

Laan et al. (2001) conclude that although the NPV approach is the more appropriate framework, AC models dominate the field of inventory control. In their paper “Average cost versus net present value: a comparison for multi-source inventory models”, the authors have shown that the traditional AC approach, which does not make a distinction between opportunity costs of holding inventories and physical inventory costs, leads to reasonable results for single-source systems, but not necessarily for multi-source systems. Single-source systems are those in which inventories consist of products that all have generated the same cash flows, as compared to multi-source systems in which inventories consist of products that have been produced in different ways against different costs. For example, this is the case with products that can be both newly manufactured and remanufactured from old products. On the other side, the NPV approach makes a clear distinction between physical inventory costs and opportunity costs, since the two are not directly related, and the latter does not depend on physical stocks at all, but only on the amount and timing of the investments. The traditional AC approach only takes the opportunity costs of holding inventories into account, but this should not be a general rule. According to the authors, all cash flows generate opportunity costs or yields that cannot be disregarded if the cash flows depend on decision parameters. As a conclusion, Laan et al. (2001) note that basically there are two classes of models: a class for which a holding cost transformation exists that does not depend on decision variables, such that NPV coincides with AC (up to a constant), and a class for which such a transformation does not exist. A typical example of the latter class is a system with manufacturing, remanufacturing, and disposal.

The goal or mission of SCM can be defined using Mr. Goldratt’s words as “Increase throughput while simultaneously reducing both inventory and operating expense” (Hughes, 2003, p. 9). The steady fall in inventory stock clearly suggests improving inventory management, but there may well be other factors, such as the changing structure of industry, the move towards services, international competition, economic cycles, inflation, changing GDP, currency value and increasing mobility. Inventories clearly respond to such external
influences. For example, in the case of business cycle, it might start with industry being over-optimistic about the future, expecting sales to rise and increasing production to meet this higher demand. Inventories build up as sales lag behind production, and at some point, industry loses confidence and cuts back on production to use the excess stocks (Waters, 2003). This causes a decline in the economy, which only picks up again when stocks are lower and production is not meeting current demand. Because it is relatively easy to change inventory levels – much easier than, say, adjusting production levels – they tend to fluctuate more than the business cycle itself (Waters, 2003). This is the point where inventories enter the macro-economical sphere.

3. THE ROLE OF INVENTORIES IN THE CONTEXT OF MACROECONOMICS

3.1. INTRODUCING THE THEORETICAL FRAMEWORK OF THE MACROECONOMIC IMPORTANCE OF INVENTORIES

According to Mankiw (2003), economic fluctuations present a recurring problem for economists and policy-makers. John Bates Clark said in 1898, “The modern world regards business cycles much as the ancient Egyptians regarded the overflowing of the Nile. The phenomenon recurs at intervals, it is of great importance to everyone, and natural causes of it are not in sight” (Mankiw, 2003).

Economical fluctuations are most often measured by the fluctuations in real Gross Domestic Product (GDP, hereafter) growth rates. According to Mankiw (2003), these short-run fluctuations in output are called business cycles and although this term suggests that economic fluctuations are regular and predictable, they are not. As a measure of the total economic activity, GDP measures the total value of goods and services produced by a nation. GDP is equal to the sum of nation’s consumption, investments, and net exports.

Investments represent around 20-30% of the GDP. Although not that large as consumption, investments are important as they add to the capital stock which is a key input used to produce output. For this reason, most of the fluctuations in output and GDP growth seem to occur because of fluctuations in investments.

According to Mankiw (2003, p. 461) “Investment is the most volatile component of GDP”. Much of the GDP decline during recessions, or more particularly the fall of expenditures on goods and services, is usually due to a drop in investment spending. As explained in Mankiw (2003) total investments as a share of GDP fall substantially below the average total investment during recessions and prior to recessions. These large fluctuations are due to many factors that affect total investments either positively or negatively. Factors that affect investments positively are business confidence and expectations, higher sales relative to
current capacity and expectations – demand conditions, technology, and so. Factors that negatively affect investments are taxes and real rate of interest or the costs of investing.

Researchers have found that another determinant of investment behavior is liquidity - the liquid asset a company has on hand and the cash flow it is currently generating. Many firms are limited in their access to financial markets and thus they must rely primarily on internal funds to finance investment. The liquidity constraint seems particularly to affect smaller corporations and helps explain investment volatility, because cash flow itself is very cyclical.

The most volatile component of GDP is inventory investments, which add the most to the investment volatility.

3.2. TYPES OF BUSINESS INVESTMENTS

There are two types of business investment spending:

1. Business fixed investment, and
2. Inventory investment.

3.2.1. BUSINESS FIXED INVESTMENTS

The largest piece of investment spending, accounting for about three-quarters of the total investment is a business fixed investment (Mankiw, 2003). Business fixed investment includes the equipment and structures that businesses buy to use in production. These investment goods are bought by firms for use in future production (Mankiw, 2003). The term “fixed” means that this spending is for capital that will stay put for a while, as opposed to inventory investment, which will be used or sold shortly later. Business fixed investment includes everything from fax machines to factories, computers to company cars.

The level of business fixed investment is related to the marginal product of capital, the interest rate, and the tax rules affecting firms (Mankiw, 2003). The author uses two types of firms to describe his view: rental firms and production firms and gives a brief description. For a firm that a rent out capital, the real benefit of a unit of capital is the marginal product of capital, which is the extra output, produced with one additional unit of capital. The marginal product of capital declines as the amount of capital rises: the more capital the firm has, the less an additional unit of capital will add to its output.

Business fixed investment depends on the marginal product of capital, the cost of capital, and the amount of depreciation. If firm does not owns its capital but rather rents it, to maximize profit, the firm rents capital until the marginal product of capital falls to equal the real rental price. The lower the stock of capital, or the greater the amount of labor employed or the better the technology, the higher the real rental price of capital. The real rental price of capital adjusts
to equilibrate the demand for capital, determined by the marginal product of capital, and the fixed supply of capital on the rental market. For renting firms the benefit of owning capital is the revenue from renting capital to firms that use it. The cost of capital for a renting firm depends on the relative price of capital, the interest rate, and the depreciation rate (Mankiw, 2003).

When firms are deciding about whether to increase or decrease the capital stock, it depends on whether owning and renting out capital is profitable. The rental firm makes a profit if the marginal product of capital is greater than the cost of capital and thus firm adds to its capital stock. Business fixed investment increases when the interest rate falls since lower interest rates lower the cost of capital and this raises the amount of profit from owning capital and increases the incentive to accumulate more of it, and vice versa. Any event that raises the marginal product of capital, such is a technological innovation, increases the profitability of investment and the amount of capital goods the firms wish to buy (Mankiw, 2003).

Tax laws influence firms’ to accumulate capital in many ways. Sometimes policymakers change the tax laws in order to shift the investment and influence aggregate demand. Two of the most important provisions of corporate taxation are the corporate income tax and the investment tax credit. Under the corporate income tax when calculating profits as a difference between rental prices of capital, firms’ deduct depreciation using historical costs of capital, the price when the capital was originally purchased. In periods of inflation, replacement cost is greater than historical cost, so the corporate tax tends to understate the cost of depreciation and overstate profit. As a result, the tax law sees a profit and levies a tax even when economic profit is zero, which makes owning capital less attractive. For this reason, many economists believe that the corporate income tax discourages investment. The investment tax credit is a tax provision that encourages the accumulation of capital since it reduces a firm’s taxes by a certain amount for each dollar spent on capital goods thus reducing the cost of capital of new investments and raises it (Mankiw, 2003).

One of the ways to measure firm’s incentive to invest, as Mankiw (2003) states, is the Tobin’s $q$ ratio proposed by Nobel-Prize-winning economist James Tobin who proposed that firms base their investment decisions on the ratio between the market value of the installed capital (value of the economy’s capital as determined by the stock market) and the replacement cost of installed capital (price of the capital if it were purchased today). Stock prices reflect the incentive to invest since they tend to be high when firms have many opportunities for profitable investment, because these profit opportunities mean higher future income for the shareholders. Tobin reasoned that net investment should be reasoned whether $q$ is greater or less than one. If $q$ is greater than one, then the stock market values installed capital at more than its replacement cost in which case managers can raise the market value of their firm’s stock by buying more capital, and conversely if $q$ is less than one, managers will not replace capital as
it wears out. Tobin’s \( q \) depends on current and expected profits from installed capital. If the marginal product of capital exceeds the cost of capital, then firms are earning profit on their installed capital raising the market value of these firm’s stock, implying a high value of \( q \), and vice versa. Changes in stock market often reflect changes in real GDP. Whenever the stock market experiences a substantial decline, there is a reason to fear that recession may be around corner. A fall in Tobin’s \( q \) reflects investors’ pessimism about the current or future profitability of capital. This means that the investment is lower and the aggregate demand for goods and services contracts, leading to lower output and employment.

### 3.2.2. INVENTORY INVESTMENT

Inventory investment includes those goods that businesses put aside in storage, including materials and supplies, work in process, and finished goods. Although, inventory investment is one of the smallest components of spending, averaging about 1 percent of GDP (Mankiw, 2003), yet its remarkable volatility makes it central to the study of economic fluctuations. In recessions, firms stop replenishing their inventory as goods are sold, and inventory investment becomes negative. In a typical recession, more than half the fall in spending comes from a decline in inventory investment (Mankiw, 2003).

According to McCain\(^9\) although investment in inventories is a small proportion of total investment, it has a special advantage. At the beginning of a period, executives can decide how much they think it will be profitable to invest in capital goods of all sorts: plant and equipment, structures, inventories. As the period goes on, the investments in plant and equipment and structures will be relatively under control. However, the investment in inventories will not, because the increase in inventories depends on how much executives sell. If businessmen do not sell as much as they had expected, they will find themselves with more inventories than they had planned to have, or wanted to have. These increases in inventories are investments, but they are not investments the businessmen had intended to make. They are “unintended investment” and are equal to the difference between planned (predicted) and realized inventory investments.

According to Hornstein (1998) the reasons for attention on changes in inventory investment appears to be related to three issues. First, changes in inventory investment apparently account for a substantial fraction of changes in GDP. Second, current changes in inventory investment are assumed to convey useful information about the near-term future of the economy. Third, there is a view that the inherent dynamics of inventory investment are destabilizing the economy.

3.3. THE RELATIONSHIP BETWEEN INVENTORY INVESTMENTS AND BUSINESS FLUCTUATIONS

The argument that inventory investment is important for the business cycle is often based on the close relationship between changes in inventory investment and GDP during recessions. Blinder (1981) and Blinder and Maccini (1991) argue that, in typical US recession, “declining inventory investment accounts for most of the decline in GDP” (Hornstein, 1998, p. 49). Hornstein (1998) supports this claim and documents the peak-to-through decline of GDP and inventory investment during postwar recessions.

The behavior of inventory investment is of a major concern of economic analysts. This concern is supported by a fact that the relationship between inventory investment and GDP is one of the most pronounced regularities of the business cycle (Tatom, 1977). Tatom (1977) states that this relationship appears to be such a dominant factor U. S. recessions that they have been referred to as “inventory recessions”. The importance of inventory investment during recessions is reflected in the ratio of changes in inventory investment to changes in real GDP (Tatom, 1977). However, the author argues that the notion of an inventory recession involves more than the relative size of fluctuations in inventory investment and GDP and suggests a more general concept of an inventory cycle, of which an inventory recession is only one stage, and it implies a specific sequence of changes in inventory investment before, during, and after recessions.

Tatom (1977) gives a brief explanation on inventory cycle theory and defines inventory cycle as “a pattern of systematic fluctuations in economic activity associated with inventory adjustments”, and explains that these adjustments are alleged to arise because the desired level of inventory stocks is related primarily to the expected sales rate. Consequently, changes in expected sales affect inventory investment and changes in demand for inventory investment influence actual and expected sales. Thus, according to this theory, such changes in investment spending are believed to affect output and employment.

Tatom (1977) offers a scenario of how an inventory cycle might occur and explains it as follows. Some unexpected exogenous force increases aggregate spending and stimulates a corresponding change in production and employment. Firms, reacting to their new sales, attempt to change their inventory levels in the same direction through inventory investment. Thus, further changes in total spending, income, and employment tend to occur. As inventory approaches its desired level, firms reduce their rate of spending on inventories causing aggregate demand and output growth to slow. The slowing of output growth is reinforced since it leads to a further slowing of inventory investment. The reduction in inventory investment brings sales and growth to a halt at the cyclical peak. As inventory investment declines further, the economy enters a recession and firms may actually attempt to meet sales by selling off
inventory stocks. Inventory stocks fall relative to sales, so firms reach a point where inventory replacement is necessary, even to maintain the low recessionary sales rate. Inventory restocking increases demand for goods and services and provides the stimulus for a recovery and the ensuing expansion.

Two basic observations about recessions emerge from an inventory cycle theory (Tatom, 1977). According to the author, the first is that inventory investment declines before and during the early stages of such a recession, and often becomes negative before beginning to recover. Second, inventory investment tends to recover before the end of a recession.

3.4. INVENTORY INVESTMENT MODELS

Generally, there are three models which are well known in inventory theory and that try to reveal the relationship between inventory investment and business fluctuations. These models are:

1. Accelerator Model - the model relies in the basic hypothesis that is best described by words of Abramovitz (1950) saying that “Manufacturers and merchants are both desirous and able to maintain inventories in constant ratio to their output or sales”. The basic accelerator model was advanced by Lundberg (1937) and Metzler (1941) and involved a Buffer-Stock Model that recognized that the appropriate level of output is based upon anticipated sales and the current level of inventories and takes into account the errors made by firms in anticipating sales, which leads to discrepancies between actual, and desired (equilibrium) inventories. Abramovitz (1950) amongst first empirically tested the most elementary hypothesis of the model but actually showed that this most simple concept is not in convergence with his results. Later on a number of authors tried to make some modifications. One of the modifications led to the concept of Flexible Accelerator Model developed by Goodwin (1948) that assumed that firms attempt only a partial adjustment of stocks to their equilibrium level during each production period. This model was further developed by Lovell (1961) into the well-known Production-Smoothing Model.

2. Production-Smoothing Model (see Chapter 4.2.1.),

3. (S, S) Inventory Policy (see Chapter 4.2.1.)

The standard accelerator model assumption says that firms try to smoothly adjust their inventories toward a desired level of inventories that is linearly related to sales Inventory smoothing). The simple production-smoothing model says that firms use inventories to smooth production in face of fluctuating sales (production-smoothing). The third model that is actually a follow up of the previous one is the (S, s) inventory policy that says that firms will produce only if their inventory stocks fall below the trigger level s and then they try to produce enough to build their inventories to some target level S. In his work “Researching inventories: Why Haven’t We Learned More?” (1994), Lovell tried to determine the
reasons why up to date there is no one single model that successfully describes inventory investment. Among all Lovell (1994) mentions and makes critics on these, three models. However, there are many other models of inventory investment that try to describe the relationship between inventory investment and business fluctuations derived from the three basic models.

Tatom (1977) implies that if one is ought to test for a relationship between inventory investment and business fluctuations, then first of all it is useful to examine the relationship between inventory investment and sales, since the notion of an inventory recession follows from this relationship. A relationship between real inventory investment, \( I_t \), and changes in real output, \( GDP_t - GDP_{t-1} \), captures the importance of sales growth inherent in the inventory cycle theory (Tatom, 1977). This relationship is helpful in comparing actual or realized inventory investment with predicted inventory investment for obtaining the unintended level of inventory investment or excess inventory. Using a simple linear regression model Tatom (1977) obtains results implying that actual inventory investment exceeds predicted inventory investment during recessions in the U. S. The difference between the actual inventory investment and the predicted one are excess inventories, which have been accumulated during the recessions. According to Tatom (1977) when actual inventory investment goes above the predicted one based on output growth, this means that other factors, which affect inventory investment, dampen the severity of the recession keeping inventory investment high. The author further states that factors as shortages, price control terminations, and high inflation tend to push inventory investment above the levels of normally desired based on output growth alone thus forming high levels of excess inventories. More importantly, it could happened that firms apparently did not anticipate the recession, its length or its severity, and were slow to lower production rates and inventory investment during the fall of the output.

The second model that tries to explain inventory investment-output relationship is the Accelerator Model of Inventories, developed half a century ago (Mankiw, 2003). The Accelerator Model of Inventories assumes that firms hold a stock of inventories that is proportional to the firm’s level of output. According to the author, there are various reasons for this assumption. When output is high, manufacturing firms need more materials and supplies on hand, and they have more goods in the process of being completed. In addition, when the economy is booming, retail firms want to have more merchandise on stock to offer to customers.

Thus, if \( N \) is the economy’s stock of inventories and \( Y \) is output, then

\[
\Delta N = \beta Y, \quad (3-1)
\]
Where $\beta$ is a parameter reflecting how much inventory, firms wish to hold as a proportion of output. Inventory investment $I$ is the change in inventories $\Delta N$. Therefore,

$$I = \Delta N = \beta Y \quad (3-2)$$

The accelerator model predicts that inventory investment is proportional to the change in output. When output rises, firms want to hold a larger stock of inventories, so inventory investment is high. When output falls, firms want to hold a smaller stock of inventory, so they allow their inventory to run down, and inventory investment is negative. Because the variable $Y$ is the rate at which firms are producing goods, $\Delta Y$ is the “acceleration” of production. This model says that inventory investment depends on whether the economy is speeding up or slowing down.

Hornstein (1998) also made a brief analysis on inventory investment and its correlation with business cycles. He based his analysis on the fact that inventory investment, or changes in inventories $\Delta N$, are the difference between production, $Y$, and sales, $X$, that is $I = \Delta N = Y - X$. He used the two leading economic theories of inventory investment, namely, the Production Smoothing Model and the $(S, s)$ inventory model. According to Hornstein (1998) both theories start with a single firm that solves a dynamic constrained-profit-maximization problem using inventory investment as one of the firm’s decision variables, but they also differ in how the implications for inventory investment, derived for an individual firm, are applied to the study of aggregate inventory investment. Although both theories apply to an individual decision unit (firm), they cannot be used in the same way in order to understand the behavior of aggregate variables. In the case of production smoothing model, a concept of a representative agent is often used based on which the behavior of aggregate variable is interpreted according to the behavior of the representative agent. In the case of the $(S, s)$ inventory model, representative agent cannot be used and the aggregation has to be studied explicitly since the behavior of a firm assumed by this model is characterized by long period of inactivity interrupted by short bursts of activity. An interpretation of both theories follows and is given by Hornstein (1998).

A simple production-smoothing model starts with the assumption that a firm’s production is subject to increasing marginal cost and that sales are exogenous. If the firm’s sales are changing over time but its marginal cost schedule is constant, then the firm minimizes cost by smoothing production, and it reduces (increases) inventories whenever sales exceed (fall short of) production. Thus, production is less volatile than sales and inventory investment and sales tend to be negatively correlated. A firm with increasing marginal cost wants to use inventories to smooth production regardless of whether or not the changes in demand are foreseen. If demand changes randomly and the firm has to decide on current production before it knows what current demand is, the firm also uses inventories as a buffer stock and accordingly reduces (increases) inventory
stocks whenever demand is unexpectedly high (low). This buffer-stock motive then reinforces the negative correlation between inventory investment and sales. This argument holds when firm faces only demand shocks. If, however, the firm predominantly faces supply shocks in the form of a changing marginal cost schedule, then the implications for inventory investment, production, and sales are very different. In order to minimize costs, the firm now increases (decreases) production and accumulates (reduces) inventories during times when marginal cost is low (high). Thus, production is more volatile than sales, and inventory investment and production tend to be positively related. The simple production-smoothing model then predicts that production will be more (less) volatile than sales if supply shocks are more (less) important than demand shocks.

A simple \((S, s)\) inventory model assumes that the seller of a good does not himself produce the good but instead, the seller orders the good from some producer and incurs a fixed cost when he places the order. The model assumes that the marginal cost of ordering one more unit of the good is constant and that sales are exogenous. A seller who chooses the order size that minimizes total cost faces the following tradeoff. On the one hand, increasing the order size reduces the average or per-unit order cost because it spreads the fixed cost over more units of the good. On the other hand, an increased order size means that the seller forgoes additional interest income on the funds that have been used to finance the larger order. Given the optimal order size, the seller places an order whenever the inventory falls below a critical lower level \(s\) and the order brings inventories up to the higher level \(S\). After that, sales reduce the inventory until the critical lower level \(s\) is reached again. If orders equal production, then production will be more volatile than sales. The relationship between sales and inventory investment is unclear (Hornstein, 1998).

The following chapter presents both the production-smoothing and the \((S, s)\) model more in detail.

### 3.4.1. THE PRODUCTION-SMOOTHING AND THE \((S, s)\) INVENTORY MODEL

According to Blinder and Maccini (1991), “a microeconomic theory of inventory behavior begins by specifying a reason why firms hold inventories.” As noted in previous chapters, there are few reasons why organizations hold inventories. They most often do it either for operational, speculative, or precautionary reasons. Manufacturers, for example, may find inventories useful in scheduling production in order to try to smooth the production in the face of demand fluctuations. Blinder and Maccini (1991) specify these reasons in more precisely saying that inventories can be held for display purposes, to improve production scheduling, to minimize stockout costs, to speculate on or hedge against price movements, to reduce purchasing costs by buying in quantity, to shorten delivery lags, to smooth production in the face of fluctuating sales, and so on. The latter reason is of a most interest in inventory theory and is a basic specification of the production smoothing-buffer stock model, first introduced by
Lovell (1961) in his work “Manufacturers’ Inventories, Sales Expectations, and the Acceleration Principle”. According to Blinder and Maccini (1991), the main idea behind the model is if marginal production costs are increasing and sales vary across time, a cost-minimizing strategy that equates marginal costs across times will smooth production relative to sales.

As a standard empirical specification for testing the production-smoothing model, the following equation was proposed by Lovell (1961):

$$\Delta N_t = \lambda (N_t^* - N_t) - b(X_t - X_t^*) + u_t$$

Manufacturers perform a stock adjustment by accumulating inventories when demand is weak and liquidating them when demand is strong. In this equation inventory change (inventory investment), $\Delta N_t$ is the sum of two components. The first term is the planned or anticipated inventory investment which depends on the gap between actual, $N_t$, and desired inventories, $N_t^*$; desired inventories typically depend on expected sales, expected costs (wage rates, raw material prices, etc.), and current expected real interest rates. The second term, unanticipated inventory investment, captures the extent to which inventories buffer sales surprises, $(X_t - X_t^*)$. $\lambda$ captures the inventory adjustment speed. The size of $b$ measures the size of buffering.

