TWO ESSAYS ON MONETARY UNION AND INTERNATIONAL FINANCE

A Dissertation

by

NAI-WEI CHEN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2005

Major Subject: Economics

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ABSTRACT

Two Essays on Monetary Union and International Finance. (August 2005)

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This dissertation studies the Economic and Monetary Union (EMU) and its effects on foreign exchange markets and corporate cash holdings. These two potential effects are examined in the dissertation in two separate essays.

The first essay examines the validity of the purchasing power parity (PPP) condition during three distinct exchange rate regimes (floating-rate, target-zone arrangement, and fixed-rate or common currency) from January 1973 through January 2004. My results support PPP, but I find that PPP during the common currency regime holds in fewer EMU countries than during the alternative exchange rate regimes. In addition, PPP between currency blocs holds for all countries examined during the first two regimes, but deteriorates after the introduction of the euro for the EMU countries as opposed to the non-EMU countries. I do not obtain strong evidence supporting PPP for the EMU countries since the euro adoption, but the faster mean reversion I observe in the few EMU countries where PPP does hold, may signal higher market efficiency and economic integration in the future.

The second essay investigates corporate liquidity (cash holdings of firms) from 15 European Union (EU) countries [12 Economic and Monetary Union (EMU) countries

that adopted the euro, and 3 non-EMU countries] from 1993 to 2002 using a dynamic panel data model. My main contributions to the corporate liquidity literature are four-fold. First, I provide evidence that creditor rights also affect corporate liquidity and their effect is more consistent than that of shareholder rights. Second, I show that the recent formation of EMU affects corporate liquidity. Debt and net working capital are better substitutes for cash in EMU countries than non-EMU countries. The adoption of a common currency reduces cash holdings in EMU countries. Third, my results suggest that agency theory plays an important role in explaining corporate liquidity. In particular, the agency view explains corporate liquidity better for EMU firms, probably because of an enhanced capital market integration that weakens the transaction and precautionary motives of holding cash. Fourth, I show that dealing with the endogeneity problem in corporate liquidity studies is important.

To my parents and sister

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I would like to acknowledge all the professors on my committee. Especially I would like to thank Dr. Arvind Mahajan, who has been so patient, kind and helpful. I also would like to give my special thanks to Dr. Andrew J. Rettenmaier and Dr. Zijun Wang for their continuous help with my research.

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CHAPTER I

INTRODUCTION

The establishment of the Economic and Monetary Union (EMU) culminating in the adoption of the common currency, euro, is one of the most important economic events in recent years. This macro change apparently affects the foreign exchange markets, especially for those countries that adopted the euro. It might also have affected the asset structure of firms in the EMU countries. This dissertation consists of two chapters, each of which aims to examine the impacts of the monetary union on the member states from the perspective of international finance. More specifically, one chapter deals with the introduction of the euro and purchasing power parity (PPP) while the other chapter deals with the effects of corporate governance and monetary union on corporate liquidity. Methodologically, the first chapter is an application of time series econometrics, i.e., unit root test using seemingly unrelated regressions (SUR) (Zellner 1962). The second chapter is an application of a dynamic panel data model (Arellano and Bond 1991). The following describes the history of European Union (EU) and how the EMU and euro came into being. After that, I provide a brief introduction for each of these two chapters.

This dissertation follows the style and format of Journal of Financial Economics.

A. EU, EMU and Euro

European countries have attempted to form a more united Europe for more than 50 years. Shortly after the Second World War, several treaties were signed with the intent of preventing wars and pursuing peace. The early treaties dealt with economic integration because the signatories believed that political conflicts and wars were less likely to happen if the countries shared common economic interests.

The Treaty of Paris was signed in 1951 to set up European Coal and Steel Community (ECSC), which consists of 6 countries, i.e., Belgium, West Germany, Luxembourg, France, Italy and the Netherlands. In 1957, these same countries signed the Treaty of Rome to set up the European Economic Community (EEC) and the European Atomic Energy Community (EURATOM). These 3 arrangements (i.e., ECSC, EEC and EURATOM) are considered the predecessor of the recently established European Union (EU). The motivation behind the establishment of these communities is to pursue higher degree of economic integration by removing trade barriers and creating a single market. Subsequently, in 1986, the Single European Act was signed. In 1992, the Treaty on European Union (also termed the Maastricht Treaty) was signed and the European Union (EU) came into being. The objective of all these treaties is to enhance political and economic integration among the member states (Leonard 2002).

The creation of the Economic and Monetary Union (EMU) and the euro was the culmination of this lengthy economic and political process and considered by many scholars as the most significant institutional innovation to occur in international markets. In fact, the monetary reforms in Europe date back to March 1979, when the European

Monetary System (EMS) was established to foster monetary stabilization. However, the exchange rate regime adopted at that time proved to be inadequate and finally led to speculative currency attacks in 1992-1993. In light of a series of monetary crisis since the 1980s, the Maastricht Treaty was agreed to in December 1991 and was signed in February 1992 to further promote monetary stabilization and form the Economic and Monetary Union (EMU).[1]

The Treaty of Maastricht specified a gradual adjustment process to a union with countries converging in monetary and fiscal policies to some desired level. More specifically, according to the Maastricht Treaty, countries wishing to join the EMU have to meet four convergence criteria related to inflation, budget deficits, exchange rates and interest rates. The objective of the convergence criteria is to ensure harmonization in economic and monetary policies among potential member states. Inflation, budget deficits and interest rates had to be lowered to a desired level while exchange rates had to be stabilized. In 1998, 11 countries meeting the criteria fixed their bilateral foreign exchange rates against the Deutsche Mark. Ultimately, in January 1999, the same 11 countries that met the convergence criteria formed the EMU and adopted a common currency, the euro. Greece was close to accession when the euro was launched, but it did not become a member state until January 1, 2001. On January 1 2002, the euro started to

[1] According to the glossary provided by http://europa.eu.int, "Economic and Monetary Union (EMU) is the name given to the process of harmonizing the economic and monetary policies of the member states of the Union with a view to introduce a single currency, the euro." In this chapter, in addition to the above definition, EMU also means the union of 12 countries, depending on the context.

circulate and became the sole legal tender of the 12 EMU countries after February 28, 2002.[2]

In June 1997, the stability and growth pact was adopted by the European Council in Amsterdam as a resolution to ensure that the EMU countries continue to maintain desirable budget deficits. In fact, some countries like Germany and France have been issued warnings of excessive budget deficits. According to the stability and growth pact, countries running excessive budget deficits will be penalized such that fiscal policies of all member countries can remain as harmonized as before they became member states. In addition, a further resolution was also adopted by the European Council in Luxembourg in December 1997, which deals with the decision that ministers of the EMU countries may meet informally to coordinate their various policies related to the common currency, implying that participating countries may harmonize policies other than monetary and fiscal policies to achieve the goal of creating a common currency area. Hence, the euro is in a sense a catalyst, which helps expedite the market integration process. Subsequently, the Treaty of Amsterdam was signed in October 1997 and went into force on May 1, 1999. The Treaty of Nice was signed in February 2001 and entered into force on February 1, 2003. These two treaties are more politically oriented, aimed to enhance cooperation between member states. Overall, the more recent treaties and resolutions also help integrate markets in the EU and the EMU.

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[2] For information about the fixed bilateral foreign exchange rates of the 12 EMU countries against the Deutsche Mark, please visit http://europa.eu.int/scadplus/leg/en/lvb/l25017.htm;http://www.portugal.org/information/economic4/info_1l.html

B. Euro and Purchasing Power Parity

Chapter II studies euro and purchasing power parity (PPP). The Economic and Monetary Union (EMU) between 12 European countries and the adoption of a new common currency, the euro, has been accompanied by convergence in monetary and fiscal policies, increased transparency, as well as reduced barriers in the financial and real sectors of the participating countries.