Blinder and Maccini (1991) have noted that the theory of production smoothing rests on seemingly weak assumptions. According to the authors, the theory has difficulties in explaining why production is frequently, more variable than sales and why inventory investment and sales are positively correlated which are the facts that were empirically shown in macroeconomic inventory behavior theory. Although being under research from 1960’s, Blinder and Maccini (1991) state that “the theory’s empirical performance in its stock-adjustment form has been distinctly disappointing, producing implausibly low adjustment speeds, little evidence that inventories buffer sales surprises, and a lack of sensitivity of inventory investment to changes in interest rates.” They also argue is it productive to devote that much research to the application of production-smoothing/buffer-stock model to the analysis of manufacturers’ inventories of finished goods when these inventories are the least volatile component of inventory investment?

According to Blinder (1981) and Blinder and Maccini (1991), the production-smoothing/buffer stock model can also be applied to retailing firms with a difference in that retailing firms face constant or declining marginal costs due to quantity discounts and similar phenomenon. They state that just as a manufacturer with declining marginal costs will want to produce output in large lots, a retailer with declining marginal costs will want to “bunch orders to reduce costs”.
This simple idea is the foundation of the (S, s) model of optimal inventory behavior. The (S, s) inventory strategy means that inventories are allowed to dwindle to some minimum level, s, at which time a purchase restores inventories to their maximum level, S. The basic idea behind the (S, s) strategy is that, owing to the fixed costs\(^{10}\), it pays for a firm to place fewer orders, make each order larger, and store more inventories than it would if fixed costs did not exist (Blinder, 1981).

Hadley and Whitin (1963) suggests the following model for determining (S, s) optimal inventory policy, which explains the rationale behind:

\[
S - s = \sqrt{\frac{2\bar{X}}{r + d} \left[ \frac{A}{c} + \frac{\delta}{c} q(s) \right]},
\]

(3-4)

and

\[
1 - H(s) = \frac{S - s}{\bar{X}}\times \frac{c}{\delta} (r + d),
\]

(3-5)

where:

- \(\bar{X}\) = mean sales
- \(H(\bar{X})\) = cumulative distribution function of sales
- \(H(s)\) = the probability that sales will be less than s in a given period
- \(r\) = real interest rate
- \(d\) = storage cost per period (as a percent)
- \(\delta\) = a penalty cost for having an order unfilled per unit
- \(q(s)\) = mean number of unfilled orders, which will depend on s and on H(X)

Hadley and Whitin (1963) give an interpretation of the above equation. If the structure of cost or demand changes, so will S and s change. If either interest costs or storage costs increase, firms reduce both S and s but they change S more, so the optimal lot size, S-s, falls. If the fixed cost of ordering rises relative to the marginal cost, firms reduce s and increase the optimal lot size but the effects on S are ambiguous. An increase in the penalty for running out of stock causes both S and s to move up, but the effect on the lot size is indeterminate. If sales increase, firms rise both S and s and increase the optimal lot size.

\(^{10}\) When retailers are considered, reasons for this cost structure lie in warehousing and transportation costs, bookkeeping costs, scarcity of managerial time and attention. In the case of manufacturers these costs include costs of processing an order, getting the goods together and shipping them out, managerial time and attention, production runs, and so.
The (S, s) model of inventory behavior has a long history in the operations research and related literature. The pioneering paper on this topic was the one of Arrow, Harris, and Marschak, “Optimal Inventory Policy”, published in 1951. From then on, a number of variations of the basic (S, s) models were introduced by different authors. According to Blinder (1981) the basic (S, s) rule emerges as optimal inventory strategy only under a wide variety of assumptions. These assumptions include matters as what is random and what deterministic, when information on sales becomes available to firms, whether it is possible to accept unfilled orders, whether there are delivery lags, whether time is continuous or discrete, and so on. However, according to Blinder (1981), there are three main features of the firm’s economic environment that seem to be critical to the optimality of the (S, s) rule. First, the cost of acquiring goods from the manufacturer must be precisely given. Second, a firm’s sales and prices must be exogenous (they have to be taken into consideration as given; the firms does not have control over them). Third, the parameters underlying the firm’s optimization problem (its cost functions, probability distribution of sales, and so on) must be constant through time.

The S-s quantity is called the “optimum lot size” and depends on such variables as the fixed cost, the purchase price, the probability distribution of sales, and the interest rate. According to Blinder and Maccini (1991) the (S, s) model differs greatly from production-smoothing/buffer-stock model in that a firm following the (S, s) strategy as compared to the latter has neither an optimal level of inventory nor a speed of adjustment but instead it has an optimal range and whenever reaches the lower trigger point, it adjusts immediately; otherwise, it does not adjust at all.

Although (S, s) model is considered as more sophisticated one, when compared to production-smoothing/buffer-stock model, it has also significant weaknesses when reflecting reality. Blinder and Maccini (1991) note “it is clear that no single model can hope to explain the rich variety of inventory behavior” and that due to this any abstract theory must simplify and generalize. Due to the unrealistic approximation given in above assumptions, it can be concluded that the (S, s) optimal inventory policy is not only difficult to determine but is also difficult to implement and because of that it does not have a wide practical implication. Authors argue both on the assumptions as well as the practical implications of the (S, s) rule.

According to Blinder and Maccini (1991) the critical point with applying the (S, s) model is that the data economists generally have are aggregated over time across products and firms, and this model “does not lend itself easily to aggregation”11.

11 In inventory theory up to date, there was an effort in a number of research papers to make an aggregate (S, s) model. The first paper was introduced by Blinder (1981), and then came Caplin (1985), Caballero and Engel (1991), Fisher and Hornstein (2000), Khan and Thomas (2003), and so, all with less or more success.
The authors think that since firms react to the same sales shock differently depending on where they are in their (S, s) range the market is not representative of the firm-level behavior. M. C. Lovell\(^{12}\) also notes that the major disadvantage of the (S, s) rule is that the aggregation is extremely difficult, and that managers might be reluctant to adopt (S, s) policies for individual product lines because it is difficult to determine the combined cash flow implications. He states that it is conceivable that optimizing inventories on each product might lead to a larger total inventories, leading the managers to reject the rule. Further, M. C. Lovell states that “the aggregation problem creates major difficulties for the econometrician interested in the industry-wide implications of (S, s) inventory behavior; and the problem is confounded by the rich variety of responses that may be generated”. One kind of a constraint, noted by the author, is the case when some firms may be inhibited by limited storage capacity from enlarging stocks in response to an increase in sales volume.

However, Blinder (1981) conclude that (S, s) model permits a far richer variety of dynamic behavior pattern than does the conventional stock-adjustment model and it helps to understand why inventory dynamics are so hard to predict. In his comment on the work of Blinder (1981), L. H. Summers\(^{13}\) notes that “although the (S, s) model is to operations research what the Phillips curve once was to economics, its macroeconomic consequences ... have never been studied.”

Later on, in the work “Taking Stock: A Critical Assessment of Recent Research on Inventories” Blinder and Maccini (1991) argue about the divergence and convergence between microeconomic and macroeconomic theory upon the issue of inventories and name it as a “fascinating question that was barely explored”. In 1991, authors note how “no one seemed to notice the tension that was developing between the emerging macroeconomic and microeconomic views of inventories”. As an example the authors name the case of production-smoothing/buffer-stock model, explained in preceding paragraphs. They state that different macroeconomists have routinely thought of inventories as “destabilizing factor”. In theory, inventory accelerator, as Blinder and Maccini (1991) said, was creating cycles in economies that otherwise might not exist. On the other side, microeconomists thought of inventories as “stabilizing factor”, something a cost-minimizing firm could use to smooth production in the face of fluctuating sales. In 1991, Blinder and Maccini (1991) showed that GDP is more volatile than sales in most industries and considering these findings set up a question why is production more volatile than sales if firms use inventories to smooth the production. On the other hand, the (S, s) model sees no paradox because it views inventories as a way to make production more variable than sales even at a micro level (Blinder and Maccini, 1991).

\(^{12}\) Comment and Discussion by M. C. Lovell (Blinder, 1981)
\(^{13}\) Comment and Discussion by L. H. Summers (Blinder, 1981)
Hornstein (1998) states that since the two inventory models discussed above capture different features of the inventory holding problem, in any one sector of the economy, one of the features will play a bigger role. Thus, when firms in the manufacturing sector choose the size of their finished goods inventories, the production-smoothing model seems to be more appropriate. When firms in the trade sector make their order decisions, or firms in the manufacturing sector decide on the size of their materials inventories, the \( (S, s) \) inventory model seems to be more appropriate. However, in his study, Hornstein (1998) concludes that it is difficult to attribute aggregate inventory investment volatility to particular sectors because inventory investment moves much the same in each sector but he also finds that although important features of the inventory holding problem differ systematically across sectors, the properties of inventory investment, production and sales are remarkably similar across sectors – for business cycle movements, production is more volatile than sales, and inventory investment and sales are positively correlated.

Blinder and Maccini (1991) however note that the classical production-smoothing/buffer-stock model and the classical \( (S, s) \) model are not the only models that try to resolve the puzzle of inventories. A great number of other models and their variations are developed like the multi-sector model, then the stockout avoidance model, and so. However, the notion of these models should be on finding the convergence between the macroeconomic and firm-level inventory behavior. An already noted in the preceding section, inventory optimization across the whole supply chain reduces the need for additional inventory investments in each node and this is the point where microeconomic and macroeconomic aspects of inventory behavior converge. On one hand, lean production and lean distribution require less inventory investments both on firm and aggregate economy level, and on the other hand increased added value at a constant investment rate which leads towards a higher GDP on a macro level. A great example is the work of Lovell (2003) who showed that by merging two complementary disciplines, microeconomics and operations research, the introduction of JIT at the whole economy level may result both in lower prices and increased product variety from which all actors of the economy benefit.

An important fact that has to be considered when trying to find the convergence between macroeconomic and microeconomic inventory behavior is that it cannot be reached using the traditional cost approach. Instead, the net present value approach (NPV) should be used as proposed by Grubbström (1980). The impact of the firm-level decisions on GDP could not be resolved unless the objective function of the model, that is to be maximized, is estimated using the net present value approach (see Chapter 2.6.1.).

Although, firm-level inventory investment behavior is greatly influenced by the financial constraints firms face, this topic came to the interest only in the last decade. Since cash flow itself is very cyclical, it is of a great influence on inventory investment volatility. However, Lovell (1994) points to the potential
influence of financing constraints on inventory investment as a major unanswered question in inventory theory.

3.5. INVENTORY INVESTMENT CONSTRAINTS

During recessions, inventories fall sharply and return only gradually and in general slowly to their pre-recession levels. In contrast, production and sales rebound fast after each trough, with growth rates exceeding their long-term averages and have relatively more moderate declines during the recession itself (Kolev, 2005).

Investment decisions of firms are influenced by the financial constraints they face. In the periods after a trough, financially constrained firms do not have enough cash to bring the stock of inventories to their pre-recession levels, to invest in long-term production assets and satisfy growing demand for their goods at the same time. Consequently, inventory investment lags the recovery that consumer demand and investment in production assets experience immediately after a trough. Similarly, constraints on financing working capital may lead to drastic reduction of own stocks during recession. Besides, firms might find it suboptimal to invest their declining revenues in a short-term asset that does not pay well in the near future (Kolev, 2005).

When a firm wants to invest in new capital, say by building a new factory, it often raises the necessary funds in financial markets (Mankiw, 2003). This financing may take several forms: obtaining loans from banks, selling bonds to the public, or selling shares in future profits on the stock market. Yet sometimes firms face financial constraints – limits on the amount they can raise in financial markets. These financial constraints can prevent firms from undertaking profitable investments. When a firm is unable to raise funds in financial markets, the amount it can spend on new capital goods is limited to the amount it is currently earning. Financial constraints cause firms to determine their investment based on their current cash flow rather than expected profitability. According to Mankiw (2003), a recession reduces employment, the rental price of capital, and profits. If firms expect the recession to be short-lived, however, they will want to continue investing, knowing that their investment will be profitable in the future. A small recession will have only a small effect on Tobin’s $q$. For firms that can raise funds in financial markets, the recession should have only a small effect on investment. However, quite the opposite is true for firms facing financial constraints. The fall in current profits restricts the amount that these firms can spend on new capital goods and may prevent them from making profitable investments. Thus, financing constraints make investment more sensitive to current economic condition. Throughout history, problems with the banking system have often coincided with economic downturns. During and after recessions many banks find themselves insolvent, as the value of their assets fall below the value of their liabilities, and they are forced to suspend operations. Problems in the banking system were part of the Great Depression of
In the 1930s, recessions in Japan, Indonesia, at other. Banks have an important role in allocating financial resources between those who have income they want to save and those who have profitable investment projects but need to borrow to invest.

When banks become insolvent, or nearly so, they are less able to serve as an intermediary and financial constraints become more common and often lead banks to credit crunches. When a credit crunch prevents some firms from investing, the financial markets fail to allocate national saving to its best use. Less productive investment projects may take the place of more highly productive projects, reducing the economy’s potential for producing goods and services (Mankiw, 2003).

4. MACROECONOMIC ANALYSIS OF INVENTORY INVESTMENT IN THE SEE, 1970-2004

4.1. RESULTS OF BUDAPEST SCHOOL AND OF SOME OTHER RELEVANT AUTHORS

Although the contemporary inventory research deals with a great number of researches devoted to inventory problems, there are only few studies that rely on a multi-country data that try to reveal some similarities and dissimilarities in inventory behavior across various economies like Csikán et al. (1999, 2003, and 2005), Dimelis (2001), and Bagliano and Sembenelli (2003)\(^\text{14}\). The most exhausting multi-country macroeconomic research was done by Csikán et al. (1999, 2003, and 2005). However, up to date, there is no research devoted to this issue in the SEE countries.

In the work “A multi-country analysis of aggregate inventory behavior”, by analyzing data of 88 countries over a 20-year period (1970-1989), Csikán et al. (1999) have concluded, “inventory behavior is a very complex phenomenon, reflecting the effects of many factors”. The authors state that the most important factor explaining long-term inventory behavior are the simultaneous volumes of the change of GDP and the change of the foreign trade balance, followed by the simultaneous variable of investment in fixed assets and the one period lagged inventory investment.. According to Csikán et al. (1999), “the results confirm that no strong statement can be made about the connection between economic development and the long-term level of inventory investment”. However, there is a slight tendency that the OECD countries react faster than the non-OECD countries (by changing the intensity of inventory investment) (Csikán et al., 1999).

\(^{14}\) Bagliano and Sembenelli (2003) have analyzed macroeconomic (firm-level) data for France, Italy and the UK.
By analyzing 14, most developed world economies across a 30-year period (1968-1997) Csikán et al. (2005) showed that even though there is a general, although not very fast, decrease of inventory investment relative to GDP in the leading economies of the world, each country has its own particular characteristics of “inventory phenomena”. According to this Csikán et al. (2005) conclude that “no general regression model can be found to explain inventory behavior in different countries” but that “speeding up a growth of a country will lead with a high probability to larger inventories”. The authors have shown that in these countries inventory investment is higher in periods of higher growth, that fluctuations in inventory investments and fixed asset investments are correlated, and that inventory investments correlate negatively with foreign trade balance. The last finding indicates that inventory change and foreign trade are two alternative ways of adaption. In general Csikán et al. (2005) show that the relative size of inventory investments has declined in the past decade but they haven’t loose from their important role as an indicator of economic fluctuations and tendencies.

On the other side, Dimelis (2001) has investigated the business cycle properties of aggregate inventory investment in the countries of the 15 European Union (EU) countries and the US over a 34-year period (1960-1994). Dimelis (2001) states that business cycles of output, sales and inventory investment were found to be more volatile in the EU and that a strong procyclical behavior characterizes inventory investment in both the US and EU countries. According to the author, inventory investment is characterized by an almost identical destabilizing effect, causing output to fluctuate on average about 11% more than sales. Additionally, Dimelis (2001) shows that decline of the inventory investment have accounted for about 32% of the fall in output during the recessionary periods in the EU as opposed to 17% in the US and concludes that this sharp difference can possibly be attributed to more sophisticated inventory management techniques applied in the US. As a conclusion Dimelis (2001) notes that, “the procyclical behavior and destabilizing nature of aggregate inventory investment are not specific only to the US but characterize the EU economies to yet a larger extent. That makes even more crucial the need for endogenizing the role of inventories in the business cycle modeling”.

To my best knowledge, there is no study that addresses inventory investment behavior in the SEE Europe from neither macroeconomic nor microeconomic perspective. Thus, this should be the first study of that kind.

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15 Csikán et al. (2005) analysed the following most developed countries of the world: Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, Spain, Sweden, UK, and US.
4.2. RESEARCH METHODOLOGY

Although there is no consensus regarding the countries, which are considered as being a part of the Southeast Europe region in 1970-2004, the following eight countries were included in the analysis (Table 4-1):

Table 4-1: List of SEE countries included in the analysis with observation periods

<table>
<thead>
<tr>
<th>Country</th>
<th>Observed period</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL - Albania</td>
<td>1970-2004</td>
</tr>
<tr>
<td>BH - Bosnia and Herzegovina</td>
<td>1990-2004</td>
</tr>
<tr>
<td>BG - Bulgaria</td>
<td>1970-2004</td>
</tr>
<tr>
<td>CR - Croatia</td>
<td>1990-2004</td>
</tr>
<tr>
<td>MC - Macedonia</td>
<td>1990-2004</td>
</tr>
<tr>
<td>RO - Romania</td>
<td>1970-2004</td>
</tr>
<tr>
<td>SM - Serbia and Montenegro</td>
<td>1990-2004</td>
</tr>
<tr>
<td>YU – Yugoslavia (Former)</td>
<td>1970-1989</td>
</tr>
</tbody>
</table>

The data for these countries were taken from the United Nation’s National Accounts Main Aggregates Database. The analysis covers the period 1970-2004 for which data was available. Although high-frequency data is recommended to be used for macroeconomic analysis, only annual data could be collected. Since the period under observation falls between 1970 and 2004, Yugoslavia is also included up to 1989 in addition to other SEE countries. Until 1989 Bosnia and Herzegovina, Croatia, FYR Macedonia, Serbia and Montenegro, and Slovenia existed as a joint country under the name of Yugoslavia when they gained independence in 1991. Due to this, in certain parts of the analysis the observed period is divided in two sub-samples: one between 1970 and 1989, and the other between 1990 and 2004.

It should be noted that the main limitation of the research comes from the lack of appropriate secondary data. Although efforts were made to correct the data using additional data from other sources, the quality and the reliability of the data is still biased due to a great number of factors. These factors are the instability of the region, high inflation rates, presence of grey economy, different accounting standards, different methodology in calculating macro-aggregates and so. Thus, the results of this research should be interpreted with caution, respecting the data bias and possible errors as an unavoidable consequence.

The empirical research presented is based on a number of statistical procedures with the ultimate purpose to resolve the performance of the SEE region with regard to inventory investments in relationship to GDP, business fluctuations and other GDP components. Some results are later compared with the ones
obtained in other EU countries, namely Austria, Hungary, Italy, and Slovenia as well as with the results obtained by other researchers. These comparisons are done to show whether there are significant differences in inventory investment behavior pattern between different European countries as regards to the different level of their economic development. Criteria for country selection were based on their closeness to the SEE region as well as the time passed from their transition and acceptance in the EU. According to the last criteria, Hungary and Slovenia are categorized as new EU members since they were accepted in 2004, and Italy (founding member) and Austria (accepted in 1995) as old EU members.

4.3. ECONOMIC FLUCTUATIONS AND INVENTORY INVESTMENT BEHAVIOR IN THE SEE, 1970-2004

As mentioned above, economic fluctuations are most often measured by the fluctuations in real GDP growth rates. According to Hornstein (1998), business cycle is different from long-term trend and short-term irregular movements in the economy. In order to separate the time series of a variable into components with different periodicities and that way isolate the cyclical (irregular) component and get the trend (regular) components, different filters are used. These two components of GDP are presented on the example of Bulgaria on Figure (4-1).

Figure 4-1: Cyclical and trend component of GDP in Bulgaria, 1970-2004

Source: Own calculation (UNNAMAD, 2006)
By following the common research practice, in order to remove short-term fluctuations that are associated with the business cycle and reveal the long-term trend of real GDP, the Hodrick-Prescott filter (HP filter) was applied to time series of output, sales and inventory investments (see Hodrick and Prescott, 1997)16. Since the sample consists of annual data, the detrending is done following the suggestion of Ravn and Uhlig (2002) who have shown that the smoothing parameter to be used to detrend the time series with HP filter should vary by the fourth power of the frequency observation ratios. This means that for annual data a smoothing parameter of 6.25 is recommended.17 By applying the filter, the cyclical output growth, cyclical sales growth and the assigned volatility were obtained for SEE and for the four selected EU countries, divided in two sub-periods. The first sub-period includes years from 1970 up to 1989, and the second years from 1990-2004. The data are presented in Table (4-2) in addition to the average real GDP growth rates and the volatility assigned. As it can be seen from Table (4-2), the volatility of output growth in the SEE during the 1970-1989 varies from a low 2.44% in Yugoslavia to a high 5.22% in Romania. The average output volatility of the region (3.72%) during 1970-1989 significantly exceeds that of the selected EU countries (1.39%). This shows that, on average, output fluctuations in the SEE had somewhat higher amplitude than that of the selected EU countries. Regarding the volatility of sales in the same period, it seems that in the SEE, aggregate sales fluctuate slightly less than output over the cycle. In fact, the average standard deviation of cyclical sales is 3.46% in the SEE and 1.34% in the selected EU countries as opposed to 3.72% and 1.39% respectively, for cyclical output. According to Dimelis (2001), the average volatility of cyclical output in the US between 1960 and 1994 was 1.99% and the volatility of cyclical sales averaged 1.79%. For a sample of 15 EU countries in the same period 1960-1994, Dimelis (2001) calculates the volatility of cyclical output and cyclical sales to be at a level of 2.23% and 2.04%, respectively. Although between 1970 and 1989 SEE countries had somewhat higher output and sales growth rates (4.77% and 3.72%, respectively) than the sample of EU countries (2.99% and 3.05%, respectively) they have faced stronger economic fluctuations and uncertainty.

However, if we consider the second sub-period, 1990-2004, we get a bit different picture. Cyclical output volatility is not only higher in SEE than in selected EU countries (5.81% and 1.58% respectively) but has also risen as compared to the previous period. The same is the case with the volatility of cyclical sales (5.76% in SEE as compared to 1.75% in EU). However, the growth rates themselves are smaller in SEE that that of the selected EU countries, both for cyclical output and cyclical sales. This means that the period between 1990 and 2004 was

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16 The HP-filter is applied to time series using the STATA 9.2 application with “hprescott” syntax command.

17 For quarterly and monthly macroeconomic data the suggested smoothing parameter equals 1600 and 129,600, respectively.
much more volatile regarding economic fluctuations that the one before, and that the growth has slowed down.

Table 4-2: Real output growth rates, cyclical real output and sales growth rates and their relative volatility over the business cycle in the SEE and selected EU countries, 1970-2004\(^{18}\)

<table>
<thead>
<tr>
<th>Country</th>
<th>Average output growth rate, %</th>
<th>Cyclical real output growth rate, %</th>
<th>Cyclical sales growth rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>4.55</td>
<td>2.51</td>
<td>3.76</td>
</tr>
<tr>
<td></td>
<td>(3.95)</td>
<td>(11.40)</td>
<td>(3.10)</td>
</tr>
<tr>
<td>BH</td>
<td>-</td>
<td>8.03</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(22.39)</td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>5.29</td>
<td>-0.53</td>
<td>5.04</td>
</tr>
<tr>
<td></td>
<td>(2.36)</td>
<td>(6.04)</td>
<td>(2.85)</td>
</tr>
<tr>
<td>CR</td>
<td>-</td>
<td>0.49</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8.32)</td>
<td></td>
</tr>
<tr>
<td>RO</td>
<td>5.55</td>
<td>0.25</td>
<td>5.51</td>
</tr>
<tr>
<td></td>
<td>(5.25)</td>
<td>(6.43)</td>
<td>(5.22)</td>
</tr>
<tr>
<td>SM</td>
<td>-</td>
<td>-3.40</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(14.03)</td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>-</td>
<td>-0.42</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.23)</td>
<td></td>
</tr>
<tr>
<td>YU</td>
<td>3.56</td>
<td>-</td>
<td>3.53</td>
</tr>
<tr>
<td></td>
<td>(4.20)</td>
<td></td>
<td>(2.44)</td>
</tr>
<tr>
<td>Total SEE</td>
<td>4.74</td>
<td>0.99</td>
<td>4.77</td>
</tr>
<tr>
<td></td>
<td>(3.94)</td>
<td>(10.41)</td>
<td>(3.72)</td>
</tr>
<tr>
<td>AU</td>
<td>2.92</td>
<td>2.32</td>
<td>2.88</td>
</tr>
<tr>
<td></td>
<td>(2.05)</td>
<td>(1.22)</td>
<td>(1.03)</td>
</tr>
<tr>
<td>HU</td>
<td>3.30</td>
<td>1.34</td>
<td>3.09</td>
</tr>
<tr>
<td></td>
<td>(2.50)</td>
<td>(4.56)</td>
<td>(2.48)</td>
</tr>
<tr>
<td>IT</td>
<td>3.01</td>
<td>1.44</td>
<td>2.99</td>
</tr>
<tr>
<td></td>
<td>(2.10)</td>
<td>(1.05)</td>
<td>(0.65)</td>
</tr>
<tr>
<td>SL</td>
<td>-</td>
<td>2.32</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.18)</td>
<td></td>
</tr>
<tr>
<td>Other EU</td>
<td>3.08</td>
<td>1.85</td>
<td>2.99</td>
</tr>
<tr>
<td></td>
<td>(2.22)</td>
<td>(2.76)</td>
<td>(1.39)</td>
</tr>
</tbody>
</table>

Source: Own calculation (UNNAMAD, 2006)

---

\(^{18}\) Values in parenthesis represent standard deviations from the mean value.
Although economies experience in majority long-run positive average growth, except Serbia and Montenegro, Macedonia and Bulgaria in the period 1990-2004, which have negative growth, this growth is not at all steady. Although the term »cycle« suggests that these fluctuations are regular and predictable, they are not. The problem of economic fluctuations can be showed by illustrating the movements in detrended real GDP. An example is shown for Bulgaria during 1970-2004 on Figure (4-1) above.

Mankiw (2003) notes those periods when the production of goods and services is declining, incomes falls, and unemployment rises, which are represented by negative growth in real GDP, are called recessions. These periods are rather frequent in SEE. Table (4-3) shows when recessions have occurred in each SEE country during the period 1970-2004.

Table 4-3: Periods and rates of real GDP contractions in the SEE countries, 1970-2004 (HP-filtered)

<table>
<thead>
<tr>
<th>Country</th>
<th>&gt;10%</th>
<th>5-10%</th>
<th>&lt;5%</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>90-94 (92)</td>
<td>96-98 (96)</td>
<td>83-86 (84)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.2%</td>
<td>9.6%</td>
<td>3.1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BH</td>
<td>91-97 (94)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25.6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>-</td>
<td>90-94 (92)</td>
<td>96-99 (97)</td>
<td>83-86 (85)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.1%</td>
<td>4.7%</td>
<td>2.7%</td>
<td></td>
</tr>
<tr>
<td>CR</td>
<td>-</td>
<td>91-95 (93)</td>
<td>99-01 (00)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.6%</td>
<td>1.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RO</td>
<td>-</td>
<td>90-94 (92)</td>
<td>97-01 (99)</td>
<td>80-83 (82)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.7%</td>
<td>3.4%</td>
<td>2.8%</td>
<td></td>
</tr>
<tr>
<td>SM</td>
<td>91-95 (93)</td>
<td>98-01 (99)</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22.6%</td>
<td>5.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>-</td>
<td>-</td>
<td>91-96 (93)</td>
<td>01-03 (02)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3.1%</td>
<td>2.0%</td>
<td></td>
</tr>
<tr>
<td>YU</td>
<td>-</td>
<td>-</td>
<td>72-77 (73)</td>
<td>88-89 (89)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.0%</td>
<td>1.9%</td>
<td></td>
</tr>
</tbody>
</table>

*Troughs are presented in parenthesis.

*Source: Own calculation (UNNAMAD, 2006)*

For the purpose of further analysis, recessions are considered when the fluctuation of cyclical real GDP declines for two consecutive periods. Recessions in the SEE countries between 1970 and 2004 are very close together and none of them exceeds six years. In the observed period, they happened in the interval of either 3, or 5, or six years. However, these intervals are not considered regular.

According to Mankiw (2003), “investment is the most volatile component of GDP” and much of the GDP decline during recessions is usually assigned to a drop in investments. During recessions, total investments fall substantially and often, become negative. Table (4-4) presents the average total investments to GDP ratio,
the assigned ratio volatility measured by the standard deviation during 1970-2004 and the ratio level in 2004 for the SEE countries. These results show that in the SEE countries, the average investment accounts for about one-fourth of GDP (25.4%). In developed economies, such as the US, investments represent around 20-30% of the GDP. Moreover, according to the results, total investments are most volatile in Albania, Bosnia and Herzegovina, and Bulgaria (11.3%, 9.2%, and 8.3%, respectively).

Table 4-4: Total investments as a share of GDP in the SEE countries, 1970-2004

<table>
<thead>
<tr>
<th>Country</th>
<th>Total investment as a share in real GDP (%)</th>
<th>Volatility of total investment to real GDP (%)</th>
<th>Investment share in GDP in 2004 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>32.7</td>
<td>11.3</td>
<td>52.2</td>
</tr>
<tr>
<td>BH</td>
<td>23.2</td>
<td>9.2</td>
<td>19.3</td>
</tr>
<tr>
<td>BG</td>
<td>24.8</td>
<td>8.3</td>
<td>22.6</td>
</tr>
<tr>
<td>CR</td>
<td>21.2</td>
<td>6.3</td>
<td>30.2</td>
</tr>
<tr>
<td>RO</td>
<td>29.3</td>
<td>6.1</td>
<td>23.1</td>
</tr>
<tr>
<td>SM</td>
<td>14.2</td>
<td>2.8</td>
<td>11.2</td>
</tr>
<tr>
<td>MC</td>
<td>19.4</td>
<td>2.2</td>
<td>19.8</td>
</tr>
<tr>
<td>YU</td>
<td>38.4</td>
<td>3.0</td>
<td>-</td>
</tr>
<tr>
<td>Total SEE</td>
<td>25.4</td>
<td>6.1</td>
<td>25.5</td>
</tr>
</tbody>
</table>

Source: Own calculation (UNNAMAD, 2006)

According to a number of researches done, the most volatile component of total investments is inventory investments, which add the most to both total investment and GDP volatility. According to Hornstein (1998) the reasons for attention on inventory investment appears to be related to three issues. First, changes in inventory investment apparently account for a substantial fraction of changes in GDP. Second, current changes in inventory investment are assumed to convey useful information about the near-term future of the economy. Third, there is a view that the inherent dynamics of inventory investment are destabilizing the economy. The argument that inventory investment is important for the business cycle is often based on the close relationship between changes in inventory investment and GDP during recession. As already mentioned, although inventory investment is one of the smallest components, averaging about 1 percent of GDP in US (Mankiw, 2003) Blinder (1981) and Blinder and Maccini (1991) showed that, in typical US recession, “declining inventory investment accounts for most of the decline in GDP” and these values range from 30-60% in a typical US recession. Table (4-5) shows the share of inventory investment to GDP in SEE and the selected EU countries in the two sub-periods as well as the volatility assigned to it.
Table 4-5: Inventory investment as a share of GDP in the SEE and selected EU countries, 1970-2004 (HP-filtered)

<table>
<thead>
<tr>
<th>Country</th>
<th>Inventory investment as a share of GDP, %</th>
<th>Volatility of GDP relative to sales, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>0.10</td>
<td>18.66</td>
</tr>
<tr>
<td></td>
<td>(1.85)</td>
<td>(9.46)</td>
</tr>
<tr>
<td>BH</td>
<td>-</td>
<td>2.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.94)</td>
</tr>
<tr>
<td>BG</td>
<td>6.95</td>
<td>1.79</td>
</tr>
<tr>
<td></td>
<td>(0.41)</td>
<td>(2.18)</td>
</tr>
<tr>
<td>CR</td>
<td>-</td>
<td>1.82</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.87)</td>
</tr>
<tr>
<td>RO</td>
<td>4.94</td>
<td>3.29</td>
</tr>
<tr>
<td></td>
<td>(1.75)</td>
<td>(3.55)</td>
</tr>
<tr>
<td>SM</td>
<td>-</td>
<td>1.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.58)</td>
</tr>
<tr>
<td>MC</td>
<td>-</td>
<td>2.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.36)</td>
</tr>
<tr>
<td>YU</td>
<td>12.40</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(5.58)</td>
<td></td>
</tr>
<tr>
<td>Total SEE</td>
<td>6.05</td>
<td>4.51</td>
</tr>
<tr>
<td></td>
<td>(2.05)</td>
<td>(3.42)</td>
</tr>
<tr>
<td>AU</td>
<td>0.67</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
<td>(0.33)</td>
</tr>
<tr>
<td>HU</td>
<td>2.72</td>
<td>2.32</td>
</tr>
<tr>
<td></td>
<td>(1.29)</td>
<td>(2.52)</td>
</tr>
<tr>
<td>IT</td>
<td>0.79</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.12)</td>
</tr>
<tr>
<td>SL</td>
<td>-</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.00)</td>
</tr>
<tr>
<td>Other EU</td>
<td>1.39</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>(0.62)</td>
<td>(0.99)</td>
</tr>
</tbody>
</table>

Source: Own calculation (UNNAMAD, 2006)

As it can be seen from Table (4-5), this ratio is usually quite small. During 1970-1989, inventory investment as a share of output in SEE has ranged from a low of 0.10% in Albania to 12.40% with an average of 6.05% for the whole region. During 1990-2004, the ratio has fallen to 4.51% on average for the SEE region, and has ranged between 1.45% for Serbia and Montenegro and 18.66% for Albania. In the selected EU countries, these values were quite smaller in both sub-periods (1.39% and 0.97%, respectively) and are much closer to the value of 1% for US obtained by Blinder and Maccini (1991). Dimelis (2001) has obtained similar results during 1960-1994, namely, 0.62% for the sample of 15 EU countries, and 0.70% for US. Thus, it can be concluded that in the SEE realm, the inventory investment as a share of GDP has been relatively low and has shown a downward trend during the 1990s.

19 Volatility, measured by the standard deviation, is shown in parenthesis.
countries, inventory investments have a higher share in real GDP than in both EU and US.

In addition to the inventory investment to GDP ratio, the volatility of GDP relative to sales was also calculated, and is shown in the last column of Table (4-5). It shows by how much, in percentage terms, is output more volatile than sales over the business cycle. Since sales are calculated as real output less real inventory investments, this ratio is a measure of the contribution of inventory investments to the overall economic instability (Dimelis, 2001). A positive number means that inventory investment has a destabilizing effect on overall economy, and a negative value shows that it has a stabilizing effect. According to the results, in SEE, during the 1970-1989, inventory investment has shows the largest destabilizing effect in Bulgaria where the production was for 29% more volatile than sales. In the second sub-period, 1990-2004, this ratio has a highest average value in Croatia and again Bulgaria. It can be noticed that during 1990-2004, all selected EU countries have negative values except Austria. The reverse is true in the first sub-period. It can be concluded that during 1970-1989, in the SEE countries production has been 7.69% more volatile than sales, meaning that inventories have shown a destabilizing effect on the overall economy. However, the ratio has substantially fallen in the upcoming period to 0.76%. On the other hand, during 1990-2004, production has been less volatile than sales in the selected EU countries for 9.46% implying a stabilizing inventory effect. Although still slightly positive in SEE countries, the ratio has substantially fallen between the two sub-periods both in SEE and between selected EU countries. According to these results, it can be supposed that inventories have played a stabilizing role on the economy during the transition between the two sub-periods.

Tatom (1977) states that in US, most of the extremely high levels of the ratio of changes in inventory investment to output fluctuations occurred during recessions. Table (4-6) shows the extent to which the changes in inventory investment have accounted for the fall in real GDP during recessions in the SEE countries between 1970 and 2004.

Overall, declines in inventory investment have accounted for about 198.71% of the output fall in the SEE countries, significantly higher than in other EU countries (34.06%). Dimelis (2001) has obtained almost the same results for the period 1960-2004 showing that the decline in inventory investment have accounted for about 32% of the output fall in 15 EU countries.
Table 4-6: Decline of inventory investment as a percentage of the decline in output during recessions, 1970-200420

<table>
<thead>
<tr>
<th>Country</th>
<th>Recession periods</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;10%</td>
<td>5-10%</td>
</tr>
<tr>
<td>AL</td>
<td>90-94 (92)</td>
<td>96-98 (96)</td>
</tr>
<tr>
<td></td>
<td>-419.99</td>
<td>371.48</td>
</tr>
<tr>
<td>BH</td>
<td>91-97 (94)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>4.68</td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>-</td>
<td>90-94 (92)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-125.74</td>
</tr>
<tr>
<td>CR</td>
<td>-</td>
<td>91-95 (93)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-268.65</td>
</tr>
<tr>
<td>RO</td>
<td>90-94 (92)</td>
<td>97-01 (99)</td>
</tr>
<tr>
<td></td>
<td>-178.03</td>
<td>-141.10</td>
</tr>
<tr>
<td>SM</td>
<td>91-95 (93)</td>
<td>98-01 (99)</td>
</tr>
<tr>
<td></td>
<td>-20.84</td>
<td>182.50</td>
</tr>
<tr>
<td>MC</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-20.04</td>
</tr>
<tr>
<td>YU</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>145.74</td>
</tr>
<tr>
<td>Total SEE</td>
<td>70-79</td>
<td>80-89</td>
</tr>
<tr>
<td></td>
<td>78.21</td>
<td>619.75</td>
</tr>
<tr>
<td>AU</td>
<td>27.13</td>
<td>15.34</td>
</tr>
<tr>
<td>HU</td>
<td>84.80</td>
<td>60.03</td>
</tr>
<tr>
<td>IT</td>
<td>24.96</td>
<td>31.67</td>
</tr>
<tr>
<td>SL</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other EU</td>
<td>45.63</td>
<td>35.68</td>
</tr>
</tbody>
</table>

Source: Own calculation (UNNAMAD, 2006)

In addition to basic statistical calculations that try to interpret aggregate data there are many models of inventory investment developed that try to describe the relationship between inventory investment and business fluctuations. Some of these models are presented in the following chapter.

4.4. EMPIRICAL TESTS OF INVENTORY INVESTMENT MODELS IN THE SEE

There are many models of inventory investment. As already mentioned in the theoretical framework in the previous chapter, Tatom (1977) suggests that it is also useful to examine the relationship between inventory investment and sales, since the notion of an inventory recession follows from this relationship. A simple illustration of the relationship between real inventory investment, $I_t$, and changes in real output, $GDP_t - GDP_{t-1}$, is given for the SEE countries for three

---

20 Years in parenthesis represent the year of trough in each recession.
periods between 1970 and 2004 presented in Table (4-7). This relationship captures the importance of sales growth inherent in the inventory cycle theory. This is done in order to compare actual or realized inventory investment with predicted inventory investment for obtaining the unintended level of inventory investment or excess inventory. According to the inventory-output relationship obtained using a simple linear regression model for each of the SEE countries, charts are drawn for Albania and Romania, which show the predicted inventory investment based on output changes. Due that data could not be obtained for all SEE countries for the same period, and that data for Former Yugoslav countries covers only a short period, the analysis is adapted to this bias.

Table 4-7: Simple inventory investment models for the SEE countries in two sub-periods, mil 1990 USD, 1970-2004

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>1970-1989</td>
<td>$I_t=-24.595+0.390(GDP_t-GDP_{t-1})$</td>
<td>$I_t=357.33+1.625(GDP_t-GDP_{t-1})$</td>
<td>$I_t=78.499+1.437(GDP_t-GDP_{t-1})$</td>
</tr>
<tr>
<td></td>
<td>R²=0.278</td>
<td>R²=0.449</td>
<td>R²=0.253</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F=6.154</td>
<td>F=5.697</td>
<td>F=8.798</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.=0.025</td>
<td>Sig.=0.048</td>
<td>Sig.=0.006</td>
<td></td>
</tr>
<tr>
<td>BH</td>
<td>1990-1997</td>
<td>$I_t=26.029+0.045(GDP_t-GDP_{t-1})$</td>
<td>$I_t=-98.139+0.533(GDP_t-GDP_{t-1})$</td>
<td>$I_t=17.598+0.180(GDP_t-GDP_{t-1})$</td>
</tr>
<tr>
<td></td>
<td>R²=0.191</td>
<td>R²=0.995</td>
<td>R²=0.819</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F=1.417</td>
<td>F=188.827</td>
<td>F=36.133</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.=0.279</td>
<td>Sig.=0.046</td>
<td>Sig.=0.000</td>
<td></td>
</tr>
<tr>
<td>BG</td>
<td>1970-1989</td>
<td>$I_t=2,004.2+0.263(GDP_t-GDP_{t-1})$</td>
<td>$I_t=303.97+0.089(GDP_t-GDP_{t-1})$</td>
<td>$I_t=1,018.4+0.399(GDP_t-GDP_{t-1})$</td>
</tr>
<tr>
<td></td>
<td>R²=0.023</td>
<td>R²=0.052</td>
<td>R²=0.089</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F=0.208</td>
<td>F=0.602</td>
<td>F=2.161</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.=0.659</td>
<td>Sig.=0.454</td>
<td>Sig.=0.156</td>
<td></td>
</tr>
<tr>
<td>CR</td>
<td>1990-1997</td>
<td>$I_t=74.723+0.358(GDP_t-GDP_{t-1})$</td>
<td>$I_t=-929.81+1.558(GDP_t-GDP_{t-1})$</td>
<td>$I_t=-556.1+1.031(GDP_t-GDP_{t-1})$</td>
</tr>
<tr>
<td></td>
<td>R²=0.085</td>
<td>R²=0.755</td>
<td>R²=0.510</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F=0.186</td>
<td>F=12.338</td>
<td>F=8.322</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.=0.709</td>
<td>Sig.=0.025</td>
<td>Sig.=0.020</td>
<td></td>
</tr>
<tr>
<td>RO</td>
<td>1970-1989</td>
<td>$I_t=643.75+0.515(GDP_t-GDP_{t-1})$</td>
<td>$I_t=1,332.7-0.429(GDP_t-GDP_{t-1})$</td>
<td>$I_t=971.00+0.172(GDP_t-GDP_{t-1})$</td>
</tr>
<tr>
<td></td>
<td>R²=0.743</td>
<td>R²=0.336</td>
<td>R²=0.067</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F=49.044</td>
<td>F=6.567</td>
<td>F=2.171</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sig.=0.000</td>
<td>Sig.=0.024</td>
<td>Sig.=0.151</td>
<td></td>
</tr>
</tbody>
</table>

(Continuing on Page 73.)
### SM

<table>
<thead>
<tr>
<th>Period</th>
<th>Regression Equation</th>
<th>R-squared</th>
<th>F-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-1997</td>
<td>$I_t = 632.139 + 0.012(GDP_t - GDP_{t-1})$</td>
<td>0.404</td>
<td>4.066</td>
<td>0.090</td>
</tr>
<tr>
<td>1998-2004</td>
<td>$I_t = 328.48 + 0.455(GDP_t - GDP_{t-1})$</td>
<td>0.112</td>
<td>0.502</td>
<td>0.518</td>
</tr>
<tr>
<td>1990-2004</td>
<td>$I_t = 255.27 + 0.018(GDP_t - GDP_{t-1})$</td>
<td>0.081</td>
<td>1.060</td>
<td>0.324</td>
</tr>
</tbody>
</table>

### MC

<table>
<thead>
<tr>
<th>Period</th>
<th>Regression Equation</th>
<th>R-squared</th>
<th>F-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990-1997</td>
<td>$I_t = 95.433 + 0.630(GDP_t - GDP_{t-1})$</td>
<td>0.749</td>
<td>14.903</td>
<td>0.012</td>
</tr>
<tr>
<td>1998-2004</td>
<td>$I_t = 164.595 + 0.036(GDP_t - GDP_{t-1})$</td>
<td>0.012</td>
<td>0.049</td>
<td>0.835</td>
</tr>
<tr>
<td>1990-2004</td>
<td>$I_t = 103.625 + 0.52(GDP_t - GDP_{t-1})$</td>
<td>0.622</td>
<td>18.124</td>
<td>0.001</td>
</tr>
</tbody>
</table>

### YU

<table>
<thead>
<tr>
<th>Period</th>
<th>Regression Equation</th>
<th>R-squared</th>
<th>F-value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-1979</td>
<td>$I_t = 1,510.36 + 0.32(GDP_t - GDP_{t-1})$</td>
<td>0.227</td>
<td>2.051</td>
<td>0.195</td>
</tr>
<tr>
<td>1980-1989</td>
<td>$I_t = 5,530.20 + 0.71(GDP_t - GDP_{t-1})$</td>
<td>0.032</td>
<td>0.234</td>
<td>0.643</td>
</tr>
<tr>
<td>1970-1989</td>
<td>$I_t = 5,235.68 - 1.35(GDP_t - GDP_{t-1})$</td>
<td>0.208</td>
<td>4.196</td>
<td>0.057</td>
</tr>
</tbody>
</table>

**Source: Own calculation (UNNAMAD, 2006)**

As an example, for Albania and Romania predictions were made for the 1990-2004 period based on 1970-1989 data and are shown in Figure (4-2) and (4-3), respectively. For the rest of the countries only a simple linear model was developed in order to count for the relationship between inventory investment and output change. The observed periods upon which the data was observed are divided in two sub-periods which and they differ such that for Bosnia and Herzegovina, Croatia, Serbia and Montenegro and Macedonia the observed periods are between 1990-1997 and 1998-2004, for Albania, Bulgaria and Romania between 1970-1989 and 1990-2004, while for Yugoslavia between 1970-1979 and 1980-1989. This period separation was done because of a high volatility of the relationship between the inventory investment and changes in output due to oft downturns and instabilities assigned to the SEE countries during 1970-2004. As mentioned in Chapter (4.3.) There were 18 recessions assigned to the SEE countries in the 24-year period under observation.