Purchasing power parity is a fundamental building block of international finance, linking prices and foreign exchange rates. It has been viewed as an equilibrium condition, an efficient arbitrage condition in goods or assets markets, and a theory of exchange rate determination.[3] PPP plays a crucial role in risk management since it implies that nominal price fluctuations in the real sector are buffered (and if PPP holds, offset) by exchange rate fluctuations to maintain same real prices across countries. Therefore, its validity has been a subject of significant empirical scrutiny that has yielded mixed results. The prevailing consensus in the literature seems to be that estimated deviations from PPP are persistent with a half-life of 4 to 5 years.[4] This chapter revisits PPP in the backdrop of the EMU and the euro adoption. Since the exchange rate fluctuations are precluded by having a common currency, the burden of maintaining PPP (or the law of one price) falls solely on harmonized inflation rates within the euro currency bloc countries.

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[3] See Officer (1976), Frenkel (1976, 1978), Dornbusch (1987), Isard (1987), and Summers and Heston (1991).

[4] See Froot and Rogoff (1995) and Rogoff (1996) for a survey of this literature.

Chapter II has two objectives. The first is to provide further evidence on the validity of the PPP using an improved empirical procedure. The second is to compare PPP performance during three different exchange rate regimes, i.e., floating-rate, target-zone arrangement, and fixed-rate or common currency regimes. More specifically, I examine whether the EMU and the adoption of the euro have improved PPP performance in the euro area. There is virtual consensus on the historic significance of the EMU and the euro. However, while skeptics have questioned the wisdom underlying this economic event, others believe that the changes associated with it will result in beneficial market integration (e.g., Mundell 1997).[5] The significant effort to integrate EMU country markets by dismantling barriers and harmonizing regulations should lead to PPP holding better within the member states. No improvement in PPP performance due to these remarkable changes will highlight the critical role that floating exchange rates play for the parity condition to hold across countries. Hence, my results will also have implications for the 10 countries that recently joined the European Union (EU) on May 1, 2004 and those aspiring to join it.[6]

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[5] For example, some economists thought that it would be better for Europe to have four or five regional currencies instead of a single currency (Tootell 1990; Krugman 1990). In addition, while some advocate that the euro adoption will further improve political integration in Europe despite economic problems which existed before the euro, Feldstein (1992; 1997; 2000) argued that this economic event may actually result in a political conflict within the EMU as well as with US.

[6] Greece's experience is especially important because it did not join the EMU until 2001. It is predicted that the potential economic benefits for Greece from joining the EMU are large (perhaps up to 20% of GDP) (Vittas 2004). In fact, my study shows that Greece is one of the few countries where PPP holds after the introduction of the euro. During my test period, EU was comprised of 15 countries. Eleven of these which joined the EMU on January 1, 1999 are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. Greece was admitted to the EMU on January 1, 2001. Denmark, Sweden and the United Kingdom are members of EU but not EMU.

I investigate PPP during the period January 1973 to January 2004, which is further divided into three sub-periods based on different exchange rate regimes, i.e., floating exchange rate regime (January 1973 to March 1979), the European Monetary System (EMS) or target-zone arrangement regime (April 1979 to April 1998), and euro or fixed-rate regime (May 1998 to January 2004). Using seemingly unrelated regression (SUR) procedure and accounting for cross-currency correlations, I evaluate the parity condition using data from the twelve EMU countries and five non-EMU countries, including two EU countries in close geographic proximity to the euro area, i.e., United Kingdom (UK, which met the convergence criteria before 1999 but chose not to join the EMU) and Switzerland, as well three non-EU countries like the United States (US), Canada and Japan. I evaluate the parity between the currency blocs and within the euro currency bloc using the US dollar (USD) and the German Deutsche Mark (DM) as numeraire currencies.

C. Effects of Corporate Governance and Monetary Union on Corporate Liquidity

Chapter III studies the effects of corporate governance and monetary union on corporate liquidity (or cash holdings of firms). Most finance literature dealing with the balance sheet studies the capital structure. Comparatively speaking, the asset structure has received little attention. This chapter examines corporate cash holdings, which is a less explored area in corporate finance. In addition, to my knowledge, this chapter is the first study of corporate liquidity using the monetary union as the backdrop and the first to examine the potential impacts of this macro change on the firm level cash holdings.

In general, firms hold cash for transaction, precautionary and speculative motives.[7] More specifically, they use cash to conduct day-to-day operations such as paying employees, purchasing inputs, and paying dividends to stockholders. Firms will hold less cash if the transaction cost (e.g., cost of liquidating assets or raising capital) is lower and vice versa. In addition, they hold cash for the precautionary reason to invest in future profitable projects in case they have difficulty raising funds from the capital markets. The precautionary motive results from information asymmetry and the agency costs of debt (Opler et al. 1999), both of which can make it difficult to raise funds in capital markets. Information asymmetry arises because outsiders know less about the firm's operation than management, while the agency costs of debt arise when the interests of the debt holders differ from those of the shareholders. The higher the level of information asymmetry and the agency costs of debt, the greater will be the precautionary motive. Further, management might hoard cash because of its own personal risk aversion or because it wants to satisfy its own needs, e.g., consuming perquisites, termed the agency cost of managerial discretion (Opler et al. 1999).[8]

Chapter III contributes to the existing international corporate liquidity literature in several ways. Many valuation models treat cash as negative debt; the amount of cash held by the firm is simply subtracted from the value of debt outstanding in order to compute shareholders' equity in the firm (Acharya et al. 2005). This assumes perfect

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[7] Firms need cash for the speculative motive to take advantage of bargain purchases, but conventional wisdom is that liquidity held for speculative motive is relatively minor and negligible compared to that held due to transaction and precautionary motives.

[8] Agency costs also include costs incurred to minimize or eliminate the conflict between debt holders and equity holders or among different kinds of debt holders.

substitutability between cash and debt. On the other hand, no one assumes perfect substitutability between cash and equity. While the relationship between cash and debt may not be perfect, cash is much closer to debt than it is to equity.[9] Therefore, creditor rights should influence the cash holdings of firms more than shareholder rights. Recent international corporate liquidity studies have highlighted the importance of shareholder rights in a country as a determinant of its firms' cash holdings (Dittmar et al. 2003), but no one has evaluated the role of creditor rights. The first contribution of Chapter III is to show that creditor rights are a significant determinant of corporate liquidity.

The creation of the European Union (EU) comprised of 15 countries, and within it, the Economic and Monetary Union (EMU) of 12 countries, adopted a common currency. The creation of the EMU provides a unique opportunity to examine what happens to cash holdings of firms operating in an area where transactions which formally occurred in multiple currencies are reduced due to the single currency. Establishment of EMU and the common currency should lead to decreased transaction costs in the EMU countries. If capital markets become more integrated within the EMU, it should be easier for firms in EMU countries to raise funds and will thus weaken the precautionary motive for holding cash. This should result in lower corporate liquidity in EMU countries in contrast to non-EMU countries that retained their national currencies. The test of this hypothesis is the second contribution of this chapter, and to my knowledge, the first examination of this issue. I also investigate how the institutional

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[9] Opler et al.(1999) note that most of the variables associated with high cash levels are also known to be associated with low leverage.

changes associated with the EMU have affected the sensitivity of corporate liquidity to its benchmark determinants (e.g., market-to-book ratio, net working capital, cash flow, etc.).

Finally, Chapter III formally deals with the endogeneity problem associated with the determinants of corporate liquidity that has received little attention in the liquidity literature. While recent studies have started recognizing this problem, they do not account for it.[10] Since ignoring the presence of the endogeneity problem can lead to biased estimation, my study explicitly deals with this issue and shows that it is important to control for endogenous variables. Furthermore, since the agency costs are embedded in each of the extant theories (i.e., tradeoff theory, financing hierarchy theory, and agency theory), the predictions of each theory about how corporate liquidity is affected by its determinants are inevitably intertwined. It is difficult to infer which theory outperforms others from the estimated coefficients of the corporate liquidity determinants. Instead of arguing which theory best explains corporate liquidity, this chapter evaluates the relevance of agency theory in explaining corporate liquidity. I examine the coefficients of the corporate governance variables, whose effects are more clearly predicted by the agency theory.