As shown on the charts, in the case of Albania and Romania, the predicted inventory investment based on output changes is markedly different from the actual inventory investment behavior. However, the patterns are similar although not at the same level. According to Tatom’s analysis (1977), actual inventory investment exceeds predicted inventory investment during recessions in the U. S. This is true for the case of Albania, Macedonia, Romania, and Yugoslavia. In Bosnia and Herzegovina, there was no recession between 1998 and 2004 thus the relationship could not be examined. The same is with Croatia. In the rest of the SEE countries, namely, in Bulgaria and Serbia and Montenegro, this relationship between actual and predicted inventory
investment in recessions was not the case and showed a reverse pattern. During the recessions in Albania, Macedonia, Romania, and Yugoslavia, actual inventory investment exceeded, by large amounts, predicted inventory investment.

Figure 4-2: A simple inventory investment model, Albania, 1970-2004

Albania:
\[ I_t = -189.86 + 0.352(GDP_t - GDP_{t-1}) \]
\[ R^2 = 0.224 \]
Observed period: 1970-1989 \[ F = 4.918 \]
Forecasted period: 1990-2004 \[ \text{Sig.} = 0.04 \]

Source: Own calculation (UNNAMAD, 2006)

The difference between the actual inventory investment and the predicted one are excess inventories, which have been accumulated during the recessions. According to Tatomin (1977) when actual inventory investment goes above the predicted one based on output growth, this means that other factors, which affect inventory investment, dampen the severity of the recession keeping inventory investment high. The author further states that factors as shortages, price control terminations, and high inflation tend to push inventory investment above the levels of normally desired based on output growth alone thus forming high levels of excess inventories. More importantly, it could happened that firms
apparently did not anticipate the recession, its length or its severity, and were slow to lower production rates and inventory investment during the fall of the output. In Romania and Macedonia, firms continued to invest in excess inventories until the end of the recession when they actually started to deplete these excess inventories. However, in Yugoslavia and Albania, firms continued to invest in excess inventories also after the end of the recession.

Figure 4-3: A simple inventory investment model, Romania, 1970-2004

Romania:
\[ I_t = 14,571.3 + 0.512(GDP_t - GDP_{t-1}) \]
\[ R^2 = 0.74 \]
Observed period: 1970-1989
Forecasted period: 1990-2004
\[ F = 48.484 \]
\[ \text{Sig.} = 0.000 \]

Source: Own calculation (UNNAMAD, 2006)

When inventory investment reaches negative levels this means that firms deplete their excess inventories meaning that they sold it off as in the case of Albania during the 1990-1992 recession and Romania during the 1997-1999 recessions. However, in the case of Romania a different pattern could be noticed. It can be seen from the graph that actual inventory investment starts to fall sharply during the 1990-1992 recession and continues to fall reaching the trough at the end of the second recession in 1999 when it starts to recover but until 2004 it
not goes above the predicted inventory investment thus excess inventories are not accumulated. The behavior of inventory investment in Albania, Romania, Macedonia, and Yugoslavia shows that firms under-anticipated the length and severity of the decline in output. While the inventory investment rate declined throughout the recessions, it remained positive and large forming huge excess inventories.

As noted above in the theoretical framework, the second model that well explains inventory investment is the Accelerator Model of Inventories. The accelerator model of inventories assumes that firms hold a stock of inventories that is proportional to the firm’s level of output (Mankiw, 2003).

According to the author, there are various reasons for this assumption. When output is high, manufacturing firms need more materials and supplies on hand, and they have more goods in the process of being completed. In addition, when the economy is booming, retail firms want to have more merchandise on stock to offer to customers. The accelerator model predicts that inventory investment is proportional to the change in output. When output rises, firms want to hold a larger stock of inventories, so inventory investment is high. When output falls, firms want to hold a smaller stock of inventory, so they allow their inventory to run down, and inventory investment is negative. Because the variable $Y$ is the rate at which firms are producing goods, $\Delta Y$ is the “acceleration” of production. This model says that inventory investment depends on whether the economy is speeding up or slowing down. Based on the data from UNNAMAD data for all seven SEE countries, an evidence for the accelerator model can be shown. Current GDP in USD, current changes in inventory in USD, and the GDP Deflator in USD were taken out in order do get the change in real GDP and the real inventory investment. Depending on the period for which data could be obtained, scatter plots were drawn, represented by Figure (4-4) on the next page to show the correlation between the real change in GDP and the real inventory investment, as proposed by the model. Scatter plots on Figure (4-4) show that inventory investment is high in years when real GDP rises and low in years when real GDP falls. Results obtained undoubtedly show that the relationship described by the accelerator model exists in all the seven SEE countries. However, the model not holds for Yugoslavia since the correlation between real inventory investment and real GDP is negative. Correlation between these two variables is shown with trend lines plotted on the scatter plots. Although, results obtained for Bosnia and Herzegovina, Romania, Serbia and Montenegro, and Macedonia, initially suggested different trends, with very weak negative correlation between the real inventory investment and real GDP. In order to look for extreme values or outliers, which can mislead the results, and exclude them from analysis, box plots were made. These years are: 1990 for Bosnia and Herzegovina, 1991 for Romania, 1990-1993 and 1999 for Serbia and Montenegro, and 1990 for Macedonia, and coincide with the years of either the whole recessions period (Serbia and Montenegro), year of the beginning of recession (Bosnia and Herzegovina and Macedonia) or with the year of the
recession trough (Romania) in these countries. Thus, these data were considered
as extreme values and were taken out when plotting the trend line. As
mentioned above, parameter $\beta$ reflects how much inventory firms wish to hold as
a proportion of output. $\beta$ parameters for each country are shown in the Table (4-
8). According to the data, for every one USD that GDP rises, there is 1.80 USD of
inventory investment in Albania, 0.20 USD of inventory investment in Bosnia
and Herzegovina, 0.10 USD in Bulgaria, 0.50 USD in Croatia, 0.40 USD in
Romania, 0.20 USD in Serbia and Montenegro, and 0.40 USD in Macedonia.
However, as shown in the scatter plot analysis, the correlation between inventory
investment and GDP change in Yugoslavia during 1970-1989 was negative,
which is also shown by the Pearson’s correlation coefficient in the table below.
The negative correlation means that for every one USD that GDP rose there was
a 1.50 USD decrease in inventory investment. Pearson’s correlation coefficients
were calculated to support the obtained results (Table 4-8). It can be seen that
five of eight countries show significant correlations, from which three show a
strong positive correlation (Albania, Bosnia and Herzegovina, and Macedonia),
one shows a strong negative correlation (Yugoslavia), one shows a moderate
positive correlation (Croatia), and three imply insignificant correlations (Bulgaria,
Romania, and Serbia and Montenegro). Inventory investment in SEE is high in
years when real GDP rises and low in years when real GDP falls. Results
obtained undoubtedly show that the relationship described by the accelerator
model exists in all the seven SEE countries. However, the model not holds for
Yugoslavia since the correlation between real inventory investment and real GDP
change is negative.

Table 4-8: Relationship between inventory investment and the change in GDP - $\beta$
parameters, SEE, 1970-2004

<table>
<thead>
<tr>
<th>Country</th>
<th>$\beta$ parameter</th>
<th>Relationship between inventory investment and GDP change</th>
<th>Pearson’s correlation coefficients$^{21}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL</td>
<td>1.8</td>
<td>I=1.8$\Delta Y$</td>
<td>0.503***</td>
</tr>
<tr>
<td>BH</td>
<td>0.2</td>
<td>I=0.2$\Delta Y$</td>
<td>0.905***</td>
</tr>
<tr>
<td>BG</td>
<td>0.1</td>
<td>I=0.1$\Delta Y$</td>
<td>0.299</td>
</tr>
<tr>
<td>CR</td>
<td>0.5</td>
<td>I=0.5$\Delta Y$</td>
<td>0.714**</td>
</tr>
<tr>
<td>RO</td>
<td>0.4</td>
<td>I=0.4$\Delta Y$</td>
<td>0.260</td>
</tr>
<tr>
<td>SM</td>
<td>0.2</td>
<td>I=0.2$\Delta Y$</td>
<td>0.285</td>
</tr>
<tr>
<td>MC</td>
<td>0.4</td>
<td>I=0.4$\Delta Y$</td>
<td>0.789***</td>
</tr>
<tr>
<td>YU</td>
<td>1.5</td>
<td>I=1.5$\Delta Y$</td>
<td>-0.456*</td>
</tr>
</tbody>
</table>

*Source: Own calculation (UNNAMAD, 2006)*

$^{21}$ * - significance at 10 percent level, ** - significance at 5 percent level, *** - significance at 1
percent level
Figure 4-4: Inventory accelerator model for the SEE countries, 1970-2004

Albania

Bosnia and Herzegovina

Bulgaria

(Continuing on Page 79.)
Croatia

Romania

Serbia and Montenegro

(Continuing on Page 80.)
4.5. CONCLUDING REMARKS

The macroeconomic analysis, presented in the rows above, was an effort to try to gain a better insight on the inventory investment behavior in the SEE countries in the period between 1970 and 2004. The argument that inventory investment is important for the business cycle, which is based on the close relationship between changes in inventory investment and GDP, holds true for the SEE countries. Inventory investment and GDP change during recessions in SEE are highly correlated which implies that inventory investment in SEE is important for the business cycle. However, SEE shows a noisier pattern of business cycles due to oft recessions and wars as compared to US. Inventory investment in SEE is high in years when real GDP rises and low in years when real GDP falls. Results obtained undoubtedly show that the relationship described by the accelerator model exists in all the seven SEE countries. However, the model not holds for Yugoslavia since the correlation between real inventory investment and real GDP change is negative. In order to benchmark...
the results some comparisons were made with results obtained for four selected
EU countries to reveal the similarities between the two regions. It was shown
that recessions in the SEE countries between 1970 and 2004 were very close
together and none of them exceeded six years. In the observed period, they
happened in the interval of either 3, or 5, or six years. The average output
volatility of the region during 1970-1989 significantly exceeded that of the
selected EU countries. This shows that, on average, output fluctuations in the
SEE had somewhat higher amplitude than that of the selected EU countries.
Regarding the volatility of sales in the same period, it seems that in the SEE,
aggregate sales fluctuate slightly less than output over the cycle. Although
between 1970 and 1989, SEE countries had somewhat higher output and sales
growth rates than the sample of EU countries, they have faced stronger
economic fluctuations and uncertainty. In the second sub-period, 1990-2004,
cyclical output volatility is not only higher in SEE than in selected EU countries
but has also risen as compared to the previous period. The same is the case with
the volatility of cyclical sales. The growth rates themselves are smaller in SEE
that that of the selected EU countries, both for cyclical output and cyclical sales.
This means that the period between 1990 and 2004 was much more volatile
regarding economic fluctuations that the one before, and that the growth has
slowed down. In the SEE countries, the average investment accounts for about
one-fourth of GDP. This number coincides with results obtained for EU countries
and US as well. In the SEE, total investments are most volatile in Albania,
Bosnia and Herzegovina, and Bulgaria. During 1970-1989, inventory investment
as a share of output in SEE has averaged 6.05%. Inventory investment as a
share of output is higher than compared to selected EU countries in both sub-
periods. It can be concluded that in the SEE countries, inventory investments
have a higher share in real GDP than in both EU and US. During 1970-1989, in
the SEE countries production has been 7.69% more volatile than sales, meaning
that inventories have shown a destabilizing effect on the overall economy.
However, the ratio has substantially fallen in the upcoming period. On the other
hand, during 1990-2004, production has been less volatile than sales in the
selected EU countries implying a stabilizing inventory effect. Although still
slightly positive in SEE countries, the ratio has substantially fallen between the
two sub-periods both in SEE and between selected EU countries. According to
the results, it can be supposed that inventories have played a stabilizing role on
the economy during the transition between the two sub-periods or at least they
have not played any significant role. On the other hand, inventory investment
have accounted for about 198.71% of the output fall in the SEE countries,
significantly higher than in other EU countries (34.06%). During recessions in
the SEE, inventory investments account for a significantly larger percent of
output decrease as compared to both EU and US.

Since this is a first study to show the patterns of inventory investment behavior
related to the SEE countries, it should be accepted only as a starting point for
other, more serious macroeconomic analyses. In order to get a complete picture
on inventory investments behavior in the SEE countries, as a follow up to the
macroeconomic research presented in the rows above, the thesis continues with a microeconomic research which will try to reveal financial constraints firms in the SEE face when making inventory investment decisions.

5. THEORETICAL FRAMEWORK ON INVENTORY INVESTMENTS AND FINANCE CONSTRAINTS

Early investment research, especially the work of John Meyer and Edwin Kuh (1957), emphasized the importance of financial considerations in business investment (Fazzari et al., 1988) especially with regard to financing constraints. As implied earlier it this work, business investment includes business fixed investment and inventory investment. When comparing these two types of business investment, inventory investment is of a greater interest since inventories have low adjustment costs compared with capital investment activities, according to Cunningham (2004). Because of this effect, inventory investment is used by financially constrained firms to respond to negative shocks (e.g., when recessions are taking place). For example, if cash flow declines, the amount of external borrowing collateralized by internal funds also declines, and the firm must reduce its borrowing or pay a premium on loans in excess of cash flow. Rather than suspend a capital project, the firm may choose to hold fewer inventories (Cunningham, 2004).

Many studies of the business cycle have noted the important role of inventory investment during economic downturns. Large number of authors concluded that the change in inventory investment accounts for a large part of the decrease of real GDP during recessions. Moreover, in some recessions the change of inventory investment is even larger that the change in real GDP itself. Due to this fact Blinder (1990) concluded that business cycles are, to surprisingly large degree, inventory cycles. In the US during the six postwar recessions until 1975 changes in inventory investment accounted on average for about 94 percent of the change in GDP and ranged between 23 to 190 percent (Hornstein, 1998) while the average change in inventory investment during expansions account for only about 9 percent of the changes in GDP which is “a striking asymmetry”, as stated in Kolev (2005, p. 2). However, these data significantly differ as to the authors. For example, Tatom (1977) has calculated that these changes in inventory investment as the part of the GDP change for the same six US postwar recessions account on average for about 144 percent ranging between 56 percent and 378 percent. Cunningham (2004) indicates that in Canada inventory investment declines by almost 200 percent more than the decline in output over an average business cycle. The results obtained in this research indicate that this is also true for SEE countries and these changes in inventory during the recessions between 1970 and 2004 account for a very high

23 Evans (1989), Dernburg and McDougall (1972), Mc Cracken (1974)
percent of the change in GDP (see Table 4-6 on page 70). In Albania it accounts on average 90.21 percent, Bosnia and Herzegovina 50.17 percent, Bulgaria 271.66 percent, Croatia 22.68 percent, Romania -89.66 percent, Serbia and Montenegro 221.07 percent and Yugoslavia 846.23 percent. Thus, these recessions easily could be assigned as being “inventory recessions”. Kolev (2005) further states that in first few quarters or even years after a trough inventory investment remains negative despite the considerable positive change it experiences. In addition, he makes an evidence of inventory investments behaving differently than real GDP relative to business cycles and states that after a trough, it takes more time for inventories to return to the levels they had in the previous peak of the business cycle than it takes real GDP. Thus, during recessions inventories fall sharply and return only gradually and in general slowly, to their pre-recession levels. In contrast, production and sales rebound fast after each trough, with growth rates exceeding their long-term averages and have relatively more moderate declines during the recession itself.

Because of low adjustment costs, inventories are used by financially constrained firms to compensate for negative shocks. However, financing constraints can amplify business cycle shocks and therefore they may help explain some of the observed volatility in inventory investment (Cunningham, 2004) in addition to the two hypotheses regarding the inventory holding problem - the production-smoothing model and the (S, s) inventory model (see Chapter 3.4.1.).

Investment decisions of many firms are influenced by the financial constraints they face. As Kolev (2005) explains in the periods after a trough, financially constrained firms do not have enough cash to bring the stock of inventories to their pre-recession levels, to invest in long-term production assets and satisfy growing demand for their goods at the same time. Consequently, inventory investment lags the recovery that consumer demand and investment in production assets experience immediately after a trough. Similarly, constraints on financing working capital may lead to drastic reduction of own stocks during recession. Besides, firms might find it suboptimal to invest their declining revenues in a short-term asset that does not pay well in the near future, concludes the author. Kolev (2005) has noticed however, that existing theoretical models do not focus on this asymmetry and do not view financial constraints as a possible source of inventory investment swings. Lot of research in inventory investment is concentrated on explaining why output is more volatile than, and inventory investment is positively correlated with, sales. The author has noticed that the reason for this interest is “that the once most popular and intuitive model of inventory investment, the production-smoothing/ buffer stock model, has exactly the opposite predictions.” However, he states that both (S, s) type models and production-smoothing models of inventory investment are used to explain input-inventory behavior and orders of trade firms and do not focus on the asymmetry of inventory investment over the business cycle or inventory fluctuations and these theoretical inventory models do not include financial variables, nor do they include capital investment. On the other hand, capital
investment models do incorporate financial constraints but do not consider inventory investment.

When a firm wants to invest in new capital, say by building a new factory, it either uses its internal funds (cash flow) or raises the necessary funds in financial markets. External financing make take several forms: using trade credit, obtaining loans from banks, selling bonds to the public or selling shares in future profits on the stock market. Yet sometimes firms face financial constraints – limits on the amount they can raise in financial markets (Mankiw, 2003). These financial constraints can prevent firms from undertaking profitable investments. When a firm is unable to raise funds in financial markets, the amount it can spend on new goods is limited to the amount it is currently earning and eventually its retained earnings.

Financial constraints cause firms to determine their investment based on their current cash flow rather than expected profitability. According to Mankiw (2003), a recession reduces employment, the rental price of capital, and profits. If firms expect the recession to be short-lived, however, they will want to continue investing, knowing that their investment will be profitable in the future. For firms that can raise funds in financial markets, the recession should have only a small effect on investment. However, quite the opposite is true for firms facing financial constraints. The fall in current profits restricts the amount that these firms can spend on new goods and may prevent them from making profitable investments. Thus, financing constraints make investment more sensitive to current economic condition.

The importance of internal finance and external sources of financing regarding investment decisions as well as financial constraints have been emphasized by many authors such are Kuznets (1965), Greenwald and Stiglitz (1993), Kashyap et al. (1993, 1994), Gertler and Gilchrist (1994) Carpenter et al. (1994, 1998), and others. In 1965 Kuznets (1965) noted how the important role of inventory liquidation in recessions has led many authors of that time to a number of studies, several of which have included financial variables to represent the effects of liquidity (internal finance), credit availability (external finance), and interest cost on inventory behavior (inventory holding costs). However, Kuznets (1965, p. 107) has stated “these (research) results have been either negative or inconclusive, implying that the instruments of stabilization policy that might influence inventory behavior through financial variables are unlikely to be effective”. The author explained that firms are assumed to adjust stocks so as partly to reduce discrepancies between actual and desired inventory levels and that desired or target levels are, in turn, a function of sales expectations and the financial variables.

Kuznets (1965) has defined three types of financial constraints in inventory investment:
1. Internal finance as the sum of net retained earnings plus depreciation and depletion allowances;
2. External finance* includes net trade credit, bank loans, long-term debt, and equity financing; and
3. Inventory holding costs represented by rates on short-term business loans of commercial banks.

Kashyap et al. (1994) find that inventory investment of firms without access to bond markets is significantly constrained during the periods of tight monetary policy24 (Kolev, 2005). Kashyap et al. (1993) find that shifts in loan supply can affect investment even after controlling for interest rate and output. Gertler and Gilchrist (1994) analyze the response of small versus large firms to monetary policy tightening and find that small firms account for a disproportionately large share of manufacturing decline that follows monetary tightening and they play a significant role in inventory investment demand slowdown.

Carpenter et al. (1994) find that firms absorb shocks to internal finance through changes in inventory investment. Internal finance is found to exert stronger effect on inventory investment of small firms that for large firms but still the effect on large firms is economically more important. In another study, Carpenter et al. (1998) analyzed the importance of three main financing constraints for inventory investment, namely, bank lending, collateral, and internal finance and have concluded the consistency with all three constraints, but emphasized internal finance as being the most significant. Thus, internal finance is found to be the most important source of investment financing. Greenwald and Stiglitz (1993) suggest that financial constraints have to do with fluctuations in both inventory and business fixed investment. As Kolev (2005) states, many economists argue that financial constraints are likely to be more important during recessions and hence are probably responsible for the asymmetric shifts that inventory investment displays over the business cycle. Carpenter et al. (1994) also support this view and find that business income is very volatile and highly procyclical. The empirical research done up to nowadays finds that financial constraints and internal cash flows have significant influence on inventory investment. As Kolev (2005) says, because financial resources are scarce, especially in recessions and around troughs, managers are constrained in allocating these resources among different uses – interest payments, fixed-capital investments (business fixed investments), working-capital investment (inventory investments), investment in R&D, dividend payments etc. Carpenter et al. (1994) note that because the costs of adjustment of inventory stocks are low relative to those of adjusting fixed capital and R&D investment, inventories absorb the shocks to internal finance.