My data span 1993 to 2002. I analyze all 15 European Union (EU) countries, including 12 EMU countries with the euro as their common currency, and 3 non-EMU

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[10] For example, Harford et al. (2005) note that corporate cash holdings and corporate governance can be jointly determined, recognizing that the endogeneity problem may arise when modeling the relation between these two variables. However, they also note the difficulty in accounting for the endogeneity problem using two-stage least squares (2SLS) because of lack of proper instrument variables. Though they recognize it, yet they do not account for it in their study.

countries which have retained their numeraires, as a control group.[11] Many changes resulting from the formation of the EU were common to all 15 member states. Therefore, selecting the 3 non-EMU country firms as the control group isolates the unique effect of the monetary union resulting in the adoption of a common currency on corporate liquidity in the 12 EMU countries. Using the dynamic panel data model (Arellano and Bond 1991) and accounting for the endogeneity problem associated with the determinants of corporate liquidity, I examine corporate cash holdings using a large sample of non-US firms. In particular, I investigate how corporate governance variables and monetary union affect corporate liquidity.

[11] The 12 EMU countries are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. The 3 non-EMU countries are Denmark, Sweden, and the United Kingdom (UK). The EU admitted 10 new countries to the Union on May 1, 2004 and these are not included in my analysis.

CHAPTER II

EURO AND PURCHASING POWER PARITY

This chapter examines the validity of the purchasing power parity (PPP) condition during three distinct exchange rate regimes (floating-rate, target-zone arrangement, and fixed-rate or common currency) from January 1973 through January 2004. Regulatory harmonization and real and financial sector changes associated with the adoption of euro as a common currency were supposed to enhance economic convergence and market integration in the euro zone. If they did, then PPP based on the law of one price should hold better. On the other hand, a single currency substitutes fixed for floating exchange rates, an important variable for restoring PPP, leaving the adjustment burden solely on domestic prices.

My results support PPP but I find that PPP during the common currency regime holds in fewer EMU countries than during alternative exchange rate regimes. In addition, PPP between currency blocs holds for all countries examined during the first two regimes but deteriorates after the introduction of the euro for the EMU countries as opposed to the non-EMU countries. I do not obtain strong evidence supporting PPP for the EMU countries since the euro adoption, but faster mean reversion observed in the few EMU countries where PPP does hold may signal higher market efficiency and economic integration in the future.

A. Introduction

Economic and Monetary Union (EMU) between 12 European countries and the adoption of a new common currency, euro, is one of the most significant recent institutional innovations in international markets. The adoption of euro is accompanied by convergence in monetary and fiscal policies, increased transparency, as well as removal of barriers in the financial and real sectors of the euro area countries. Purchasing power parity (PPP) is a fundamental building block of international finance, linking prices and foreign exchange rates. It has been viewed as an equilibrium condition, an efficient arbitrage condition in goods or assets markets, and a theory of exchange rate determination.[12] PPP plays a crucial role in risk management since it implies that nominal price fluctuations in the real sector are buffered (and if PPP holds, offset) by exchange rate fluctuations to maintain same real prices across countries. Therefore, its validity has been a subject of significant empirical scrutiny that has yielded mixed results. The prevailing consensus in the literature seems to be that estimated deviations from PPP are persistent with a half-life of 4 to 5 years.[13] This chapter revisits PPP in the backdrop of EMU and euro adoption. Since the exchange rate fluctuations are precluded by having a common currency, the burden of maintaining PPP (or the law of one price) falls solely on harmonized inflation rates within the euro currency bloc countries.

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[12] See Officer (1976), Frenkel (1976, 1978), Dornbusch (1987), Isard (1987), and Summers and Heston (1991).

[13] See Froot and Rogoff (1995) and Rogoff (1996) for a survey of this literature.

This chapter has two objectives. The first is to provide further evidence on the validity of the PPP using a better empirical procedure. The second is to compare PPP performance during three different exchange rate regimes (floating-rate, target-zone arrangement, and fixed-rate or common currency). More specifically, I examine whether the EMU and the adoption of the euro have improved PPP performance in the euro area. There is virtual consensus on the historic significance of the EMU and euro. However, while skeptics have questioned the wisdom underlying this economic event, others believe that the changes associated with it will result in beneficial market integration (e.g., Mundell 1997). [14] The significant effort to integrate EMU country markets by dismantling barriers and harmonizing regulations should lead to PPP holding better within the EMU. No improvement in PPP performance due to these remarkable changes will highlight the critical role floating exchange rates play for parity to hold across countries. Hence, my results will also have implications for the 10 countries that recently joined the European Union (EU) on May 1, 2004 and those aspiring to join it.[15]

I test PPP during the period January 1973 to January 2004 further divided into three sub-periods based on different exchange rate regimes, i.e., floating exchange rate

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[14] For example, some economists thought that it would be better for Europe to have four or five regional currencies instead of a single currency (Tootell 1990; Krugman 1990). In addition, while some advocate that the euro adoption will further improve political integration in Europe despite economic problems which existed before the euro, Feldstein (1992; 1997; 2000) argued that this economic event may actually result in a political conflict within the EMU as well as with US.

[15] Greece's experience is especially important because it did not join the EMU until 2001. It is predicted that the potential economic benefits for Greece from joining the EMU are large (perhaps up to 20% of GDP) (Vittas 2004). In fact, my study shows that Greece is one of the few countries where PPP holds after the introduction of the euro. During my test period, EU was comprised of 15 countries. Eleven of these which joined the EMU on January 1, 1999 are Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. Greece was admitted to the EMU on January 1, 2001. Denmark, Sweden and the United Kingdom are members of EU but not EMU.

regime (January 1973 to March 1979), the European Monetary System (EMS) or target-zone arrangement regime (April 1979 to April 1998), and euro or fixed-rate regime (May 1998 to January 2004). Using seemingly unrelated regression procedure and accounting for cross-currency correlations, I evaluate the parity using data from the twelve EMU countries, two non-EMU countries in close geographic proximity to the euro area, i.e., United Kingdom (UK, which is a member of the European Union) and Switzerland, as well as the United States (US), Canada, and Japan. I evaluate the parity between the currency blocs and within the euro currency bloc using the US dollar (USD) and the German Deutsche Mark (DM) as numeraire currencies. In general, I provide stronger evidence on the validity of the PPP against USD with significantly shorter half-life than that documented in previous studies. Significantly, however, I do not obtain evidence of PPP holding better (i.e., domestic prices converging) within the rationale the EMU since the adoption of the euro. I observe PPP holding between currency blocs but not within a currency bloc, and reject geographic proximity between two countries as the rationale for PPP holding between them as argued by some researchers.

This chapter is structured as follows. Section B provides a brief discussion of the EMU and euro. Section C discusses PPP and reviews the relevant literature. Section D discusses the model tested and the econometric issues associated with it. It also describes the data employed. Section E contains a discussion of my results and Section F concludes this chapter.

B. EMU and Euro

The euro came into being in 1999 at the end of a long convergence process that began in March 1979 with the establishment of the European Monetary System (EMS) designed to facilitate monetary stabilization. In 1992, after the EMS collapsed, European countries tried to restore monetary integration and signed the Maastricht Treaty, which specified a plan and the convergence criteria for the monetary union to occur in 1999. The adjustment process towards a union was to be gradual and countries had to dismantle barriers and converge in monetary and fiscal policies to an agreed upon level prior to forming a monetary union. Finally, countries that met the convergence criteria were formally admitted to the EMU on January 1, 1999 though their currencies' exchange rates were fixed a few months earlier in May 1998.