24 A central bank policy designed to curb inflation by reducing the reserves of commercial banks and consequently the money supply, through open market operations (the buying and selling of government securities by a central bank). (www.investorwords.com)
Guariglia and Mateut (2006) explained their view of financial variables affecting inventory investments. They state that according to the credit channel, monetary policy is transmitted to the real economy through its effects on bank loans (bank lending channel) and firms’ balance sheet variables (balance sheet channel). In the case of a tightening in monetary policy bank loans supplies to firms are reduced, and this diminishes the ability of those firms that are more bank-dependent to carry out desired investment and employment plans. Similarly, a tightening in monetary policy is associated with a rise in borrowers’ debt-service burdens, a reduction in the present value of their collateralizable resources, and a reduction in their cash flow and net worth. This makes it more difficult and/or more costly for firms, for which asymmetric information issues are more relevant to obtain loans, forcing them to reduce their activities (Mishkin, 1995; Bernanke and Gertler, 1995; Guariglia and Mateut, 2006). If a firm’s activity is strongly affected by financial variables, then, in periods of tight monetary policy, when all firms’ financial situations become worse, this firm will have to contract its activity. Furthermore, if the credit channel were operative, one would expect financial variables to mainly affect the behavior of those firms which are relatively more constrained in credit markets (namely more bank-dependent firms, which are typically smaller, younger, and less collateralized), and this effect to be stronger in periods of recession and tight monetary policy (Guariglia and Mateut, 2006).

Fazzari et al. (1988) analyses in brief financial constraints on corporate investments and implies that there are generally two different views on business investment research assumptions. The first group of research is based on the assumption that all firms have equal access to capital markets, and thus a firm’s financial structure is irrelevant to investment because external funds provide a perfect substitute for internal capital. In general, with perfect capital markets, a firm’s investment decisions are independent of its financial condition. On the other hand, there is an alternative view that internal and external finance are not perfect substitutes. According to this view, investment may depend on financial factor, such as the availability of internal finance, access to new debt or equity finance, or the functioning of particular credit markets. Under these circumstances, firms’ investment and financing decisions are interdependent. Fazzari et al. (1988) identify few reasons why internal and external finance are not perfect substitutes in practice and thus why internal finance may be less costly than new share issue or debt finance abound.

Authors identify few “most prominent” reasons why internal and external finance are not perfect substitutes (Fazzari et al., 1988):

- Transaction costs,
- Tax advantages,
- Agency costs,
- Costs of financial distress, and
- Asymmetric information.
In his article “The Problem of Social Cost”, Ronald Coase describes transaction costs with following statement: “In order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on.” According to the author transaction, costs include search and information costs, bargaining and decision costs, and policing and enforcement costs. According to Fazzari et al. (1988), tax savings arise when corporate earnings are retained rather than paid out as dividends, because higher dividend tax is replaced with a lower tax on capital gain, which makes internal equity finance less costly than external equity finance. Agency costs arise from the limited-liability feature of debt contracts that creates incentives for firm managers to act counter to the interest of creditors under some circumstances. For example, if covenants impose working capital requirements, the supply of internal funds available to finance investment may be reduced, hence shocks to working capital, such as a debt deflation or a decline in internal finance, will make debt finance more expensive (Fazzari et al., 1988). Costs of financial distress arise when a firm has difficulties meeting its principal and interest obligations – the extreme case being bankruptcy. Asymmetric information arises when lenders cannot distinguish borrower quality, when firms have private information that cannot be costlessly observed by outside lenders. Asymmetric information can increase the cost of new debt, or even result in credit rationing.

One of the most recent research works regarding the issue of inventory investment financial constraints is a working paper by Rose Cunningham (2004) named “Finance Constraints and Inventory Investment: Empirical Tests with Panel Data”. The upcoming pages in the second thematic part of this master’s thesis are assigned to a research conducted using this research as a baseline. An empirical research is made by following the procedure suggested by Cunningham (2004) on a sample of SEE manufacturing firms observing the 1999-2004 period. This empirical research is done in order to show inventory investment patterns in the SEE region and make conclusions regarding financial constraints that underpin inventory investment decisions.

6. INVENTORY INVESTMENT AND FINANCE CONSTRAINTS IN THE SEE: EMPIRICAL RESEARCH WITH DYNAMIC PANEL DATA

6.1. INTRODUCTION

Models of finance constraints attempt to explain how information asymmetries between borrowers and lenders can cause some profitable investment projects to remain unexploited (Cunningham, 2004). Information asymmetries in capital markets arise when firms have private information that cannot be costlessly
observed by outside lenders. Fazzari et al. (1988) show that such firms may have to pay a premium for external financing that is not fully collateralized by their internal funds. Cunningham (2004) states that in models of finance constraints, the higher cost of external finance causes firms that have high degrees of information asymmetry to finance more of their investment activities with internal funds. Firms that have low degrees of information asymmetry and therefore low information costs do not face such premiums on external funds, and therefore their investment activities are less constrained by their internal funds. On the other hand, Cunningham (2004, p.1) states that “finance constraints are believed to bind most strongly when interest rates rise and during recessions, when internal funds decline and collateral values weaken”, which means that that external finance becomes more expensive for firms that have high information costs. These more financially constrained firms reduce their investment spending and production, intensifying the business cycle downturn, and similarly positive shocks can cause these firms to have greater access to external credit, which increases their investment and production and further strengthens an expansion. This effect is known as financial accelerator effect. Cunningham (2004) suggests that understanding the extent to which financial constraints affect firms may shed light on business cycle fluctuations, since financial constraints can amplify business cycle shocks through inventory investments, as noted earlier under this title.

Inventory investment is of interest because inventories have low adjustment costs compared with capital investment activities (Cunningham, 2004). Thus, one would expect that inventory investment would be used by finance-constrained firms to respond to negative shocks. If, for example, cash flow declines, the amount of external borrowing collateralized by internal funds also declines, and the firm must reduce its borrowing or pay a premium on loans in excess of cash flow. According to Cunningham (2004) rather than suspend a capital project, the firm may choose to hold fewer inventories. Blinder and Maccini (1991) show that inventory investment is one of the most volatile, procyclical, components of output over the business cycle in the United States.25 Finance constraints can amplify business cycle shocks and therefore they may help explain some of the observed volatility in inventory investment.

The analysis on the upcoming pages tests a model by Povel and Raith (2002) as suggested by Cunningham (2004). Their model derives optimal investment behavior in the presence of negative cash flow and varying degrees of asymmetric information. Thus, it provides “a more solid theoretical underpinning for conventional empirical tests for finance constraints” (Cunningham, 2004). I test the predictions of Povel and Raith’s model on SEE firm-level, low frequency data on inventory investment for the period 1999-2004 using the Amadeus commercial database as a source of secondary data. This is a first study of

25 The detailed macro-economical analysis of inventory investment patterns with regard to SEE region is given in the preceding, first thematic part.
finance constraints and inventory investment using SEE data. Two tests were made. Considering the first test, findings indicate that negative cash flow observations have a significant effect on the sensitivity of inventory investment to cash flow, consistent with the U-shaped relationship predicted by the Povel and Raith’s model. The second test that was made represents a strong evidence of finance constraints due to asymmetric information for firms believed to be more finance constrained.

6.2. RECENT EMPIRICAL LITERATURE

Cunningham (2004) gives a brief interpretation on recent empirical research regarding the issue under the question. Much of the empirical work on finance constraints faced by firms focuses on capital stock investment. Hubbard (1998) conducts a survey of the empirical literature on capital market imperfections and investment. These studies generally test the standard model of Fazzari et al. (1988) by comparing the sensitivities of investment to cash flow across groups of firms. These firms are categorized a priori as finance-constrained or unconstrained, based on characteristics that proxy for information asymmetries. Characteristics commonly used to categorize firms include age, size, bond ratings, dividends, and membership in industrial groups. Evidence obtained by the majority of studies supports the theory that finance constraints reduce investment by firms that have high information costs. Examples of these studies include Fazzari et al. (1988) and Whited (1992), who use data from the United States; Schaller (1993), who tests Canadian data; Hoshi, Kashyap, and Scharfstein (1991), who test finance-constraint models on Japanese panel data (Cunningham, 2004).

According to Cunningham (2004), an important debate on investment-cash flow sensitivities has arisen in the literature. Several recent studies do not find the predicted differences in cash flow sensitivities based on asymmetric information; in some cases, unconstrained firms’ investment is more sensitive to cash flow than that of financially constrained firms (Allayannis and Mozumdar, 2001; Cleary, 1999; Kaplan and Zingales, 1997; Gilchrist and Himmelberg, 1995; Cunningham, 2004). Allayannis and Mozumdar (2001) specifically examine the influence of negative cash flows in tests for investment-cash flow sensitivities. They find that negative cash flow observations can generate findings that contradict the standard theory. However, once they remove negative cash flow observations, the investment-cash flow sensitivities do not differ between the finance-constraint categories.

Povel and Raith (2002) develop a theoretical model of finance constraints that helps to explain some of these contradictory findings. Their model is explained in the Chapter (5). Cleary, Povel, and Raith (2003) test Povel and Raith’s model using capital investment data and find evidence of a U-shaped relationship between investment and cash flow. They also find that investment is more
sensitive to cash flow for firms that are expected to face greater finance constraints, consistent with the standard models (Cunningham, 2004).

In the literature on inventory investment, the results more clearly support the theory of the finance constraints. Carpenter et al. (1994, 1998), Guariglia (1999), Zakrajsek (1999), Gertler and Gilchrist (1994), Kashyap et al. (1993, 1994) examine data on inventory investment for evidence of finance constraints (Cunningham, 2004). They all test some form of partial-adjustment inventory model augmented with financial variables that proxy for internal funds, such as cash flow, interest coverage ratio, liquidity ratios, or other financial ratios. These studies typically feature firm-level data analyzed over periods of recession or periods when monetary policy was known to be restrictive. The augmented model of inventory investment is estimated separately for the finance-constrained and unconstrained groups of firms. Most authors focus on manufacturing firms; the exceptions are Kashyap et al. (1993), who use aggregate data, and Zakrajsek (1997), who studies retail sector inventories. According to Cunningham (2004), six of seven papers analyze data from the United States; Guariglia (1999) tests for United Kingdom. The paper of Cunningham (2004) is one of the first inventory studies to explicitly consider the effects of negative cash flow observations. That is the reason why it has been chosen to be the baseline for the empirical research for SEE region.

Previous studies on inventory investment and finance constraints find that the financial variables have significant and larger coefficients for firms in finance-constrained group compared with the unconstrained firms. Kashyap et al. (1993) also find that financial variables are significant in explaining inventory investment using aggregate data. Although the evidence in the literature on fixed investment and finance constraints is mixed, research to date on inventory investment is less ambiguous. Existing studies more clearly support the view that finance constraints lead to a positive relationship between cash flow and inventory investment.

6.3. DATA DESCRIPTION

This study uses Amadeus data on annual financial statement items from publicly traded Southeast Europe manufacturing firms. Countries included in the analysis are Bosnia and Herzegovina, Bulgaria, Croatia, Macedonia, Romania, and Serbia and Montenegro. Albania is excluded from the analysis due to the lack of data since there is no manufacturing company listed in Tirana Stock Exchange. The analysis is conducted on the 106 manufacturing firms from SEE region for the six-year period between 1999 and 2004 using panel data analysis technique.

Panel data analysis is a method of studying a particular subject within multiple sites, periodically observed over a defined period. In economics, panel data analysis is most often used to study the behavior of firms over time. With
repeated observations of enough cross-sections, panel analysis permits the researcher to study the dynamics of change with short time series. The combination of time series with cross-sections can enhance the quality and quantity of data in ways that would be impossible using only one of these two dimensions. Panel data analysis endows regression analysis with both spatial and temporal dimension. The spatial dimension pertains to a set of cross-sectional units of observation. These could be countries, firms, commodities, etc. The temporal dimension, on the other hand, pertains to periodic observations of a set of variables characterizing these cross-sectional units over a particular time span. Panel data structure for the purpose of my analysis uses a set of 106 SEE manufacturing firms with unique ID numbers (spatial dimension), as well as the country of origin, year of incorporation, and industrial sector. There are six years of observation for each firm ranging from 1999-2004, with overall number of observations being 636. Thus, the analysis is based on a low frequency, balanced panel dataset since the data are annual and balanced regarding the number of observations - every firm has the same number of observations (six). Companies were selected non-randomly since there was no choice because of a poor number of companies listed on both national stock exchanges and the Amadeus database. Only companies with full data on all variables were selected. There are a number of same economic variables for each firm for regression testing: total assets, sales, inventory stock, and cash flow.

As in the other studies on finance constraints using panel data, firms are categorized as likely to be more or less finance-constrained based on proxies for a high or low degree of information asymmetry between the firm and outside lenders. Three different criteria proxy for information asymmetries used are age, the presence of a bond rating, and size. However, all of these studies were conducted upon data for developed countries. Although bond ratings provide a better, exogenous proxy for splitting the sample to reflect differences in information available to external lenders, since SEE is constituted from seven transition countries, it has to be excluded from the analysis since these countries do have neither a bond nor a credit rating. Thus, for the purpose of analysis, an additional exogenous proxy beside the criteria proxies for information asymmetries already mentioned (age and size) will be used and that is trade credit utilization, as suggested in the work of Guariglia and Mateut (2006).

Based on its date of incorporation (establishment), a firm is classified as young if its age is less than that of the median firm in the sample. An old firm has an age equal to or greater than the median age of firms in the sample. Firms that are classified as young are expected to have more costly asymmetric information problems with borrowers, and a priori are assumed more finance-constrained.

Small firms are defined as those that have total assets of less than the median value of total assets in the sample, and they are expected to be more finance-
constrained. Firms that have total assets greater than or equal to the median value are considered large, and expected to be less constrained.

Although Guariglia and Mateut (2006) incorporate in their analysis both credit channel and trade credit channel, I decided to use only the second one as a proxy for information asymmetry since firms in SEE are biased towards the usage of the credit channel, especially credits for the purpose of financing inventory due to the undeveloped financial sector where there is a credit offer mostly for the purpose of the fixed assets financing when considering the business sector. Other types of financing are also not available thus, for the purpose of inventory financing, firms from the SEE use only the trade credits channel and the sources of internal finance.

The authors provide the following rationale on the side of trade credit channel as a criteria proxy for information asymmetries (Guariglia and Mateut, 2006). According to the trade credit channel, monetary policy is transmitted to the real economy through its effects on bank loans (credit channel) and firms’ balance sheet variables (balance sheet channel). In the case of a tightening in monetary policy, bank loans supplies to firms are reduced. This diminishes the ability of those firms that are more bank-dependent to carry out desired investment and employment plans. Similarly, a tightening in monetary policy is associated with a rise in borrowers’ debt service burdens, a reduction in the present value of their collateralizable resources, and a reduction in their cash flow and net worth. This makes it more difficult and/or more costly for firms, for which asymmetric information issues are more relevant to obtain loans or other ways of external financing, forcing them to reduce their activities (Mishkin, 1995, Bernanke and Gertler, 1995; in Guariglia and Mateut, 2006). Many studies regarding this issue, (Fazzari et al., 1988; Kashyap et al., 1994; Carpenter et al., 1994, 1998; Guariglia, 1999, 2000; in Guariglia and Mateut, 2006), have found a positive correlation between financial variables and firms’ activities, generally stronger for firms facing tighter financing constraints. Yet, a number of authors have found that the sensitivity of investment to financial variables is in fact weaker for firms likely to face particularly strong financing constraints (Kaplan and Zingales, 1997; Cleary, 1999; in Guariglia and Mateut, 2006). According to Guariglia and Mateut (2006) one strong argument which could be put forward to explain why some firms exhibit a low sensitivity of investment to financial variables is that, particularly in periods when bank-lending is rationed or, more in general, when external finance becomes more difficult to obtain and/or more costly, these firms make use of another source of finance to overcome liquidity shortages, namely trade credit.

Trade credit (i.e. accounts payable) is given by short-term loans provided by suppliers to their customers upon purchase of their products. It is automatically created when the customer delay payment of their bills to the suppliers. Trade credit is typically more expensive than bank credit especially when customers do not use the early payment discount (Petersen and Rajan, 1997; in Guariglia and
Mateut, 2006). As stated in Guariglia and Mateut (2006), Rajan and Zingales (1995) document that in 1991, funds loaned to customers represented 17.8% of the total assets for US firms, 22% for UK firms, and more than 25% for countries such as Italy, France, and Germany. According to own calculations, in the chosen sample of 106 SEE (Bosnia and Herzegovina, Bulgaria, Croatia, Romania, Serbia, Macedonia, Serbia, firms, this ratio is 28.15% for the year 2004. Guariglia and Mateut (2006) state that it is therefore possible that even in periods off tight monetary policy and recession, when bank loans are hard or more costly to obtain or even impossible, financially constrained firms are not forced to reduce their investment too much as they can finance it with trade credit. Biais and Gollier (1997) claim that by using trade credit, firms that cannot initially access bank debt may actually enhance their subsequent access to bank debt. The use of trade credit can in fact be seen as a signal revealing to banks the suppliers’ unique information relative to the firm, and causing banks to update their beliefs about the quality of the firm, which might lead them to start supplying funds to the firm. This implies that firms, which are a low-level trade credit users tend to be more financially constrained, compared to ones who are a high-level trade credit users.

Splitting the sample at the median for size and age is an intuitive method and is consistent with several earlier studies. In this analysis a new proxy criteria will be added instead of bond rating, namely trade credit usage. All firms whose trade credit falls bellow the median of the trade credit usage (3.8 million USD) are considered low-level trade credit users and thus tend to be more financially constrained, as explained above. Nevertheless, the median may not necessarily be consistent with the true boundary between firms that are more finance constrained and those that have little difficulty obtaining external finance. The assumption used further is that small, young, and low-level trade credit user firms fall into the overall category of financially constrained firms, and vice versa.

Table (A-1), (A-2), (A-3), and (A-4) in Appendix, report summary statistics for the full sample of 106 firms, sub-samples by size, age, trade credit usage (Table A-1), finance constraints (Table A-2), country of origin (Table A-3), and industry sectors (Table A-4). Although the upper and lower 1 percent values of observations are removed, in order to ensure the results are not driven by a few outlying observations, median value as a measure of central tendency were used since it is the only value that is unbiased due to the presence of outliers. One of the most important features of the data is the prevalence of negative cash flow observations; 43.87 percent of 636 observations. 8.49 percent of firms have at least 1 year with negative cash flow, 9.43 percent have all the six years with negative cash flow, and 23.58 percent has positive cash flows in all six years under analysis.

The absolute levels of all the variables differ significantly between the groups of firms, regardless of whether age, size, cash flow negativity, or trade credit usage
characteristics are used to split the sample. However, this is an expected fact since the criteria assumes that. Nevertheless, when these variables are scaled down by total assets, these differences across financially constrained and non-constrained categories are reduced considerably.

Table (A-1) in Appendix summarizes the mean, median, and std. deviation values of all the variables, namely, total assets, inventory stock, inventory investment, sales, and cash flow, as well as variables scaled down by total assets for both full sample and every category separately – small, large, young, old, and low- and high-level trade credit usage in the 1999-2004 period. Table (A-2) in Appendix summarizes the same variables according to the above proposed firm categorization by which financially constrained firms are small, young and low-level trade credit users, on one hand, and financially unconstrained firms are large, old, and high credit users, again in the 1999-2004 periods. Table (A-3) in Appendix summarizes descriptive statistics for the variables under analysis according to the country of origin for the period 1999-2004, and the Table (A-4) in Appendix the same but according to industrial sector a firm belongs to.

The results in Table (A-2) in Appendix show that financially constrained firms have lower median values of sales (0.725/0.872), inventory stock (0.182/0.225), inventory investment (0.008/0.013), and cash flow (0.001/0.010), both in absolute values and when scaled down by total assets, as compared to unconstrained firms. The median of cash flow to total assets, $\frac{CF}{TA}$, shown in Table (A-1) in Appendix, is smaller for the firms in the more finance-constrained categories (small, young, low level trade credit user) relative to other firms. The median of $\frac{CF}{TA}$ is 0.001 for small firms, and 0.003 for large firms. For young firms it is again 0.001 and for old 0.003. The only firm category where this relationship is reverse is in trade credit usage categories where low level trade credit users tend to have higher $\frac{CF}{TA}$ (0.003) as opposed to high trade credit users. However, this was expected since firms that have to use less trade credit possibly have stronger internal finance when considering SEE countries.

The dependent variable in the regressions is the ratio of inventory investment to total assets, $\frac{INV}{TA}$. It is interesting that for small firms that are expected to be more finance constrained tend to have higher ratio (0.009/0.008) despite lower ratios of average cash flow. It is worth attention that although small firms are more financially constrained they tend to invest more in stocks (0.009/0.008), and hold more inventories on stock (0.196/0.180) than financially

26 All values (except total assets) are scaled down with total assets in order to overcome the effect of the size of a single company.
27 Values in parenthesis are median values of financially constrained firms compared to the median values of financially unconstrained firms.
unconstrained firms. The reason is explained with Povel and Raith’s model below.

The ratio of sales to inventory stock, $S/N$, is used to reflect the firm’s long-run target inventory. The median of the sales-to-inventory ratio does not differ substantially across finance-constraint categories, which suggests that there are similar inventory targets for different categories of firms. However, this ratio is also higher for small firms (3.708/3.516) and this means that small firms tend to hold greater stock of inventories relative to sales, which also supports the above statement.

6.4. THEORETICAL MODEL OF FINANCE CONSTRAINTS

6.4.1. POVEL AND RAITH’S MODEL

Povel and Raith’s (2002) model of the optimal level of investment under finance constraints provides a theoretical basis for many existing empirical tests of finance constraints, and explains some of the recent contradictory findings on fixed investment and finance constraints (Cunningham, 2004). However, it has certain similarities across different types of business investments, thus it is a good basis for the analysis of inventory investment too. First, it assumes that the firm may determine the scale of its investment rather than make a binary choice on whether to undertake an investment choice. Decisions upon inventories are a scalable decision since it is done in order to adjust the levels of existing inventories. Second, internal funds (cash flow) may be negative, and often are. This is also a case in the sample of SEE firms under analysis in this work. Thus, according to Cunningham, it should be possible to analyze inventory investment using Povel and Raith’s (2002) model, since it applies to any debt-financed investment. A firm may finance inventory investment out of debt rather than internal funds if it plans to significantly increase inventory levels or the desired ratio of inventories to sales. This may occur in response to sales expanding rapidly or just becoming harder to predict, for example, if the firm is expanding into new markets or selling new product lines, or if increased competition increases its incentive to avoid stockout by maintaining a larger inventory buffer (Cunningham, 2004). However, it is a question whether, and in which amount firms in SEE use debt financing for the purpose of inventory investment. Although, they use debt-finance in the form of trade credit rather than bank lending. In Povel and Raith’s (2002) model, a firm earns revenues that are not observable to the external investor, creating a potential moral hazard problem due to asymmetric information (Cunningham, 2004). Thus, internal and external funds will not be equivalent in cost to the firm. Their main finding is that the firm’s optimal investment function is U-shaped over the range of feasible levels of internal funds.

The solid line in Figure (6-1) above shows this relationship for a firm that has no information asymmetry problems. The first best level of investment, $I^*$, is
undertaken if the firm can fund the investment internally with its own cash flow, CF, i.e., when CF equals I*.

Figure 6-1: The effect of cash flow and asymmetric information on investment in Povel and Raith’s model

With cash flow positive and less than I*, the optimal investment is also less than I* but positive and increasing in cash flow. According to Cunningham (2004), this is consistent with earlier models based on Fazzari et al. (1988) that imply a positive, monotonic relationship between investment and internal funds. In the range where internal funds are negative, however, investment may raise or fall as cash flow increases. In the most extreme case, the firm’s cash flow is at the lower bound, where is still possible to obtain financing, CF. In this case, optimal investment would be as high as the first best level, I*.

According to Cunningham (2004), the U-shaped investment-cash flow relationship is the result of two opposing effects: a cost effects and revenue effects. In the case of the cost effect, higher levels of investment increase the firm’s repayment costs and thereby raise its risk of default and liquidation, in turn raising the marginal cost of debt finance. In the case of the revenue effect, higher levels of investment generate more revenue, which increases the firm’s chance of survival and lowers the marginal cost of debt finance. Povel and Raith (2002) prove that the cost effect dominates when the firm has positive or slightly negative cash flow, and that revenue effect dominates when the firm has substantially negative cash flow. The dominance of the cost effect implies the familiar, positive monotonic investment-cash flow relationship such that an increase in cash flow leads to an increase in investment: as internal funds (cash
flow) increase, the probability of default declines, and the marginal cost of borrowing falls. Negative cash flow means that part of the firm’s borrowing must be used to offset its negative cash flow, and as cash flow becomes more negative, a larger share of any loan must be used to cover these non-revenue generating expenses, and in that case, for investor to break even, the firm must be able to generate revenue increasing the scale of its projects (Cunningham, 2004). With respect to inventory investment, this would mean that the firm increases its production and inventory levels more as cash flow falls, to generate enough sales to repay the loan. It is also an issue in the dataset used for SEE in the case of small firms, as it is stated above, next to the results of variable descriptive. Small firms that are expected to be more finance constrained tend to have higher ratios (0.009/0.008) (Table A-1) in Appendix despite lower ratios of average cash flow. Thus, in SEE Povel and Raith’s (2002) model is appropriate since financially constrained firms tend to invest more in stocks, and hold more inventories on stock than financially unconstrained firms.

Povel and Raith (2002) also demonstrate that a U-shaped investment function occurs when there is asymmetric information between the firm and the outside investor. The dashed line in Figure (6-1) above shows the effects of information asymmetry on the investment function. As the degree of information asymmetry increases, the investment function becomes steeper almost everywhere, except in the region of the minimum. Asymmetric information leads to increased sensitivity of investment to cash flow (Cunningham, 2004).

6.4.2. RESEARCH HYPOTHESES

According to Cunningham (2004), Povel and Raith’s (2002) model yields at least two testable implications. In the presence of both positive and negative cash flow observations, the model predicts that the investment-cash flow function will be non-monotonic. Specifically, it will be U-shaped. First, non-monotonicity can be tested by removing the negative cash flow observations. This should result in a positive monotonic relationship between cash flow and inventory investment for all firms. Second, one can also test whether there is a negative relationship in the region where cash flow is negative. A third set of empirical tests can assess the influence of asymmetric information on inventory investment. Firms believed to have a higher degree of asymmetric information are predicted to have larger slope coefficients on the cash flow variable that firms that have fewer asymmetric information problems (Cunningham, 2004).

6.5. BASELINE SPECIFICATION AND ESTIMATION METHODOLOGY

6.5.1. BASELINE SPECIFICATION

In order to analyze inventory behavior patterns of manufacturing firms across SEE and observe the financial constraints effects on their inventory investment performance, suggestions of Rose Cunningham (2004) were followed since her
work incorporates the most similar hypothesis and uses the most confronted during data collection.

The baseline specification that will be used is a variant of Lovell’s (1961) partial adjustment model as suggested by Cunningham (2004). Gertler and Gilchrist (1994) point out that these types of models are most appropriate for aggregate inventory data that are not broken down into work-in-progress, raw materials, or finished goods. Partial-adjustment inventory models describe a process of inventory investment whereby each firm has a desired or “target” level of inventories. As Cunningham (2004) states, augmenting the model with variables to reflect the firm’s financial situation is a common technique used to test for finance constraints. I’ve broadened the Cunningham (2004) model and assumed that the desired inventory level, $N^*$, depends on expected sales relative to existing inventories, the real interest rate (the bank lending rate corrected with inflation rate based on the GDP deflator), trade credit and cash flow.

Equation 6-1: Inventory Investment Equation – A Variation of Lovell’s (1961) Partial Adjustment Model

$$
\Delta N_{it} = \beta_1 \left( \frac{E_{it} - S_{it}}{N_{it-1}} \right) + \beta_2 r_{it - 1} + \beta_3 CF_{it - 1} + \beta_4 TC_{it - 1} + \sum_{k=1}^{2} \beta_6 k \Delta N_{it - k} + \sum_{k=1}^{2} \beta_7 k \Delta r_{it - k} + \sum_{k=1}^{2} \beta_8 k \Delta CF_{it - k} + \sum_{k=1}^{2} \beta_9 k \Delta TC_{it - k} + \nu_{it} + \epsilon_{it}
$$

The variables $N_{it}$, $S_{it}$, $CF_{it}$, and $TC_{it}$ denote firm $i$’s real stock level, sales, cash flow, and trade credit (accounts payable) respectively, for period $t$. The dependent variable is inventory investment, $\Delta N_{it}$ which is equal to $N_{it} - N_{it-1}$. The real interest rate, $r$, is defined as a prime bank lending rate less the inflation rate based on the GDP deflator. The effects of firm’s desired inventory stock are captured by the first four regressors in levels: the ratio of expected sales to lagged inventory levels, the lag of the real interest rate, the lag of cash flow, and the lag of trade credit. These terms reflect the influence of a long-run inventory investment dynamics. In addition to these level terms, lagged differences of inventory investment, sales, the interest rate, cash flow, and trade credit are included to capture the effects of short-run dynamics.

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28 Since the data include some observations with negative cash flow, it is not possible to transform this data using logs. In order to control for possible heteroscedasticity, stocks, sales, cash flow, and trade credit levels are divided by total assets first, in addition to differencing or other transformations. The expected sales are already scaled by inventory in the previous period, so it is not scaled by total assets.
The error term in Equation (6-1) is made up of three components: firm-specific component \((\nu_i)\); time-specific component \((\nu_t)\) which accounts for possible business cycle fluctuations; and idiosyncratic \((\epsilon_{it})\) component of the error term. I control for \(\nu_i\) by estimating the equation in first-difference and for \(\nu_t\) by including a full set of time dummies. This specification includes both long run and short-run effects, so it has an error-correction format in which the ratio of expected sales to lagged inventories is the error correction term. Thus, \(\beta_1\) should have a positive coefficient, since increases in the ratio (due to either increased expected sales or low levels of previous inventories) should rise \(N^*\) and therefore increase current inventory investment. Real bank lending interest rates affect the holding cost of inventories, so \(\beta_2\) is expected to be negative. The sign of \(\beta_3\) depends on whether the model includes negative cash flows, due to the predicted U-shaped relationship, as discussed below. The \(\beta_i\) is expected to be positive since a higher trade credit usage leads to higher stock levels.

The theoretical model is static and can be interpreted as explaining steady-state behavior. Therefore, (as suggested in Cunningham, 2004) the influence of finance constraints is expected to be reflected primarily in the long-run behavior of inventories. The variables that capture short-run dynamics do not have clear sign predictions. Since lagged dependent variables are included as regressors and there are relatively small number of time periods for each firm (four), both fixed effects and generalized least squares (GLS) random-effects estimators will be inconsistent. Their inconsistency arises from the correlation of the lagged dependent variable with the fixed-effect component of the error term. First differencing removes the firm-specific effect, which provides the model to estimate:

\[
\Delta \Delta N_{it} = \beta_1 \Delta \left[ \frac{E_{t-1}S_{it}}{N_{it-1}} \right] + \beta_2 \Delta r_{t-1} + \beta_3 \Delta CF_{it-1} + \beta_4 \Delta T_{C_{it-1}}
\]

\[+ \sum_{k=1}^{2} \beta_{5k} \Delta N_{it-k} + \sum_{k=1}^{2} \beta_{6k} \Delta S_{it-k} + \sum_{k=1}^{2} \beta_{7k} \Delta r_{it-k} + \sum_{k=1}^{2} \beta_{8k} \Delta CF_{it-k} + \sum_{k=1}^{2} \beta_{9k} \Delta T_{c_{it-k}} + \Delta \nu_t + \Delta \epsilon_{it}
\]

### 6.5.2. ESTIMATION METHODOLOGY

Given the possible endogeneity of the regressors, Equation (6-2) estimated using the Arellano and Bond (1991) first-difference Generalized Method of Moments (GMM) approach, which is a dynamic panel model, needed to account for dynamic effects.

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29 In the desired sales term, expected sales, \(E_{t-1}S_{it}/N_{it-1}\), is proxied by \(S_{i01}/N_{i01}\).
The consistency of the Arellano-Bond estimator requires that there is no second-order autocorrelation in the residual. In order to evaluate whether the model is correctly specified, two criteria will be used: the Sargan test (also known as $J$ test) and the test for second-order serial correlation of the residuals in the differenced equation, $m2$. Both results are reported. Sargan test (p-value) checks for the validity of over-identifying restrictions used by the Arellano-Bond estimator (or instruments validity in other words). Since the Sargan test tends to over-reject the null hypothesis of valid instruments in the one-step Arellano-Bond estimator, the two-step estimator results are reported for the $m2$, and the Sargan test. The coefficient estimates and standard errors reported, however, are from the one-step estimation procedure, since Arellano-Bond recommends using one-step results for inference (Cunningham, 2004). The assumption underlying the analysis is that all variables except the lagged dependent variable are exogenous. Cunningham (2004) suggests that it may be more accurate to treat sales, cash flow, and trade credit as predetermined, a weaker assumption than exogeneity, but this would require more observations per firm than are available.

**6.6. ESTIMATION RESULTS**

6.6.1. NEGATIVE CASH FLOW OBSERVATIONS

Table (A-5) in Appendix reports the results of testing for a U-shaped relationship between cash flow and inventory investment by estimating the model using: all observations (first column) (318 observations), observations with only positive cash flows (second column) (190 observations), and observations with only negative cash flows (third column) (128 observations). The p-values of the Sargan test do not reject the hypothesis that the moment restrictions used in the model are valid, which suggests that the model is correctly specified. Similarly, the $m2$ test statistics in all three columns imply that one cannot reject the hypothesis of no second-order autocorrelation in the residuals, so the estimates are consistent. Although there are many observations in the sample with negative cash flow, several lags are required to estimate the model. Therefore, relatively fewer observations are available for the regression in the third column.

The theoretical model does not clearly imply the nature of the short-run movements in inventory investment in response to changes in cash flow, so the primary variable of interest is the first difference of the cash flow, $\Delta CF_{i,t-1}/TA_{i,t-1}$, third in a row in each table ($\Delta CF$, hereafter). Its purpose is to capture the steady-state nature of the inventory investment-cash flow relationship. The first column in Table 5 contains three variables that are significantly different from zero: the sales-to-inventory ratio, real interest rate, and the long-run sales variable. When all observations are included in the regression, the cash flow variable (-0.040) is not significantly different from zero. This is consistent with changes in slopes if
there is a U-shaped relationship between inventory investment and cash flow, because the sign may change as cash flow becomes negative. In the second column, when the negative cash flow observations are removed, the cash flow has a slightly larger, but still negative coefficient (-0.034) with small standard error, albeit also not significantly different from zero. In the third column, the regression using only observations with negative cash flow, the coefficient on $\Delta CF$ is negative as expected and larger than in previous cases, -0.069, which is significant at a 10 percent level. These results provide some moderate, albeit partial, support for the U-shaped function predicted by Povel and Raith’s (2002) model.

Tables (A-5) through (A-8) in Appendix show the regression results for estimating Equation (6-2) when the sample of firms is split by age, size, and trade credit usage, respectively. In this set of tables, the first two columns of each table contain the regression results with all cash flow observations included. The third and fourth columns show the regression results when negative cash flow observations are removed. The fifth and sixth columns show regressions when negative cash flow observations are included. When the negative cash flow observations are removed, the coefficient of $\Delta CF$ increases for small firms, young firms and firms with high trade credit usage. On other hand, for large, old and firms with low trade credit usage, $\Delta CF$ decreases when negative cash flow observations are removed. When all observations are considered, $\Delta CF$ is significant only for young firms at 10 percent level. Removing negative cash flow leads $\Delta CF$ to become significant at 5 percent for young firms and 10 percent for small firms and firms with high trade credit usage. When only negative cash flow observations are considered, the coefficients decrease and are negative for young and small firms with 10 and 5 percent significance, respectively, and decrease but are not significant in the case of high trade credit users.

The regression results with and without negative cash flow observations suggest that, when firms are not undergoing financial distress, inventory investment increases as cash flow increases only in the case of young firms, small firms and high trade credit user firms. On the other hand, when firms are undergoing financial distress and have negative cash flows, inventory investment increases as cash flow decreases in the case of young and small firms with results addressing significant coefficients. In the case of high trade credit user firms, the results show also a same pattern, although the coefficient is not significantly different from zero.

These findings support the first and second hypothesis of Povel and Raith’s (2002) model for small and young firms, and moderately for firms, which tend to be high trade credit users.
6.6.2. FINANCE CONSTRAINTS AND ASYMMETRIC INFORMATION

The primary concern in the finance-constraint literature is the effect of asymmetric information in capital markets on investment behavior (Cunningham, 2004). Tables 6 to 8 show the estimation results when firms are grouped a priori to reflect information asymmetries. Ignoring the negative cash flow observations, Povel and Raith’s model and earlier models of asymmetric information in capital markets imply that the young, small and low-level trade credit user firms would have positive and significant coefficients on the cash flow term, and that the cash flow term coefficients for these firms would be larger than the cash flow coefficients estimated for the old, large and high trade credit user firms.

Table (A-6) in Appendix compares small and large firms. The point estimates on the cash flow coefficient are positive, larger, and significant at 10 percent for small firms (0.265) when compared to large firms (-0.215). Table (A-7) in Appendix shows regressions in which young and old firms are compared (Table A-7) with young firms having positive and larger coefficients significant at 5 percent (0.116) compared to old firms (0.037). However, this is not the case in Table (A-8) in Appendix, which compares low- and high-level trade credit users, although coefficients on low-level trade credit users are larger and positive (0.139) as compared to high-level trade credit users (0.017), but still they are statistically not different from zero.

Considering the results obtained, it can be concluded that the model estimated fits the theoretical models mentioned above, since the inventory investment by small, young, and partially for low-level trade credit users, depend more on cash flow than does that by large, old, and high-level trade credit user firms. Thus, these results support the view that information asymmetries generate greater sensitivity between inventory investment and cash flow in the sample of SEE manufacturing firms, and they support the third hypothesis of Povel and Raith’s (2002) model.

6.7. CONCLUDING REMARKS

This research that was done on the sample of 106 SEE manufacturing firms during the 1999-2004 period, has contributed to the preceding research that examines the effect of financial variables on inventory investment. Following the procedure suggested in Cunningham (2004), an error-correction model for inventory investment has been estimated augmented with cash flows (Equation 2). The model incorporates negative cash flow observations, as an important factor that has only recently begun to be studied (Cunningham, 2004). Povel and Raith (2002) demonstrate that the relationship between investment and cash flow in the presence of negative cash flow is non-monotonic and U-shaped, contrary to earlier linear (monotonic) models. The regression model was estimated using the Arellano-Bond (1991) estimator. First, it was estimated with
all cash flow observations and than with negative cash flows removed, and with only negative cash flows included, separately. Negative cash flow means that part of the firm’s borrowing must be used to offset its negative cash flow, and as cash flow becomes more negative, a larger share of any loan must be used to cover these non-revenue generating expenses, and it that case, for investor to break even, the firm must be able to generate revenue increasing the scale of its projects. With respect to inventory investment, this would mean that the firm increases its production and inventory levels more as cash flow falls, to generate enough sales to repay the loan. On other hand, when internal funds (cash flow) increase, the probability of default declines and the marginal cost of borrowing falls, which increases, inventory investment.

Findings presented in this work support the first two hypotheses from the Povel and Raith’s model for small and young firms showing that in the sample of SEE firms cash flow coefficients are positive and significant only when negative cash flow observations are omitted. Estimating the model only with observations where cash flow was negative yielded a negative and significant relationship between inventory investment and cash flow. This is strong evidence that the relationship between inventory investment and cash flow is U-shaped for small and young firms, with less significance in the case of high-level trade credit user firms.

A second set of regressions were conducted to test for finance constraints due to information asymmetries between firms and external lenders. These regressions estimated the model separately for small versus large firms, young versus old firms, and low- versus high-trade credit user firms. In each pair of regressions, the first group of firms (small/young/low-level trade credit user) was expected to be more finance constrained. These findings confirmed to the predictions of the theory. Once the negative cash flow observations were removed, there was statistically significant difference between estimated cash flow coefficients for small and large firms, young and old firms, and less significant difference for low- and high-level trade credit user firms. This implies that small, young and (moderately confirmed) low-level trade credit user firms as more financially constrained firms rely more on internal funds to finance inventory investment than the firms with strong access to external finance (large, old, and high-level trade credit users). Therefore, information asymmetries between borrowers and lenders generated a strong link between cash flow and inventory investment for SEE manufacturing firms over the sample period, 1999-2004. These findings are consistent with previous works on inventory investment that have supported theories of asymmetric information and finance constraints.

7. CONCLUSION

In the last decade researchers have shown that the behavior of inventories at the aggregate (macro) level is opposite to the behavior on a firm (micro) level pointing
to the case of the classical production-smoothing/buffer-stock model of inventory behavior (see Blinder and Maccini, 1991). The paradox behind these theories is that macroeconomists see inventories as a major destabilizing factor creating cycles that otherwise would not exist whereas microeconomists see it as a stabilizing factor that firms use to smooth the production. Blinder and Maccini (1991) describe this inventory investment behavior puzzle as a “fascinating question that was barely explored” and they conclude, “no one seemed to notice the tension that was developing between the emerging macroeconomic and microeconomic views of inventories”. Although, firm-level inventory investment behavior is greatly influenced by the financial constraints firms face, this topic came to the interest only in the last decade. There is a number of research papers devoted to the issue of the influence finance constraints play on firm-level inventory investments behavior like Blinder and Maccini (1991), Lovell (1994), Gertler and Gilchrist (1994), Kashyap et al. (1994), Carpenter et al. (1994), Guariglia and Matteut (2006) and a number of others, each of them employing different financial variables and econometric approaches and emphasizing a different channel through which financing constraints operate. Since cash flow itself is very cyclical, it is of a great influence on inventory investment volatility. However, Lovell (1994) points to the potential influence of financing constraints on inventory investment as a major unanswered question in inventory theory.

Although these an related issues are less or more explored by a great number of researches, none of them concerns the issue of inventory investment behavior in Southeast Europe (SEE), although this region is well know of oft downturns and poor macroeconomic performance. According to the analysis presented above, in the twenty-four year period (1970-2004), there were 18 recessions addressed to SEE, making them a very frequent event that happens every three to five years. Another important characteristic of the SEE region is the underdeveloped financial market and financial instability in all of the seven SEE countries, which in a combination with high illiquidity presents a strong limitation for economic development. Due to all these factors, the majority of firms is limited in using external sources of financing and is required to rely on internal sources and trade credits under unfeasible conditions in order to finance their working capital. These constraints strongly affect firms in the SEE region when trying to improve business since a lack of contemporary knowledge and financial sources, limits them in making optimal investment decisions. Thus, a significant difference between the SEE countries and other EU countries is expected. However, these constraints also have a kind of a positive effect since they retain firms to undertake unfeasible investment projects and stockpile inventories.

These stylized facts were assumptions to start from in order to get better insight into inventory investment behavior in the SEE both on macro- and micro- level. In order to check for the impact economic development plays on differences in inventory investment behavior, the results are later compared with the results
obtained for some developed EU countries (Austria, Hungary, Italy, and Slovenia).

Chapters above present an integrated research on two most important fields of inventory investments - the macroeconomic and microeconomic inventory investment behavior. In accordance with this, the work was divided in two thematic parts, respectively.

The purpose of the first part was to show the macroeconomic context of inventory investment behavior and get a clearer picture on the relationship between inventory investments, economic fluctuations, GDP, and its components in SEE. In order to show the relationships under the issue, a number of statistical procedures were used on secondary data obtained from UNNAMAD database for the 1970-2004. The most important results obtained for SEE in the observed period, show that:

- The average output volatility of the region during 1970-1989 significantly exceeded that of the selected EU countries. This shows that, on average, output fluctuations in the SEE had somewhat higher amplitude than that of the selected EU countries;
- The period between 1990 and 2004 was much more volatile regarding economic fluctuations that the one before, and the growth has slowed down;
- The average investment accounts for about one-fourth (25.4%) of the GDP;
- Albania, Bosnia and Herzegovina, and Bulgaria are the most volatile countries in the region with regard to investments;
- Inventory investment is high in years when real GDP rises and low in years when real GDP falls;
- The correlation between GDP and inventory investment is positive statistically significant for Albania, Bosnia and Herzegovina, Croatia, and Macedonia. For Yugoslavia, the correlation is significant but negative. For rest of the SEE countries, namely, Bulgaria, Romania, and Serbia and Montenegro the correlation showed insignificant;
- Between 1970 and 2004 inventory investment as a share of output in SEE has averaged 5.3% which is more than its share in both EU and US (about 1%);
- In the SEE, aggregate sales fluctuate slightly less than output over the cycle;
- During 1970-1989, in the SEE countries production has been 7.69% more volatile than sales, meaning that inventories have shown a destabilizing effect on the overall economy. However, the ratio has substantially fallen in the upcoming period. On the other hand, during 1990-2004, production has been less volatile than sales in the selected EU countries implying a stabilizing inventory effect. Although still slightly positive in SEE countries, the ratio has substantially fallen between the
two sub-periods both in SEE and between selected EU countries. According to the results, we suppose that inventories have played a stabilizing role on the economy during the transition between the two sub-periods or at least they have not played any significant role. On the other hand, inventory investment have accounted for about 198.71% of the output fall in the SEE countries, significantly higher than in other EU countries (34.06%). During recessions in the SEE, inventory investments account for a significantly larger percent of output decrease as compared to both EU and US.