The adoption of a single currency was associated with many other reforms affecting both financial and real markets in the EMU. In addition to convergence in monetary and fiscal policies as well as reconciliation between national banks in the euro zone, trade policies and regulations dealing with cross-border flows were relaxed to facilitate the flow of capital, labor, and goods across countries in the euro area. These led Issing (2001) to claim that prices of tradable goods will converge and co-movement of price and output will become better in the EMU. Rogoff (2001) noted that goods markets are less integrated than we might think due to trade costs (including transport costs, tariff as well as differences in regulations and currencies), and adoption of a single currency is one way to reduce trade costs. If reforms associated with the euro are effective in harmonizing markets by reducing regulatory and structural barriers and transaction costs,

they should result in a more integrated market with the law of one price (same price for a basket of goods in two countries) prevailing.

The collapse of the fixed exchange rate Bretton Woods system in 1971 leading to the floating exchange rate system resulted in a significant debate regarding the pros and cons of these regimes. The periodic discontent with the floating-rate regime, especially in periods of high inflation and widely fluctuating exchange rates, still prompts occasional calls for a return to the fixed-rate system. However, such calls are short lived because a fixed-rate or common currency regime entails governments surrendering a significant control over their monetary policy (to assure uniform price stability across all member nations) and governments may be reluctant or unable to do so. Hence, whether PPP and price convergence improve with reduced barriers but fixed exchange rates is an empirical issue and adoption of the euro provides a unique opportunity to test it. This provides the motivation for my study. I compare PPP performance during different exchange rate regimes, and in particular, I examine whether adoption of the euro results in price convergence with PPP holding better. The next section discusses empirical issues associated with testing the PPP.

C. PPP: Empirical Issues and Literature Review

1. Purchasing Power Parity

The PPP is based on the law of one price, which states that in the absence of any frictions, identical goods should trade for the same real price in different countries. If we

construct a basket of similar goods in two countries, PPP specifies that the exchange rate for any two currencies should equal the relative own-currency price of the two baskets. Disparity from PPP $\left(d_{i,t}\right)$ can be expressed as:

$$d_{i,t} = \ln\left(\frac{S_{i,t}P^*_{i,t}}{P_{i,t}}\right) = \ln\left(1 + k_{i,t}\right), \tag{1}$$

where S is the spot exchange rate in terms of base currency (USD or DM) per unit of foreign currency, P^* is the foreign price level, P is the base country price level, k stands for some level of market imperfection or measurement errors, subscript i stands for country i and t is the time subscript.[16]

Mixed empirical validity of PPP in previous studies has been attributed to a variety of reasons in the literature. Price levels are typically proxied by monthly price indices for consumer or wholesale goods. Since these indices contain a large fraction of non-tradable goods (both tradable and non-tradable goods can have country specific weights in the indices reflecting differing national tastes), their use can increase the probability of erroneously rejecting the PPP.[17] Besides, in practice, available price indices data do not have the same base year, which can lead to estimated $d_{i,t} \neq 0$. Researchers respond to this problem by either assuming PPP holding in the base period (e.g., Rogoff 1996) or by ignoring the intercept when performing estimation (e.g., Flôres

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[16] Note that for consistency, we continue to use DM (and USD) as the base currency for evaluating PPP during the third sub-period. Since the exchange rates of all EMU currencies are fixed against each other, $S_{i,t}$ in equation 1during this period is a constant for EMU countries when using DM as the numeraire, but fluctuates when USD is the base currency (since euro fluctuates against USD).

[17] Tradable goods indices have other problems, are available for fewer countries, and have lower (quarterly) frequency data.

et al. 1999). Furthermore, d_t can also be non-zero if PPP is actually violated due to existence of non-arbitragable imperfections.

2. Literature Review

The importance of PPP has resulted in a burgeoning body of empirical literature testing its validity.[18] Recent studies test for the existence of unit root in the real exchange rate. Rejection of a unit root (random walk) implies existence of mean reversion of real exchange rate towards the parity condition. The more robust panel data approach or multivariate unit root test entails pooling data for different currencies.[19] Imposing the condition of common speed of mean reversion for all currencies, Abuaf and Jorion (1990), Jorion and Sweeney (1996) and Frankel and Rose (1996) provide evidence against unit root. However, given differential regulations and nature of markets in different countries, their real exchange rates could display different speeds of adjustment and mean reversion. This could also be due to differential trading costs (e.g., Sercu et al. (1995)) as well as the nature of shocks, real or monetary, borne by an economy. For example, highly inflationary economies display faster mean reversion (see McNown and Wallace (1989)). In addition, slow productivity gains in Japanese nontradable goods due to government protection vis-à-vis competitive tradable goods resulting in sustained real

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[18] See Froot and Rogoff (1995) and Rogoff (1996) for studies that review this literature.

[19] Another technique called cointegration analysis, developed by Engle and Granger (1987), has also been applied to test PPP. It segregates the real exchange rate into its nominal and price-level components and tests the stationarity of the residuals. These tests suffer from problems of endogeneity of regressors, frequently obtain estimates of cointegration vector that are hard to interpret and by allowing for non-proportional relationships, can not shed light on whether real exchange rates are mean-reverting.

appreciation of yen led to very slow mean reversion (see Marston (1987) and Yoshikawa (1990)). That is also the case when relative prices adjusted for exchange rates are correlated with relative productivity of economies (see Balassa (1964) and Canzoneri et al. (1999)). Thus, the speed of mean reversion depends on the unique nature of a shock and the way it affects a currency, which is ignored by studies assuming a common speed of adjustment. My panel data approach allows for this.

Furthermore, it is well known that in today's interrelated markets, a shock in one country can have repercussions in other countries (e.g., the 1997 Asian currency crises). This can result in non-zero correlations and cross-sectional dependence across currencies. Recent studies that econometrically account for such dependence increase the power of their tests.[20] Tests conducted in this chapter account for cross sectional dependence among currencies and allow for differential speeds of mean reversion.

This chapter sheds light on another issue, i.e., how well the PPP holds within a currency bloc in contrast to between currency blocs. I separately examine how well PPP performs in the 12 EMU and 5 non-EMU countries with both USD and DM as the numeraire. Evidence on this issue is sparse and seems to suggest that PPP holds better within the currency blocs but not between them. Koedijk et al. (1998) conjecture that lower volatility of currencies and geographic proximity within the currency bloc contribute to more effective arbitrage and thus lead to evidence in favor of PPP within the bloc. This is supported by Eun and Lai (2003) who report that, with DM as the benchmark, PPP holds between Germany and other EMU countries but does not hold

[20] See Koedijk et al. (1998) and Flôres et al. (1999).

between Germany and non-EMU countries that are proximate to the euro area, i.e., UK and Switzerland, from 1994 to 2001. The real exchange rates for these two countries behave like those of other non-EMU but geographically distant countries (like the US) suggesting that institutions may overwhelm geographic proximity regarding their effects on PPP. However, Koedijk et al. (2003) support PPP holding within the euro currency bloc for only 4 out of 9 countries they analyzed.[21] Hence, existing evidence regarding PPP holding better within a currency bloc than between currency blocs is mixed and unreliable.

I examine PPP between European countries that are geographically close to the euro zone but not members of the EMU (i.e., UK and Switzerland) as well as non-EMU countries which are geographically distant from the euro zone (i.e., US, Canada, and Japan), to see how geographic proximity affects PPP.[22] Using DM as numeraire, I find much weaker support for PPP holding between Germany and other EMU countries than between Germany and non-EMU countries, suggesting that PPP holds better between currency blocs rather than within a bloc. Geographic proximity plays no role for PPP to hold. In general, my results support PPP but I find no evidence of PPP holding better within the EMU after the adoption of the common currency (fixed-rate) regime whether PPP is evaluated using USD or DM.

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[21] Their results are questionable. Koedijk et al. (2004) divide their test period (1975-2003) into 3 overlapping sub-periods, each starting in March 1973 (March 1973 to December 1991, March 1973 to December 1998, and March 1973 to March 2003) to examine whether Maastricht Treaty and the euro improve PPP. However, this procedure of simply adding more observations by just extending the test period cannot shed light on the key issue of PPP performance during the euro period. We test for PPP over three distinct non-overlapping sub-periods so my results are not contaminated by data from other regimes.

[22] UK is a member of EU (that includes EMU countries), sharing common policies with EMU countries except that it has not adopted the common currency.