The second part, which included an empirical research on firm-level data, was intended to show the relationship between inventory investments and finance constraints firms face when making these investment decisions. The database used for the purpose of the analysis was AMADEUS. Although a small sample of SEE manufacturing firms was used (106), and the period under the observation was, only six years (1999-2004) the results obtained are significant and are in accordance with expectations. Firms were initially categorized as being financially constrained and financially unconstrained. Firms that were assumed during the categorization to be financially constrained are small, young, and low-level trade credit users, and firms to be financially unconstrained, large, old, and high-trade credit users. The model incorporated negative cash flow observations, following the research procedure suggested in Povel and Raith (2002) and Cunningham (2004). The purpose was to show that the relationship between investment and cash flow in the presence of negative cash flow is non-monotonic and U-shaped. Results obtained show strong evidence that the relationship between inventory investment and cash flow is U-shaped for small and young firms. The second part of the firm-level analysis was intended to test for finance constraints due to information asymmetries between firms and external lenders. The results obtained imply that small, young and (moderately confirmed) low-level trade credit user firms, that were assumed to be more financially constrained, rely more on internal funds to finance inventory investment than the firms with strong access to external finance (large, old, and high-level trade credit users). Therefore, information asymmetries between borrowers and lenders generated a strong link between cash flow and inventory investment for SEE manufacturing firms over the sample period, 1999-2004.

The most difficult task during the research was to collect appropriate data for both the purpose of the macroeconomic analysis, and firm-level analysis. Since the SEE is known for its low transparency these results should be looked at as an effort to get an approximation of inventory investment behavior in the SEE region. However, this research could be used as a good starting point for some future researches. Further research could be build on these findings by using data for a larger sample of firms divided by sectors as well as by observing a longer time period or by using high frequency data such as quarterly or semiannual data.
8. REFERENCES AND SOURCES

REFERENCES


141. KOBSON Database – Konzorcijum Biblioteka Srbije za Objedinjenu Nabavku.


# Appendix

Table A-1: Summary statistics for the sample of SEE manufacturing firms split by size, age, and trade credit usage, 1999-2004, mil 1990 USD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full sample</th>
<th>Small</th>
<th>Large</th>
<th>Young</th>
<th>Old</th>
<th>Low TC</th>
<th>High TC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total assets</td>
<td>60.071</td>
<td>11.485</td>
<td>108.66</td>
<td>62.481</td>
<td>57.630</td>
<td>20.380</td>
<td>99.761</td>
</tr>
<tr>
<td></td>
<td>26.372</td>
<td>9.790</td>
<td>82.624</td>
<td>27.647</td>
<td>25.279</td>
<td>10.960</td>
<td>70.555</td>
</tr>
<tr>
<td></td>
<td>79.903</td>
<td>7.433</td>
<td>89.431</td>
<td>76.031</td>
<td>83.692</td>
<td>23.237</td>
<td>95.333</td>
</tr>
<tr>
<td>Inventory stock</td>
<td>15.100</td>
<td>2.940</td>
<td>27.259</td>
<td>15.108</td>
<td>15.091</td>
<td>4.7690</td>
<td>25.430</td>
</tr>
<tr>
<td></td>
<td>5.1710</td>
<td>0.197</td>
<td>6.2190</td>
<td>0.141</td>
<td>0.064</td>
<td>0.9310</td>
<td>0.5420</td>
</tr>
<tr>
<td></td>
<td>24.662</td>
<td>3.121</td>
<td>30.199</td>
<td>27.259</td>
<td>19.175</td>
<td>3.1210</td>
<td>31.024</td>
</tr>
<tr>
<td>Inventory inv.</td>
<td>1.2190</td>
<td>0.197</td>
<td>2.2040</td>
<td>1.0340</td>
<td>1.4070</td>
<td>0.2860</td>
<td>2.1040</td>
</tr>
<tr>
<td>Sales</td>
<td>45.621</td>
<td>10.693</td>
<td>80.549</td>
<td>47.483</td>
<td>43.736</td>
<td>14.332</td>
<td>76.910</td>
</tr>
<tr>
<td></td>
<td>66.965</td>
<td>10.465</td>
<td>80.160</td>
<td>66.606</td>
<td>67.379</td>
<td>25.430</td>
<td>82.365</td>
</tr>
<tr>
<td>Cash flow</td>
<td>-1.033</td>
<td>0.093</td>
<td>-2.159</td>
<td>-0.581</td>
<td>-1.491</td>
<td>0.8380</td>
<td>-2.904</td>
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<tr>
<td></td>
<td>0.0240</td>
<td>0.007</td>
<td>0.1730</td>
<td>0.0220</td>
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<td>0.0300</td>
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<tr>
<td></td>
<td>12.698</td>
<td>1.414</td>
<td>17.844</td>
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<td>16.596</td>
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<td>S/TA</td>
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<td>0.7390</td>
<td>0.8990</td>
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<tr>
<td></td>
<td>0.7420</td>
<td>0.732</td>
<td>0.7450</td>
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<td>0.8270</td>
<td>0.6680</td>
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</tr>
<tr>
<td></td>
<td>0.4710</td>
<td>0.516</td>
<td>0.4200</td>
<td>0.4220</td>
<td>0.5040</td>
<td>0.5000</td>
<td>0.4380</td>
</tr>
<tr>
<td>N/TA</td>
<td>0.2670</td>
<td>0.259</td>
<td>0.2740</td>
<td>0.2370</td>
<td>0.2970</td>
<td>0.2600</td>
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<tr>
<td></td>
<td>0.1880</td>
<td>0.196</td>
<td>0.1800</td>
<td>0.1600</td>
<td>0.2270</td>
<td>0.1870</td>
<td>0.1880</td>
</tr>
<tr>
<td></td>
<td>0.2270</td>
<td>0.218</td>
<td>0.2350</td>
<td>0.2110</td>
<td>0.2380</td>
<td>0.2320</td>
<td>0.2210</td>
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<tr>
<td>∆N/TA</td>
<td>0.0190</td>
<td>0.016</td>
<td>0.0220</td>
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<td>0.0230</td>
<td>0.0190</td>
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<tr>
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<td>0.009</td>
<td>0.0080</td>
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<td>0.0970</td>
<td>0.0910</td>
<td>0.0900</td>
</tr>
<tr>
<td>CF/TA</td>
<td>0.0060</td>
<td>0.008</td>
<td>0.0040</td>
<td>0.0040</td>
<td>0.0070</td>
<td>0.0250</td>
<td>-0.014</td>
</tr>
<tr>
<td></td>
<td>0.0020</td>
<td>0.001</td>
<td>0.0030</td>
<td>0.0010</td>
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<tr>
<td></td>
<td>0.1020</td>
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<td>0.1070</td>
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<tr>
<td></td>
<td>2.4660</td>
<td>2.669</td>
<td>2.2320</td>
<td>2.4960</td>
<td>2.4390</td>
<td>2.3820</td>
<td>2.5420</td>
</tr>
</tbody>
</table>

Source: Own calculations (AMADEUS, 2006)

1 S=Sales, N=Inventory stock, ∆N= Inventory investment, CF=Cash flow (all scaled down by total assets); 1st value in a row=mean, 2nd value in a row=median, 3rd value in a row=std. deviation.
Table A-2: Summary statistics for the sample of SEE manufacturing firms split by finance constraint characteristics, 1999-2004, mil 1990 USD

<table>
<thead>
<tr>
<th>Variable</th>
<th>Full sample</th>
<th>Financially unconstrained</th>
<th>Financially constrained</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>636 obs.</td>
<td>508 obs.</td>
<td>128 obs.</td>
</tr>
<tr>
<td>Total assets</td>
<td>60.071</td>
<td>69.115</td>
<td>57.792</td>
</tr>
<tr>
<td></td>
<td>26.372</td>
<td>28.501</td>
<td>25.924</td>
</tr>
<tr>
<td></td>
<td>79.903</td>
<td>80.972</td>
<td>79.550</td>
</tr>
<tr>
<td>Inventory stock</td>
<td>15.100</td>
<td>23.292</td>
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<td>5.1710</td>
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<td></td>
<td>24.662</td>
<td>38.468</td>
<td>19.232</td>
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<td>Inventory inv.</td>
<td>1.2190</td>
<td>2.6470</td>
<td>0.8580</td>
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<tr>
<td></td>
<td>0.1410</td>
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</tr>
<tr>
<td></td>
<td>6.2190</td>
<td>10.730</td>
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</tr>
<tr>
<td>Sales</td>
<td>45.621</td>
<td>59.475</td>
<td>42.130</td>
</tr>
<tr>
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<td>22.683</td>
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<td>66.965</td>
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<td>Cash flow</td>
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<td>13.550</td>
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<td>S/TA</td>
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<td>0.2110</td>
</tr>
<tr>
<td>ΔN/TA</td>
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<td>S/N</td>
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<td>4.1810</td>
<td>4.0260</td>
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<tr>
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<td>3.7040</td>
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<tr>
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<td>2.4660</td>
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<td>2.4480</td>
</tr>
</tbody>
</table>

Source: Own calculations (AMADEUS, 2006)

1 S=Sales, N=Inventory stock, ΔN= Inventory investment, CF=Cash flow (all scaled down by total assets);
1st value in a row=mean, 2nd value in a row=median, 3rd value in a row=std. deviation.
2 Large/Old/High level trade credit user
3 Small/Young/Low level trade credit user
Table A-3: Summary statistics for the sample of SEE manufacturing firms split by country of origin, 1999-2004, mil 1990 USD

<table>
<thead>
<tr>
<th>Variable</th>
<th>BH</th>
<th>BG</th>
<th>CR</th>
<th>MC</th>
<th>RO</th>
<th>SM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16 firms</td>
<td>23 firms</td>
<td>21 firms</td>
<td>11 firms</td>
<td>15 firms</td>
<td>20 firms</td>
</tr>
<tr>
<td></td>
<td>96 obs.</td>
<td>138 obs.</td>
<td>126 obs.</td>
<td>66 obs.</td>
<td>90 obs.</td>
<td>120 obs.</td>
</tr>
<tr>
<td>Total assets</td>
<td>23.139</td>
<td>55.080</td>
<td>74.572</td>
<td>38.450</td>
<td>78.396</td>
<td>78.276</td>
</tr>
<tr>
<td></td>
<td>10.092</td>
<td>28.494</td>
<td>27.168</td>
<td>23.917</td>
<td>29.152</td>
<td>45.520</td>
</tr>
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<td>27.083</td>
<td>69.430</td>
<td>92.081</td>
<td>31.618</td>
<td>105.427</td>
<td>89.267</td>
</tr>
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<td></td>
<td>1.6150</td>
<td>8.0800</td>
<td>5.7050</td>
<td>4.2580</td>
<td>7.2540</td>
<td>9.9180</td>
</tr>
<tr>
<td>Inventory inv.</td>
<td>0.1350</td>
<td>1.4860</td>
<td>1.1940</td>
<td>0.2240</td>
<td>1.0030</td>
<td>2.5160</td>
</tr>
<tr>
<td></td>
<td>0.0240</td>
<td>0.3530</td>
<td>0.0980</td>
<td>-0.146</td>
<td>0.0430</td>
<td>0.6550</td>
</tr>
<tr>
<td></td>
<td>1.0080</td>
<td>4.3090</td>
<td>10.164</td>
<td>3.5420</td>
<td>5.1150</td>
<td>6.8010</td>
</tr>
<tr>
<td>Sales</td>
<td>12.642</td>
<td>38.068</td>
<td>63.101</td>
<td>22.567</td>
<td>84.224</td>
<td>46.063</td>
</tr>
<tr>
<td></td>
<td>5.6420</td>
<td>25.582</td>
<td>15.238</td>
<td>15.863</td>
<td>34.467</td>
<td>35.299</td>
</tr>
<tr>
<td></td>
<td>15.541</td>
<td>37.403</td>
<td>91.562</td>
<td>17.774</td>
<td>108.95</td>
<td>39.745</td>
</tr>
<tr>
<td>Cash flow</td>
<td>0.3350</td>
<td>3.8370</td>
<td>0.4240</td>
<td>2.0610</td>
<td>-5.288</td>
<td>-7.770</td>
</tr>
<tr>
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<td>0.0010</td>
<td>1.7950</td>
<td>0.0190</td>
<td>0.8980</td>
<td>-0.147</td>
<td>-1.233</td>
</tr>
<tr>
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<td>2.6860</td>
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<td>6.2400</td>
<td>5.4240</td>
<td>15.967</td>
<td>21.710</td>
</tr>
<tr>
<td>S/TA</td>
<td>0.5530</td>
<td>0.8910</td>
<td>0.7070</td>
<td>0.7500</td>
<td>1.2410</td>
<td>0.7860</td>
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<tr>
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<td>0.5720</td>
<td>0.8460</td>
<td>0.6090</td>
<td>0.6990</td>
<td>1.0780</td>
<td>0.7720</td>
</tr>
<tr>
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<td>0.2650</td>
<td>0.5250</td>
<td>0.3800</td>
<td>0.4230</td>
<td>0.4930</td>
<td>0.4070</td>
</tr>
<tr>
<td>N/TA</td>
<td>0.1930</td>
<td>0.3000</td>
<td>0.2580</td>
<td>0.2360</td>
<td>0.3200</td>
<td>0.2740</td>
</tr>
<tr>
<td></td>
<td>0.1580</td>
<td>0.2430</td>
<td>0.1590</td>
<td>0.1680</td>
<td>0.2410</td>
<td>0.2010</td>
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<tr>
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<td>0.1420</td>
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<td>0.2250</td>
<td>0.1740</td>
<td>0.2780</td>
<td>0.2510</td>
</tr>
<tr>
<td>∆N/TA</td>
<td>0.0070</td>
<td>0.0300</td>
<td>0.0150</td>
<td>-0.004</td>
<td>0.0120</td>
<td>0.0390</td>
</tr>
<tr>
<td></td>
<td>0.0030</td>
<td>0.0200</td>
<td>0.0090</td>
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<td>0.0020</td>
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</tr>
<tr>
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<td>0.0270</td>
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<td>0.0540</td>
<td>0.0910</td>
<td>0.1370</td>
<td>0.1130</td>
</tr>
<tr>
<td>CF/TA</td>
<td>0.0030</td>
<td>0.0660</td>
<td>0.0100</td>
<td>0.0550</td>
<td>-0.024</td>
<td>-0.072</td>
</tr>
<tr>
<td></td>
<td>0.0003</td>
<td>0.0430</td>
<td>0.0010</td>
<td>0.0380</td>
<td>-0.008</td>
<td>-0.049</td>
</tr>
<tr>
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<td>0.0560</td>
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<td>0.1070</td>
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<td>2.8810</td>
<td>2.9580</td>
<td>2.3737</td>
</tr>
</tbody>
</table>

Source: Own calculations (AMADEUS, 2006)

1 S=Sales, N=Inventory stock, ∆N= Inventory investment, CF=Cash flow (all scaled down by total assets); 1st value in a row=mean, 2nd value in a row=median, 3rd value in a row=std. deviation.
Table A-4: Summary statistics for the sample of SEE manufacturing firms split by industry sector, 1999-2004, mil 1990 USD

<table>
<thead>
<tr>
<th></th>
<th>Chemicals, pharmaceuticals, cosmetics</th>
<th>Food, beverages, tobacco</th>
<th>Machinery, vehicles, appliances</th>
<th>Metals, non-metals</th>
<th>Textiles, leather</th>
<th>Wood, paper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 firms</td>
<td>40 firms</td>
<td>17 firms</td>
<td>16 firms</td>
<td>5 firms</td>
<td>8 firms</td>
</tr>
<tr>
<td></td>
<td>120 obs.</td>
<td>240 obs.</td>
<td>102 obs.</td>
<td>96 obs.</td>
<td>30 obs.</td>
<td>40 obs.</td>
</tr>
<tr>
<td>Total assets</td>
<td>72.930</td>
<td>50.388</td>
<td>66.079</td>
<td>89.737</td>
<td>34.466</td>
<td>20.240</td>
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<tr>
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<td>83.161</td>
<td>53.614</td>
<td>107.83</td>
<td>103.43</td>
<td>59.785</td>
<td>22.416</td>
</tr>
<tr>
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<td>7.1540</td>
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<td>15.142</td>
<td>31.435</td>
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<td>23.252</td>
<td>11.576</td>
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</tr>
<tr>
<td>Inventory inv.</td>
<td>1.1210</td>
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<td>1.8570</td>
<td>1.0450</td>
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<td>0.3240</td>
<td>0.1400</td>
<td>0.0990</td>
<td>0.0880</td>
<td>0.1680</td>
<td>0.1140</td>
</tr>
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<td>8.0500</td>
<td>4.4310</td>
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<td>Sales</td>
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<td>43.395</td>
<td>47.643</td>
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<td>19.374</td>
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<td>16.701</td>
<td>34.799</td>
<td>9.8500</td>
<td>10.659</td>
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<tr>
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<td>70.917</td>
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<td>75.647</td>
<td>88.085</td>
<td>28.019</td>
<td>14.527</td>
</tr>
<tr>
<td>Cash flow</td>
<td>-1.979</td>
<td>-0.375</td>
<td>-2.533</td>
<td>-1.528</td>
<td>2.9640</td>
<td>-0.279</td>
</tr>
<tr>
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<td>0.0950</td>
<td>0.0020</td>
<td>0.0670</td>
<td>0.0180</td>
<td>0.1440</td>
<td>-0.0002</td>
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<tr>
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<td>13.002</td>
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<td>23.199</td>
<td>10.946</td>
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</tr>
<tr>
<td>S/TA</td>
<td>0.7930</td>
<td>0.8590</td>
<td>0.8870</td>
<td>0.6810</td>
<td>1.0040</td>
<td>0.6960</td>
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<tr>
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<td>0.6750</td>
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<td>0.7190</td>
</tr>
<tr>
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<td>0.4050</td>
<td>0.4890</td>
<td>0.4800</td>
<td>0.4410</td>
<td>0.6180</td>
<td>0.3810</td>
</tr>
<tr>
<td>N/TA</td>
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</tr>
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<td>0.1110</td>
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<td>0.1260</td>
</tr>
<tr>
<td>ΔN/TA</td>
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<td>0.0290</td>
<td>0.0090</td>
<td>0.0160</td>
<td>0.0120</td>
<td>0.0180</td>
</tr>
<tr>
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<td>0.0060</td>
<td>0.0090</td>
<td>0.0050</td>
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<td>0.0150</td>
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<tr>
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<td>0.1030</td>
<td>0.0960</td>
<td>0.0390</td>
<td>0.0479</td>
<td>0.2000</td>
<td>0.0650</td>
</tr>
<tr>
<td>CF/TA</td>
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<td>0.0220</td>
<td>0.0100</td>
<td>0.0120</td>
<td>-0.002</td>
</tr>
<tr>
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<td>0.0070</td>
<td>0.0003</td>
<td>0.0090</td>
<td>0.0020</td>
<td>0.0320</td>
<td>0.0000</td>
</tr>
<tr>
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<td>0.0990</td>
<td>0.0760</td>
<td>0.1070</td>
<td>0.0640</td>
</tr>
<tr>
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<td>4.5490</td>
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<td>4.0100</td>
<td>3.7080</td>
<td>3.3130</td>
<td>3.8880</td>
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<tr>
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<td>2.0110</td>
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<td>2.4030</td>
<td>1.8800</td>
<td>1.6760</td>
<td>2.3830</td>
</tr>
</tbody>
</table>

Source: Own calculations (AMADEUS, 2006)

1 S=Sales, N=Inventory stock, ΔN= Inventory investment, CF=Cash flow (all scaled down by total assets);
1st value in a row=mean, 2nd value in a row=median, 3rd value in a row=std. deviation.
Table A-5: Regression results for the full sample of firms using all cash flow versus non-negative and negative cash flow observations

<table>
<thead>
<tr>
<th></th>
<th>All cash flow observations</th>
<th>Non-negative cash flow observations</th>
<th>Negative cash flow observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>318 observations</td>
<td>190 observations</td>
<td>128 observations</td>
</tr>
<tr>
<td>∆Sit-1/Nit-1</td>
<td>0.048***</td>
<td>0.030***</td>
<td>0.060**</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.005)</td>
<td>(0.022)</td>
</tr>
<tr>
<td>∆rt-1</td>
<td>-0.562**</td>
<td>-0.290</td>
<td>-0.743</td>
</tr>
<tr>
<td></td>
<td>(0.270)</td>
<td>(0.210)</td>
<td>(0.745)</td>
</tr>
<tr>
<td>∆CFit-1/TAit-1</td>
<td>-0.040</td>
<td>-0.034</td>
<td>-0.069*</td>
</tr>
<tr>
<td></td>
<td>(0.228)</td>
<td>(0.087)</td>
<td>(0.405)</td>
</tr>
<tr>
<td>∆TCit-1/TAit-1</td>
<td>0.016</td>
<td>-0.077</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.065)</td>
<td>(0.042)</td>
</tr>
<tr>
<td>S∆∆Nit/TAit</td>
<td>-0.143</td>
<td>0.038</td>
<td>-0.240*</td>
</tr>
<tr>
<td></td>
<td>(0.100)</td>
<td>(0.029)</td>
<td>(0.142)</td>
</tr>
<tr>
<td>S∆∆Sit/TAit</td>
<td>0.282***</td>
<td>0.172***</td>
<td>0.378***</td>
</tr>
<tr>
<td></td>
<td>(0.069)</td>
<td>(0.051)</td>
<td>(0.135)</td>
</tr>
<tr>
<td>S∆∆r</td>
<td>0.540</td>
<td>0.272</td>
<td>0.447</td>
</tr>
<tr>
<td></td>
<td>(0.805)</td>
<td>(0.440)</td>
<td>(1.701)</td>
</tr>
<tr>
<td>S∆∆CFit/TAit</td>
<td>0.188</td>
<td>-0.003</td>
<td>0.174</td>
</tr>
<tr>
<td></td>
<td>(0.213)</td>
<td>(0.092)</td>
<td>(0.249)</td>
</tr>
<tr>
<td>S∆∆TCit/TAit</td>
<td>0.001</td>
<td>-0.030</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.021)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Sargan test</td>
<td>0.3589</td>
<td>0.3398</td>
<td>0.8655</td>
</tr>
<tr>
<td>m2</td>
<td>0.1154</td>
<td>0.7674</td>
<td>0.1810</td>
</tr>
</tbody>
</table>

Note: The dependent variable is the first-difference of inventory investment divided by total assets in period t, ∆Nit/TAit. S∆∆X provides the sum of coefficients for two lags of the second difference of X. All specifications were estimated using Arellano-Bond GMM first-difference estimator with ∆Sit-1/Nit-1, ∆rt-1, ∆CFit-1/TAit-1, ∆TCit-1/TAit-1, two lags of ∆Nit/TAit, ∆Sit-1/TAit, ∆rt, ∆CFit-1/TAit, ∆TCit-1/TAit, and further lags as instruments. Estimated coefficients are obtained from one-step estimators. Model specification tests are obtained from two-step estimators. Coefficients on constants are omitted. The significance of coefficients at various levels is indicated by *** for the 1 per cent level, ** for the 5 per cent level, and * for the 10 per cent level. The figures reported in parentheses are robust standard errors. A full set of time dummies and time dummies interacted with country dummies were included in all specifications as instruments. Two-step results for the Sargan test and m2 test are reported. Sargan test (J statistic) is a test of the overidentifying restrictions and is used to check the validity of instruments (null hypothesis is to satisfy over-identification). m2 test is a test for second order serial correlation in the first-differenced residuals (null hypothesis is no serial correlation). Reported figures are p-values of underlying test.

Source: Own calculations (AMADEUS, 2006)
Table A-6: Regression results with sample split by size using all cash flow versus non-negative and negative cash flow observations

<table>
<thead>
<tr>
<th></th>
<th>All CF observations</th>
<th>Non-negative CF observations</th>
<th>Negative CF observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Large</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td></td>
<td>167 obs.</td>
<td>151 obs.</td>
<td>93 obs.</td>
</tr>
<tr>
<td>∆Sit-1/Nit-1</td>
<td>0.041*</td>
<td>0.057***</td>
<td>0.081***</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.019)</td>
<td>(0.017)</td>
</tr>
<tr>
<td>∆r_t-1</td>
<td>-0.491*</td>
<td>-0.490</td>
<td>-0.454*</td>
</tr>
<tr>
<td></td>
<td>(0.288)</td>
<td>(0.563)</td>
<td>(0.256)</td>
</tr>
<tr>
<td>∆CF_it-1/TA_it-1</td>
<td>0.080</td>
<td>0.028</td>
<td>-0.215</td>
</tr>
<tr>
<td></td>
<td>(0.199)</td>
<td>(0.346)</td>
<td>(0.209)</td>
</tr>
<tr>
<td>∆TC_it-1/TA_it-1</td>
<td>-0.030</td>
<td>0.035</td>
<td>-0.085</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.042)</td>
<td>(0.088)</td>
</tr>
<tr>
<td>S∆∆Nit/TA_it</td>
<td>-0.101</td>
<td>-0.096</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>(0.324)</td>
<td>(0.075)</td>
<td>(0.123)</td>
</tr>
<tr>
<td>S∆∆S_it/TA_it</td>
<td>0.205**</td>
<td>0.337***</td>
<td>0.208***</td>
</tr>
<tr>
<td></td>
<td>(0.079)</td>
<td>(0.117)</td>
<td>(0.044)</td>
</tr>
<tr>
<td>S∆∆r</td>
<td>-0.728</td>
<td>2.215</td>
<td>-0.783**</td>
</tr>
<tr>
<td></td>
<td>(0.565)</td>
<td>(1.503)</td>
<td>(0.394)</td>
</tr>
<tr>
<td>S∆∆CF_it/TA_it</td>
<td>0.039</td>
<td>0.541</td>
<td>-0.131</td>
</tr>
<tr>
<td></td>
<td>(0.160)</td>
<td>(0.386)</td>
<td>(0.093)</td>
</tr>
<tr>
<td>S∆∆TC_it/TA_it</td>
<td>-0.005</td>
<td>-0.010</td>
<td>-0.027</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.030)</td>
<td>(0.038)</td>
</tr>
<tr>
<td>Sargan test</td>
<td>0.5803</td>
<td>0.6370</td>
<td>0.9566</td>
</tr>
<tr>
<td>m2</td>
<td>0.5738</td>
<td>0.2420</td>
<td>0.4474</td>
</tr>
</tbody>
</table>

Note: The dependent variable is the first-difference of inventory investment divided by total assets in period t, \( D\Delta N_{it}/TA_{it} \). \( S\DeltaAX \) provides the sum of coefficients for two lags of the second difference of \( X \). All specifications were estimated using Arellano-Bond GMM first-difference estimator with \( D\Delta N_{it}/TA_{it} \), \( D\Delta S_{it}/TA_{it} \), \( D\Delta r_t \), \( D\Delta CF_{it}/TA_{it} \), \( D\Delta TC_{it}/TA_{it} \), and further lags as instruments. Estimated coefficients are obtained from one-step estimators. Model specification tests are obtained from two-step estimators. Coefficients on constants are omitted. The significance of coefficients at various levels is indicated by *** for the 1 per cent level, ** for the 5 per cent level, and * for the 10 per cent level. The figures reported in parentheses are robust standard errors. A full set of time dummies and time dummies interacted with country dummies were included in all specifications as instruments. Two-step results for the Sargan test and \( m2 \) test are reported. Sargan test (J statistic) is a test of the over-identifying restrictions and is used to check the validity of instruments (null hypothesis is to satisfy over-identification). \( m2 \) test is a test for second order serial correlation in the first-differenced residuals (null hypothesis is no serial correlation). Reported figures are p-values of underlying test.

Source: Own calculations (AMADEUS, 2006)
<table>
<thead>
<tr>
<th></th>
<th>All CF observations</th>
<th>Non-negative CF observations</th>
<th>Negative CF observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Old</td>
<td>Young</td>
<td>Old</td>
</tr>
<tr>
<td></td>
<td>157 obs.</td>
<td>161 obs.</td>
<td>92 obs.</td>
</tr>
<tr>
<td>$\Delta S_{it-1}/N_{it-1}$</td>
<td>0.050***</td>
<td>0.044**</td>
<td>0.026***</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.020)</td>
<td>(0.008)</td>
</tr>
<tr>
<td>$\Delta r_{t-1}$</td>
<td>-0.670**</td>
<td>-0.583</td>
<td>-0.290</td>
</tr>
<tr>
<td></td>
<td>(0.321)</td>
<td>(0.452)</td>
<td>(0.205)</td>
</tr>
<tr>
<td>$\Delta CF_{it-1}/TA_{it-1}$</td>
<td>0.204</td>
<td>-0.476*</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>(0.316)</td>
<td>(0.278)</td>
<td>(0.095)</td>
</tr>
<tr>
<td>$\Delta TC_{it-1}/TA_{it-1}$</td>
<td>0.006</td>
<td>0.002</td>
<td>-0.074</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.079)</td>
<td>(0.095)</td>
</tr>
<tr>
<td>$S\Delta N_{it}/TA_{it}$</td>
<td>-0.210**</td>
<td>0.035</td>
<td>0.029</td>
</tr>
<tr>
<td></td>
<td>(0.095)</td>
<td>(0.072)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>$S\Delta S_{it}/TA_{it}$</td>
<td>0.297***</td>
<td>0.268***</td>
<td>0.153***</td>
</tr>
<tr>
<td></td>
<td>(0.104)</td>
<td>(0.097)</td>
<td>(0.094)</td>
</tr>
<tr>
<td>$S\Delta r$</td>
<td>1.022</td>
<td>0.006</td>
<td>0.484</td>
</tr>
<tr>
<td></td>
<td>(1.310)</td>
<td>(0.666)</td>
<td>(0.406)</td>
</tr>
<tr>
<td>$S\Delta CF_{it}/TA_{it}$</td>
<td>0.356</td>
<td>-0.146</td>
<td>0.017</td>
</tr>
<tr>
<td></td>
<td>(0.308)</td>
<td>(0.111)</td>
<td>(0.097)</td>
</tr>
<tr>
<td>$S\Delta TC_{it}/TA_{it}$</td>
<td>-0.022</td>
<td>0.009</td>
<td>-0.046</td>
</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.024)</td>
<td>(0.051)</td>
</tr>
<tr>
<td>Sargan test</td>
<td>0.3056</td>
<td>0.6716</td>
<td>0.1918</td>
</tr>
<tr>
<td>m2</td>
<td>0.0921</td>
<td>0.9767</td>
<td>0.4417</td>
</tr>
</tbody>
</table>

**Note:** The dependent variable is the first-difference of inventory investment divided by total assets in period $t$, $\Delta N_{it}/TA_{it}$. $S\Delta X$ provides the sum of coefficients for two lags of the second difference of $X$. All specifications were estimated using Arellano-Bond GMM first-difference estimator with $\Delta S_{it}/N_{it-1}$, $\Delta r_{t-1}$, $\Delta CF_{it}/TA_{it}$, $\Delta TC_{it}/TA_{it}$, two lags of $\Delta N_{it}/TA_{it}$, $\Delta S_{it}/TA_{it}$, $\Delta r_{t-1}$, $\Delta CF_{it}/TA_{it}$, $\Delta TC_{it}/TA_{it}$, and further lags as instruments. Estimated coefficients are obtained from one-step estimators. Model specification tests are obtained from two-step estimators. Coefficients on constants are omitted. The significance of coefficients at various levels is indicated by *** for the 1 per cent level, ** for the 5 per cent level, and * for the 10 per cent level. The figures reported in parentheses are robust standard errors. A full set of time dummies and time dummies interacted with country dummies were included in all specifications as instruments. Two-step results for the Sargan test and $m^2$ test are reported. Sargan test ($J$ statistic) is a test of the over-identifying restrictions and is used to check the validity of instruments (null hypothesis is to satisfy over-identification). $m^2$ test is a test for second order serial correlation in the first-differenced residuals (null hypothesis is no serial correlation). Reported figures are p-values of underlying test.

**Source:** Own calculations (AMADEUS, 2006)
Table A-8: Regression results with sample split by trade credit usage using all cash flow versus non-negative and negative cash flow observations

<table>
<thead>
<tr>
<th></th>
<th>All CF observations</th>
<th>Non-negative CF observations</th>
<th>Negative CF observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High TC</td>
<td>Low TC</td>
<td>High TC</td>
</tr>
<tr>
<td></td>
<td>175 obs.</td>
<td>143 obs.</td>
<td>100 obs.</td>
</tr>
<tr>
<td>( \Delta S_{it-1}/N_{it-1} )</td>
<td>0.053**</td>
<td>0.038**</td>
<td>0.038***</td>
</tr>
<tr>
<td></td>
<td>(0.021)</td>
<td>(0.015)</td>
<td>(0.009)</td>
</tr>
<tr>
<td>( \Delta r_{t-1} )</td>
<td>-0.708*</td>
<td>-0.563</td>
<td>-0.307</td>
</tr>
<tr>
<td></td>
<td>(0.362)</td>
<td>(0.500)</td>
<td>(0.347)</td>
</tr>
<tr>
<td>( \Delta CF_{it-1}/TA_{it-1} )</td>
<td>-0.229</td>
<td>0.452</td>
<td>0.017*</td>
</tr>
<tr>
<td></td>
<td>(0.204)</td>
<td>(0.685)</td>
<td>(0.129)</td>
</tr>
<tr>
<td>( \Delta TC_{it-1}/TA_{it-1} )</td>
<td>0.027</td>
<td>-0.004</td>
<td>-0.102</td>
</tr>
<tr>
<td></td>
<td>(0.030)</td>
<td>(0.056)</td>
<td>(0.075)</td>
</tr>
<tr>
<td>( S\Delta N_{it}/TA_{it} )</td>
<td>0.062</td>
<td>-0.309***</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(0.074)</td>
<td>(0.101)</td>
<td>(0.042)</td>
</tr>
<tr>
<td>( S\Delta S_{it}/TA_{it} )</td>
<td>0.261***</td>
<td>0.375**</td>
<td>0.165***</td>
</tr>
<tr>
<td></td>
<td>(0.081)</td>
<td>(0.161)</td>
<td>(0.050)</td>
</tr>
<tr>
<td>( S\Delta r )</td>
<td>0.288</td>
<td>0.041</td>
<td>0.621</td>
</tr>
<tr>
<td></td>
<td>(0.476)</td>
<td>(1.172)</td>
<td>(0.635)</td>
</tr>
<tr>
<td>( S\Delta CF_{it}/TA_{it} )</td>
<td>0.063</td>
<td>0.491</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>(0.166)</td>
<td>(0.550)</td>
<td>(0.111)</td>
</tr>
<tr>
<td>( S\Delta TC_{it}/TA_{it} )</td>
<td>0.013</td>
<td>-0.016</td>
<td>-0.043*</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
<td>(0.040)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>Sargan test</td>
<td>0.5883</td>
<td>0.1812</td>
<td>0.7726</td>
</tr>
<tr>
<td>m2</td>
<td>0.2889</td>
<td>0.1674</td>
<td>0.5662</td>
</tr>
</tbody>
</table>

Note: The dependent variable is the first-difference of inventory investment divided by total assets in period \( t \). \( \Delta N_{it}/TA_{it} \), \( S\Delta X \) provides the sum of coefficients for two lags of the second difference of \( X \). All specifications were estimated using Arellano-Bond GMM first-difference estimator with \( \Delta S_{it-1}/N_{it-1} \), \( \Delta r_{t-1} \), \( \Delta CF_{it-1}/TA_{it-1} \), \( \Delta TC_{it-1}/TA_{it-1} \), two lags of \( \Delta N_{it}/TA_{it} \), \( \Delta S_{it}/TA_{it} \), \( \Delta r \), \( \Delta CF_{it}/TA_{it} \), \( \Delta TC_{it}/TA_{it} \), and further lags as instruments. Estimated coefficients are obtained from one-step estimators. Model specification tests are obtained from two-step estimators. Coefficients on constants are omitted. The significance of coefficients at various levels is indicated by *** for the 1 per cent level, ** for the 5 per cent level, and * for the 10 per cent level. The figures reported in parentheses are robust standard errors. A full set of time dummies and time dummies interacted with country dummies were included in all specifications as instruments. Two-step results for the Sargan test and m2 test are reported. Sargan test (J statistic) is a test of the over-identifying restrictions and is used to check the validity of instruments (null hypothesis is to satisfy over-identification). m2 test is a test for second order serial correlation in the first-differenced residuals (null hypothesis is no serial correlation). Reported figures are p-values of underlying test.

Source: Own calculations (AMADEUS, 2006)
Table A-9: List of the most relevant crises in the SEE, 1970-2004

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Significant events</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973-1979</td>
<td>Worldwide</td>
<td>1971 Collapse of Breton Woods</td>
<td>Worldwide recession: Debtor countries preferred to deal with commercial banks rather than go to the IMF and the World Bank (the Breton Woods institutions). The combination of declining real interest rates, expanding world trade, improving commodity prices, and the depreciating dollar enabled and encouraged the debtor countries to increase their indebtedness.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1973 OPEC price rise</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1973-1979 International Credits</td>
<td></td>
</tr>
<tr>
<td>1979-1982</td>
<td>Worldwide</td>
<td>1979 OPEC price rise</td>
<td>Creditworthiness of the debtors was illusory. Consumption remained high, savings was discouraged by low or negative interest rates. Investment was stimulated by availability of cheap loans. Flight from monetary to real assets. The combination of high consumption, high inventories, and strong investment activity created boom conditions. The boom kept the demand for energy growing. The OPEC countries grew richer and less in need of current income, while negative real interest rates made it more attractive to keep oil in the ground than cash in the bank. This provided the setting in which the disruption of Iranian production in 1979 caused a second crisis and a second jump in the price of oil. Continental Europe and Japan had escaped inflation by following a more restrictive monetary policy and allowing their currencies to appreciate. The debtor countries were hit by increase in oil prices, plunging commodity prices, soaring interest rates, a strong dollar and a worldwide recession.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1980 Third World syndicated bank loans, failure by central banks to regulate Eurodollar market and stop commercial banks from reckless credit</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>Albania</td>
<td>1990-1992 End of the 46 years of xenophobic Communist rule</td>
<td>Between 1990 and 1992 Albania ended 46 years of xenophobic Communist rule and established a multiparty democracy. The transition has proven difficult as successive governments have tried to deal with high unemployment, widespread corruption, a dilapidated infrastructure, powerful organized crime networks with links to government officials, and disruptive political opponents. Albania has made incremental progress in its democratic development since first holding multiparty elections in 1991, but deficiencies remain - particularly in regard to the rule of law. Despite some lingering problems, international observers have judged elections to be largely free and fair since the restoration of political stability following the collapse of pyramid schemes in 1997.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1997 Collapse of pyramid schemes</td>
<td></td>
</tr>
<tr>
<td>1991-1993</td>
<td>Bosnia and Herzegovina</td>
<td>1991 Dissolution of Yugoslavia</td>
<td>Bosnia and Herzegovina’s declaration of sovereignty in October 1991, was followed by a declaration of independence from the former Yugoslavia on 3 March 1992 after a referendum boycotted by ethnic Serbs. Bosnia and Herzegovina ranked next to Macedonia as the poorest republic in the old Yugoslav federation. The interethnic warfare in Bosnia caused production to plummet by 80% from 1992 to 1995 and unemployment to soar.</td>
</tr>
<tr>
<td>1989-1993</td>
<td>Bulgaria</td>
<td>1996 Collapse of the Bulgarian banking sector, when 14 out of the 35 registered commercial banks failed</td>
<td>Communist domination ended in 1990, when Bulgaria held its first multiparty election since World War II and began the contentious process of moving toward political democracy and a market economy while combating inflation, unemployment, corruption, and crime. A major economic downturn in 1996 led to the fall of the then socialist government. In 1997, macroeconomic stability was reinforced by the imposition of a fixed exchange rate of the Leva against the German D-mark</td>
</tr>
<tr>
<td>1996-1997</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
and the negotiation of an IMF standby agreement. Looking at the development of the financial sector in Bulgaria, the real reforms started only in 1997, after the introduction of the currently-operating currency board in the country. The way the previous reformist governments had handled the reform in the sector could be characterized mildly as passivity or financial policy mismanagement, without comprehensiveness in the reform initiatives. Privatization, consolidation, decapitalization, and other similar initiatives that intended to be market driven were introduced, but quite sporadically and in an inconsistent manner. In addition, the regulatory system in the sector was inadequate, allowing personal deposits and state funds to be misallocated towards shady organizations.

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-1993</td>
<td>Croatia</td>
<td>1991 Dissolution of Yugoslavia</td>
<td>Before the dissolution of Yugoslavia, the Republic of Croatia, after Slovenia, was the most prosperous and industrialized area, with a per capita output perhaps one-third above the Yugoslav average. The economy emerged from a mild recession in 2000 with tourism, banking, and public investments leading the way.</td>
</tr>
<tr>
<td>1999-2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1988-1992</td>
<td>Romania</td>
<td>1989 Execution of Ceausescu</td>
<td>The decades-long rule of dictator Nicolae Ceausescu, who took power in 1965, and his Securitate police state became increasingly oppressive and draconian through the 1980s. Ceausescu was overthrown and executed in late 1989. Former Communists dominated the government until 1996, when they were swept from power by a fractious coalition of centrist parties. Romania began the transition from Communism in 1989 with a largely obsolete industrial base and a pattern of output unsuited to the country's needs. The country emerged in 2000 from a punishing three-year recession thanks to strong demand in EU export markets.</td>
</tr>
<tr>
<td>1997-1999</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991-1993</td>
<td>Serbia and Montenegro</td>
<td>1991 Dissolution of Yugoslavia</td>
<td>In the early 1990s, post-Tito Yugoslavia began to unravel along ethnic lines: Slovenia, Croatia, Macedonia, and Bosnia and Herzegovina were recognized as independent states in 1992. The remaining republics of Serbia and Montenegro declared a new &quot;Federal Republic of Yugoslavia&quot; (FRY) in April 1992 and, under President Slobodan Milosevic, Serbia led various military intervention efforts to unite ethnic Serbs in neighboring republics into a &quot;Greater Serbia.&quot; Federal elections in the fall of 2000 brought about the ouster of Milosevic and installed Vojislav Kostunica as president. Milosevic-era mismanagement of the economy, an extended period of economic sanctions, and the damage to Yugoslavia's infrastructure and industry during the NATO air strikes in 1999 left the economy only half the size it was in 1990. After the ousting of former Federal Yugoslav President Milosevic in October 2000, the Democratic Opposition of Serbia (DOS) coalition government implemented stabilization measures and embarked on an aggressive market reform program.</td>
</tr>
<tr>
<td>1999-2000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991-1995</td>
<td>Macedonia</td>
<td>1991 Dissolution of Yugoslavia</td>
<td>Macedonia gained its independence peacefully from Yugoslavia in 1991. The undetermined status of neighboring Kosovo, implementation of the Framework Agreement - which ended the 2001 ethnic Albanian armed insurgency - and a weak economy continue to be challenges for Macedonia. At independence in September 1991, Macedonia was the least developed of the Yugoslav republics, producing a mere 5% of the total federal output of goods and services. The collapse of Yugoslavia ended transfer payments from the center and eliminated advantages from inclusion in a de facto free trade area. An absence of infrastructure, UN sanctions on the downsized Yugoslavia, one of its largest markets, and a Greek economic embargo over a dispute about the country's constitutional name and flag hindered economic growth until</td>
</tr>
</tbody>
</table>
1996. GDP subsequently rose each year through 2000. However, the leadership’s commitment to economic reform, free trade, and regional integration was undermined by the ethnic Albanian insurgency of 2001. The economy shrank 4.5% because of decreased trade, intermittent border closures, increased deficit spending on security needs, and investor uncertainty. Growth barely recovered in 2002.

Source:
3. CIA World Factbook [URL: http://www.cia.gov/cia/publications/factbook], 13.05.2006;