D. Methodology Issues

I use the seemingly unrelated regression (SUR) or the multivariate unit root test as the estimation procedure in this chapter. It has more power than the univariate unit root test.[23] Furthermore, SUR derived estimators are more efficient than those obtained from OLS (Zellner 1962) when real exchange rates across currencies are contemporaneously correlated as documented in some studies.[24]

The model for the multivariate unit root test takes the form:

$$d_{i,t} = \alpha_i + \beta_i d_{i,t-1} + u_{i,t} \tag{2}$$

where $d_{i,t}$ is PPP disparity as defined in equation (1). Each data series was stacked on each other to perform the SUR, which was conducted using EViews statistical package by including intercepts and allowing iterations to obtain convergence in weights and therefore feasible GLS estimators.

As discussed earlier, many factors can lead to observation of PPP violations and non-zero α_i in equation (2).[25] Therefore, unlike previous studies, I allow for a non-zero intercept when performing the SUR. In general, my focus is to test whether β_i is significantly less than one. My null hypothesis is that PPP disparity, $d_{i,t}$, follows random walk or $H_o : \beta_i = 1$. If the estimated β_i is not significantly different from one, I conclude that real exchange rates follow random walk (are nonstationary) and are not mean

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[23] See Edison, et al (1997), and Papell and Theodoridis (1998).
[24] See, for example, O'Connell (1998) and Flôres et al. (1999).
[25] For example, different base years of price indices used and existence of frictions (a la Sercu et al. (1995), Devereux (1997)) can lead to PPP violations.

reverting, i.e., PPP does not hold. My alternative hypothesis is $H_a : \beta_i < 1$, which implies existence of mean reversion towards parity.[26] The estimated speed of mean reversion towards PPP can be discerned from the half-life (i.e., $\ln(0.5)/\ln(\beta_i)$), which reveals how fast a shock will die out to restore PPP over time. More specifically, half-life tells us how long it takes a shock to become half of its initial size. A short half-life implies that PPP is restored quickly and holds better as opposed to a long half-life.

The critical values used to determine statistical significance of the results have to be derived by simulation analysis, taking into account the historical covariance matrix obtained from the estimation results. However, previous studies (Abuaf and Jorion 1990; Flôres et al. 1999) assume that the intercept is zero (i.e., $\alpha = 0$) for the true process when performing simulations. This procedure inappropriately assumes that PPP is holding in the base year, markets are devoid of frictions and uneven base years for price indices do not result in any measurement problems. If these assumptions are violated, observed disparity could converge to some level that may not be zero and I can still test for the existence of mean reversion towards that level. Therefore, forcing the intercept to be zero as done by previous studies is economically inappropriate. I conducted simulation analysis in Gauss assuming that the data were generated by equation (2) with $\beta = 1$ and without imposing the restriction of α being zero (i.e., unit root model with drift). Hence, the assumed true model and the estimated model are the same. This is in contrast to

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[26] Under the mean reversion alternative hypothesis, the current real rate will revert to the long run equilibrium rate at the speed of $\alpha_i / (1 - \beta_i)$. Unless the long run rate is unity, α_i must be non-zero. Due to reasons mentioned earlier, the estimated long run disparity need not be zero, therefore, α_i need not equal zero under H_a.

previous papers (Abuaf and Jorion 1990; Flôres et al. 1999) that assume random walk with drift for their estimation model but random walk without drift for simulation or their assumed true model.

Since my interest is the mean reversion (i.e., β) and I do not really know if the intercept is zero, I can eliminate the constant by the Frisch-Waugh-Lovell (FWL) theorem when conducting simulation and still get the same estimator for β (Baltagi 2002). This is different from the Abuaf and Jorion (1990) approach, in which the sample's estimate of the intercept is inappropriately used for simulation.

Suppose the simulation model is as follows:

$$d_{i,t} = \alpha_i + d_{i,t-1} + u_{i,t}\,. \tag{3}$$

Pre-multiplying each series $\left\{d_{i,t}\right\}_{t=1}^{T}$ in equation (1) by $Q = I_T - \frac{\iota_T \iota_T'}{T}$, I have

$$\tilde{d}_{i,t} = \tilde{d}_{i,t-1} + \tilde{u}_{i,t}\,, \tag{4}$$

where I_T is an identity matrix with the dimension of $T \times T$; $\iota_T = \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}_{T\times 1}$;

$\tilde{d}_{i,t} = d_{i,t} - \overline{d}_{i,\cdot}$ and $\overline{d}_{i,\cdot} = \frac{\sum_{t=1}^{T} d_{i,t}}{T}$.

Then data are generated according to the above transformed process. The values of $\left\{u_{i,t}\right\}_{t=1}^{T}$ $\left(i = 1 \ldots N\right)$ are generated simultaneously by the random number generator with standard normal distribution. Pre-multiplying each series $\left\{u_{i,t}\right\}_{t=1}^{T}$ by Q and

obtaining $\left\{\tilde{u}_{i,t}\right\}_{t=1}^{T}$, the random walk process $\tilde{d}_{i,t}$ is generated based on the following equation:

$$\tilde{d}_{i,t} = \sum_{s=1}^{t} \tilde{u}_{i,t} \ , t = 1 \ldots T. \tag{5}$$

The historical covariance matrices obtained from EViews were used to generate GLS estimators for the experiment. Then, the estimated coefficient is calculated based on the standard OLS formula, i.e.,

$$\hat{\beta}_i = \frac{\sum_{t=2}^{T} \hat{d}_{i,t} \hat{d}_{i,t-1}}{\sum_{t=2}^{T} \hat{d}_{i,t-1}^2} \ , \tag{6}$$

where $i = 1, \ldots, N$, and $\hat{d}_{i,t}$ is $\tilde{d}_{i,t}$ adjusted for cross sectional correlation. The number of iterations is 5000. The coefficient $\hat{\beta}_i$'s were then derived and they are asymptotically distributed Gaussian (Hamilton 1994) since both the estimation model and the true model are characterized by the process of random walk with drift. It follows that the only relevant test statistic is t-test statistic, i.e.,

$$t = \frac{\hat{\beta}_i - 1}{se\left(\hat{\beta}_i\right)}, \tag{7}$$

which was used to determine whether to reject the null hypothesis of random walk. The one-sided critical values were generated at 1%, 5%, and 10 % levels based on the empirical distribution of t-test statistics[27].

[27] Critical values obtained from my simulations are reported in Appendix A.

Ahn (1994) shows that ignoring known structural breaks can lead to incorrect inferences when performing tests of stationarity. Since I are interested in the validity of PPP during different exchange rate regimes, I separately analyze data over three sub-periods: January 1973 to March 1979 (the floating exchange rate regime), April 1979 to April 1998 (the target-zone arrangement regime), and May 1998 to January 2004 (the fixed-rate euro regime). [28]

In addition to evaluating PPP for each individual country within the euro area, I also want to assess the unique effect of the euro on price convergence in EMU countries as a group. I examine the whole data set from January 1973 to January 2004 as well as pre and post euro sub-periods for EMU and non-EMU countries. To examine this issue, I implement two other SUR setups. One allows for different country coefficients and the other imposes a common coefficient. For each setup, I have two models. One model has two time dummies to distinguish the three sub-periods. The other model has only one time dummy that distinguishes only the third (euro) sub-period from the rest. I want to see if the coefficients associated with the euro period time dummies (D_2) are significantly different from zero (and if PPP holds better due to increased market integration, they should be significantly less than zero). The following are the specifications of the two models under each setup.

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[28] The European Council approved the entry of the 11 countries into the EMU on May 2, 1998. Bilateral exchange rates between 11 EMU countries were fixed on May 3, 1998 (http://europa.eu.int/scadplus/leg/en/lvb/l25017.htm; http://www.portugal.org/information/economic4/info_1l.html). Since we test for PPP against DM, we chose May 1998 as the breaking point where the euro was implicitly introduced for the EMU countries instead of January 1999 when financial markets started operating in euro. For similar reasons, Bris (2003) also uses 1998 as the benchmark for the adoption of the euro.

Different coefficient model:

$$\text{Model 1: } d_{i,t} = \alpha_i + \beta_i \cdot d_{i,t-1} + \gamma_{i1} \cdot D_1 \cdot d_{i,t-1} + \gamma_{i2} \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$$

$$\text{Model 2: } d_{i,t} = \alpha_i + \beta_i \cdot d_{i,t-1} + \gamma_i \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$$

Common coefficient model:

$$\text{Model 1: } d_{i,t} = \alpha + \beta \cdot d_{i,t-1} + \gamma_1 \cdot D_1 \cdot d_{i,t-1} + \gamma_2 \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$$

$$\text{Model 2: } d_{i,t} = \alpha + \beta \cdot d_{i,t-1} + \gamma \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$$

where D_1 is the time dummy variable which equals one for the second sub-period from April 1979 to April 1998 and zero otherwise; D_2 is the time dummy which equals one for the third sub-period from May 1998 to January 2004 and 0 otherwise; other notations are the same as defined earlier. Again, I used EViews statistical package to conduct the estimation. For the different country coefficients model, I conducted SUR for the full sample of 16 countries as a whole. However, SUR was performed for 11 EMU countries and 5 non-EMU countries separately for the common coefficient model. My null hypothesis is $H_0 : \gamma = 0,\ \gamma_i = 0$ and my alternative hypothesis is $H_a : \gamma \neq 0,\ \gamma_i \neq 0$. If I reject the null hypothesis and the estimated coefficient γ associated with the second time dummy (D_2) is significantly less (greater) than zero (i.e., mean reversion is faster (slower) due to the introduction of euro), I will conclude that the adoption of the euro improves (worsens) PPP and price harmonization. In contrast, if I am unable to reject the null hypothesis, I will conclude that PPP performance has not been affected by the common currency.

Table 1. System Autoregression against USD. $d_{i,t} = \alpha_i + \beta_i d_{i,t-1} + u_{i,t}$**,**

Monthly Data: January 1973 - January 2004

$d_{i,t}$ is disparity from PPP and defined as $d_{i,t} = \log\left(\frac{S_t P_t^*}{P_t}\right)$, where S_t denotes spot exchange rate in unit of USD per foreign currency; P_t and P_t^* are price levels (represented by CPIs) for US and some other country, respectively.

	(A) 1973:1-1979:3			(B) 1979:4-1998:4			(C) 1998:5-2004:1		
Country	β_i (se(β_i))	half-life	$\tau(\beta_i)$	β_i (se(β_i))	half-life	$\tau(\beta_i)$	β_i (se(β_i))	half-life	$\tau(\beta_i)$
Austria	0.944 (0.013)	11.97	-4.20*	0.970 (0.004)	23.01	-6.73***	0.980 (0.007)	n.a.	-2.89
Belgium	0.944 (0.013)	n.a.	-4.36	0.970 (0.004)	n.a.	-6.86	0.982 (0.007)	n.a.	-2.43
Finland	0.924 (0.020)	8.80	-3.86***	0.965 (0.008)	19.32	-4.60***	0.978 (0.007)	n.a.	-3.26
France	0.946 (0.025)	12.59	-2.12**	0.970 (0.005)	22.83	-5.81***	0.982 (0.007)	n.a.	-2.75
Germany	0.925 (0.019)	8.89	-3.93*	0.968 (0.005)	21.48	-6.89***	0.984 (0.008)	n.a.	-2.16
Greece	0.893 (0.046)	6.10	-2.32***	0.979 (0.009)	32.97	-2.31***	0.952 (0.027)	14.05	-1.81***
Ireland	0.902 (0.042)	6.71	-2.36**	0.956 (0.008)	15.51	-5.31***	0.971 (0.007)	23.27	-4.32***
Italy	0.872 (0.039)	5.07	-3.29***	0.968 (0.007)	21.08	-4.88***	0.983 (0.007)	n.a.	-2.37
Luxembourg	0.939 (0.015)	n.a.	-4.13	0.969 (0.004)	n.a.	-6.82	0.981 (0.008)	n.a.	-2.28
Netherlands	0.929 (0.017)	9.41	-4.12***	0.948 (0.012)	12.93	-4.22***	0.976 (0.008)	28.97	-3.03**
Portugal	0.846 (0.044)	4.15	-3.48***	0.985 (0.006)	45.55	-2.69***	0.978 (0.008)	31.15	-2.73*
Spain	0.954 (0.036)	14.79	-1.28**	0.975 (0.006)	27.80	-4.38***	0.976 (0.007)	28.09	-3.33**
Average half-life		8.85			24.25			25.10	
No. of countries where PPP is supported			10			10			5
Canada	0.961 (0.032)	n.a.	-1.20	0.993 (0.010)	n.a.	-0.67	0.963 (0.038)	n.a.	-0.96
Japan	0.947 (0.018)	12.75	-2.99***	0.978 (0.008)	31.44	-2.79***	0.946 (0.036)	12.59	-1.48**
Switzerland	0.933 (0.020)	9.98	-3.41***	0.966 (0.006)	20.10	-5.29***	0.944 (0.013)	12.12	-4.18***
UK	0.936 (0.029)	n.a.	-2.19	0.974 (0.010)	26.14	-2.50***	0.989 (0.028)	n.a.	-0.41
Average half-life		11.36			25.89			12.36	
No. of countries where PPP is supported			2			3			2
Overall average half-life		9.27			24.63			21.46	
Total no. of countries where PPP is supported			12			13			7

Notes: Statistics are defined as $\tau(\beta_i) = \frac{\beta_i - 1}{se(\beta_i)}$. One-sided critical values of $\tau(\beta_i)$ are obtained from simulation under the null hypothesis that $\beta_i = 1$ without assuming $\alpha_i = 0$.

Half-life (months) is calculated only for those countries associated with rejections by the formula: $\ln(0.5)/\ln(\beta_i)$. Rejections of the null hypothesis at 10%, 5%, and 1% are represented by *, **, and ***, respectively. Data are obtained from International Financial Statistics and DataStream.

I obtain end of month data on foreign exchange rates and consumer price indices from International Financial Statistics (IFS) and DataStream spanning 31 years and 1 month from 1973 (start of the floating exchange rate regime) to 2004. These data are obtained for 17 countries, the 12 euro-zone countries and 5 countries outside the euro zone. Since I am also interested in evaluating PPP between and within currency blocs, I evaluate PPP using two different numeraire currencies. The between currency blocs tests are conducted with all foreign exchange rates measured in USD. To test PPP within the euro zone, all exchange rates are measured in DM.

E. Empirical Results

Tables 1 and 2 present the unit root test results for the PPP. The tables have three panels, each containing results for the three sub-periods associated with a distinct exchange rate regime. Panel A reports results for the floating-rate regime spanning January 1973 to March 1979, panel B for the target-zone arrangement EMS regime spanning April 1979 to April 1998 and panel C for the fixed-rate euro regime covering May 1998 to January 2004. Each table reports results obtained from the SUR analysis, i.e., the slope coefficients, their standard errors, the half-life, t-test statistic, and the significance of the slope coefficient $\left(H_0 : \beta_i = 1;\ H_a : \beta_i < 1\right)$. I first discuss the results obtained with USD as the numeraire for 16 currencies (i.e., between currency blocs test) followed by the results with DM as the numeraire for 11 euroland countries (i.e., within currency bloc test) and five non-EMU countries which serve as a control group.

Table 2. System Autoregression against DM. $d_{i,t} = \alpha_i + \beta_i d_{i,t-1} + u_{i,t}$**,**

Monthly Data: January 1973 - January 2004

$d_{i,t}$ is disparity from PPP and defined as $d_{i,t} = \log\left(\frac{S_t P_t^*}{P_t}\right)$, where S_t denotes spot exchange rate in unit of DM per foreign currency; P_t and P_t^* are price levels (represented by CPIs) for Germany and some other country, respectively.

	(A) 1973:1-1979:3			(B) 1979:4-1998:4			(C) 1998:5-2004:1		
Country	β_i (se(β_i))	half-life	$\tau(\beta_i)$	β_i (se(β_i))	half-life	$\tau(\beta_i)$	β_i (se(β_i))	half-life	$\tau(\beta_i)$
Austria	0.948 (0.017)	n.a.	-3.04	0.979 (0.008)	n.a.	-2.58	0.882 (0.034)	n.a.	-3.50
Belgium	0.970 (0.016)	n.a.	-1.93	0.953 (0.011)	n.a.	-4.31	0.921 (0.032)	n.a.	-2.48
Finland	0.956 (0.019)	15.40	-2.34*	0.974 (0.009)	26.75	-2.88***	0.752 (0.043)	2.43	-5.73***
France	0.936 (0.033)	10.56	-1.93**	0.948 (0.016)	12.95	-3.21***	0.967 (0.027)	n.a.	-1.23
Greece	0.784 (0.044)	2.84	-4.86***	0.924 (0.021)	8.75	-3.60***	0.804 (0.049)	3.18	-4.01***
Ireland	0.841 (0.046)	4.01	-3.45***	0.974 (0.011)	26.41	-2.34***	0.979 (0.009)	n.a.	-2.43
Italy	0.831 (0.034)	3.74	-4.91***	0.977 (0.009)	30.33	-2.40***	0.960 (0.014)	n.a.	-2.82
Luxembourg	0.978 (0.022)	n.a.	-1.01	0.951 (0.011)	n.a.	-4.55	0.840 (0.044)	3.99	-3.66***
Netherlands	0.918 (0.027)	8.07	-3.01*	0.988 (0.012)	56.67	-1.05*	0.969 (0.017)	n.a.	-1.82
Portugal	0.936 (0.033)	10.49	-1.94***	0.996 (0.010)	n.a.	-0.43	0.963 (0.015)	n.a.	-2.54
Spain	0.863 (0.048)	4.71	-2.85***	0.974 (0.011)	26.53	-2.30***	0.946 (0.015)	12.57	-3.59**
Average half-life		7.48			26.91			5.54	
No. of countries where PPP is supported			8			7			4
Canada	0.939 (0.022)	10.99	-2.78*	0.988 (0.008)	n.a.	-1.59	0.925 (0.027)	8.85	-2.84***
Japan	0.972 (0.025)	n.a.	-1.12	0.987 (0.011)	52.32	-1.20***	0.913 (0.028)	7.66	-3.09***
Switzerland	0.961 (0.027)	n.a.	-1.47	0.968 (0.017)	21.10	-1.91*	0.944 (0.029)	n.a.	-1.94
UK	0.878 (0.035)	5.32	-3.48***	0.951 (0.013)	13.79	-3.87***	0.845 (0.039)	4.13	-3.97***
US	0.903 (0.026)	6.81	-3.74**	0.988 (0.008)	n.a.	-1.47	0.934 (0.021)	10.21	-3.12***
Average half-life		7.71			29.07			7.71	
No. of countries where PPP is supported			3			3			4
Overall average half-life		7.54			27.56			6.63	
Total no. of countries where PPP is supported			11			10			8

Notes: Statistics are defined as $\tau(\beta_i) = \frac{\beta_i - 1}{se(\beta_i)}$. One-sided critical values of $\tau(\beta_i)$ are obtained from simulation under the null hypothesis that $\beta_i = 1$ without assuming $\alpha_i = 0$. Half-life (months) is calculated only for those countries associated with rejections by the formula: $\ln(0.5)/\ln(\beta_i)$. Rejections of the null hypothesis at 10%, 5%, and 1% are represented by *, **, and ***, respectively. Data are obtained from International Financial Statistics and DataStream.

Table 3. System Autoregression with different coefficients against DM to examine the effect of euro adoption.

Model 1: $d_{i,t} = \alpha_i + \beta_i \cdot d_{i,t-1} + \gamma_{i1} \cdot D_1 \cdot d_{i,t-1} + \gamma_{i2} \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$,

Model 2: $d_{i,t} = \alpha_i + \beta_i \cdot d_{i,t-1} + \gamma_i \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$,

Monthly Data: January 1973 - January 2004

$d_{i,t}$ is disparity from PPP and defined as $d_{i,t} = \log\left(\frac{S_t P_t^*}{P_t}\right)$, where S_t denotes spot exchange rate in unit of DM per foreign currency; P_t and P_t^* are price levels (represented by CPIs) for Germany and some other country, respectively; D_1 is the time dummy which takes on the value of 1 if the time is from April 1979 to April 1998 and zero otherwise; D_2 is the time dummy which takes on the value of 1 if the time is from May 1998 to January 2004 and 0 otherwise.

	Model 1				Model 2	
Country	γ_{i1} (se(γ_{i1}))	$\tau(\gamma_{i1})$	γ_{i2} (se(γ_{i2}))	$\tau(\gamma_{i2})$	γ (se(γ))	$\tau(\gamma_i)$
Austria	-0.00142 (0.00056)	-2.53	-0.00174 (0.00074)	-2.34**	-0.00010 (0.00043)	-0.23
Belgium	0.00096 (0.00036)	2.65**	0.00080 (0.00045)	1.76	0.00003 (0.00036)	0.09
Finland	-0.00280 (0.00240)	-1.17	0.00080 (0.00284)	0.28	0.00283 (0.00234)	1.21
France	-0.00190 (0.00139)	-1.37	-0.00079 (0.00164)	-0.48	0.00057 (0.00132)	0.43
Greece	-0.00119 (0.00066)	-1.81	-0.00297 (0.00097)	-3.05***	-0.00192 (0.00076)	-2.53**
Ireland	0.02200 (0.00653)	3.37***	0.02403 (0.00716)	3.36***	0.00301 (0.00349)	0.86
Italy	-0.00146 (0.00044)	-3.34***	-0.00137 (0.00053)	-2.60**	-0.00018 (0.00040)	-0.45
Luxembourg	0.00116 (0.00042)	2.74**	0.00086 (0.00051)	1.68	-0.00009 (0.00038)	-0.25
Netherlands	0.02332 (0.02270)	1.03	0.00435 (0.03676)	0.12	-0.00913 (0.03384)	-0.27
Portugal	-0.00081 (0.00060)	-1.34	-0.00126 (0.00090)	-1.40	-0.00055 (0.00073)	-0.76
Spain	-0.00088 (0.00084)	-1.06	-0.00117 (0.00101)	-1.16	-0.00048 (0.00070)	-0.68
Canada	0.01409 (0.01089)	1.29	0.00347 (0.01588)	0.22	-0.00699 (0.01359)	-0.51
Japan	-0.00131 (0.00115)	-1.14	-0.00197 (0.00161)	-1.22	-0.00078 (0.00108)	-0.72
Switzerland	0.01273 (0.02533)	0.50	0.02024 (0.02431)	0.83	0.01012 (0.01181)	0.86
UK	0.02019 (0.00543)	3.72***	0.02676 (0.00674)	3.97***	0.00486 (0.00338)	1.44
US	0.01652 (0.00892)	1.85	0.01454 (0.01002)	1.45	-0.00065 (0.00589)	-0.11

Notes: Statistics are defined as $\tau(\gamma) = \frac{\gamma}{se(\gamma)}$. Rejections of the null hypothesis at 10%, 5%, and 1% are represented by *, **, and ***, respectively. Data are obtained from International Financial Statistics and DataStream.

Table 4. System Autoregression with common coefficient against DM to examine the effect of euro adoption.

Model 1: $d_{i,t} = \alpha + \beta \cdot d_{i,t-1} + \gamma_1 \cdot D_1 \cdot d_{i,t-1} + \gamma_2 \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$,

Model 2: $d_{i,t} = \alpha + \beta \cdot d_{i,t-1} + \gamma \cdot D_2 \cdot d_{i,t-1} + u_{i,t}$,

Monthly Data: January 1973 - January 2004

$d_{i,t}$ is disparity from PPP and defined as $d_{i,t} = \log\left(\frac{S_t P_t^*}{P_t}\right)$, where S_t denotes spot exchange rate in unit of DM per foreign currency; P_t and P_t^* are price levels (represented by CPIs) for Germany and some other country, respectively; D_1 is the time dummy which takes on the value of 1 if the time is from April 1979 to April 1998 and zero otherwise; D_2 is the time dummy which takes on the value of 1 if the time is from May 1998 to January 2004 and 0 otherwise.

	Model 1				Model 2	
Group	γ_1 (se(γ_1))	$\tau(\gamma_1)$	γ_2 (se(γ_2))	$\tau(\gamma_2)$	γ (se(γ))	$\tau(\gamma)$
11 EMU countries	-0.00004 (0.00020)	-0.19	-0.00002 (0.00025)	-0.06	0.00001 (0.00020)	0.06
5 non-EMU countries	0.00059 (0.00073)	0.80	0.00035 (0.00093)	0.38	-0.00009 (0.00075)	-0.12

Notes: Statistics are defined as $\tau(\gamma) = \frac{\gamma}{se(\gamma)}$. Rejections of the null hypothesis at 10%, 5%, and 1% are represented by *, **, and ***, respectively.

Data are obtained from International Financial Statistics and DataStream.

Following this, I discuss structural break results obtained from the SUR including time dummy variables to see if euro adoption affects PPP performance (or more specifically, mean reversion) in the euro area. I also examine what happens to PPP for countries outside the euro area to provide a contrast. These results are contained in Tables 3 and 4, which show the significance of coefficients associated with the dummy variables $\left(H_0 : \gamma = 0;\ H_a : \gamma \neq 0\right)$. Table 3 presents results from SUR allowing for different country coefficients while Table 4 contains results from SUR imposing the restriction of common coefficients. Time paths for the relevant variables are presented in Figures 1 and 2 to visually understand my findings.

1. Unit Root Test Results

Table 1 contains PPP results for 16 countries using USD as the benchmark currency. In the first sub-period (floating-rate regime), panel A shows that the null of random walk $\left(\beta_i = 1\right)$ cannot be rejected for only 4 of the 16 countries at the 10% level, which are Belgium, Luxembourg, Canada and UK. Evidence supporting mean reversion towards PPP ($\beta_i < 1$) is obtained for 12 countries (Austria, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Spain and Switzerland) during this sub-period. Panel B results for the second sub-period (target-zone arrangement regime) show an increase in the number of rejections and an even stronger support (at 1% level) for PPP. Mean reversion is supported in this sub-period for one more country (i.e., UK) compared to the first sub-period. Panel C results for the third sub-period (fixed-rate euro

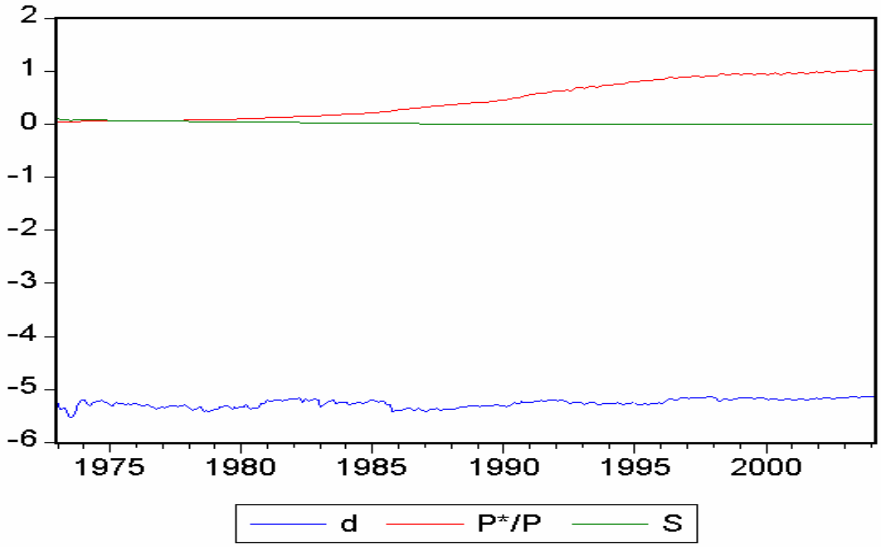

Figure 1. Time path for Greek Drachma against DM.
Monthly Data: January 1973 - January 2004
Time-series plot of monthly data of disparity from PPP (d_t), price ratio $\left(P_t^* / P_t\right)$, and nominal exchange rate (S_t)

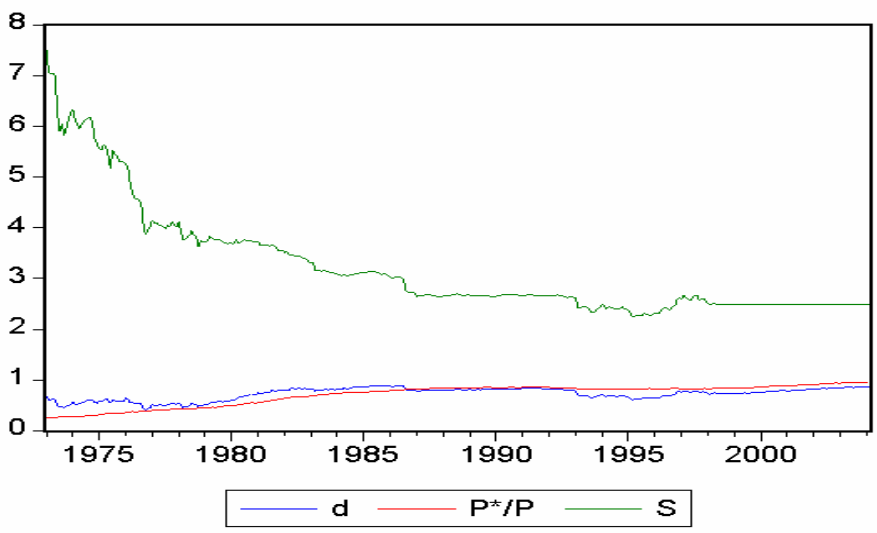

Figure 2. Time path for Irish Pound against DM.
Monthly Data: January 1973 - January 2004
Time-series plot of monthly data of disparity from PPP (d_t), price ratio $\left(P_t^* / P_t\right)$, and nominal exchange rate (S_t)

regime) show $\beta_i < 1$ at 10% significance level in only 5 EMU countries (i.e., Greece, Ireland, Netherlands, Portugal, and Spain) and 2 non-EMU countries (i.e., Japan and Switzerland). PPP is not supported for 7 EMU countries and 2 non-EMU countries in this sub-period. The above results provide strong support for the PPP evaluated with USD as the numeraire before the adoption of the euro. PPP performance worsens after implementation of reforms and the introduction of the euro, being violated in a majority of the countries adopting the common currency.

Even more telling are the half-life results (calculated only when the null hypothesis is rejected, i.e., mean reversion exists) reported in Table 1. The table reports half-life results for each country and for each of the three sub-periods. I also report the average half-life for the 12 EMU countries and 4 non-EMU countries as well as the overall average half-life over all 16 countries for each sub-period. For the EMU countries, I obtain the average half-life of 8.85, 24.25, and 25.10 months for sub-periods 1, 2 and 3, respectively. For the non-EMU countries, the average half-life is 11.36, 25.89, and 12.36 months for sub-periods 1, 2, and 3, respectively. Focusing on the EMU countries, the half-life appears to be the shortest during the first sub-period (floating-rate regime) and the longest during the third sub-period (fixed-rate euro regime). Overall, the average half-life across all countries is 9.27, 24.63, and 21.46 months for the three sub-periods. In contrast to the half-life estimates of four to five years obtained by previous research, my results suggest that the rate at which PPP deviations dampen out is much faster than commonly believed. Half of the disparity disappears in about two years and with floating exchange rates, it takes less than a year.

Table 2 shows the regression results for the disparity from PPP using DM as the base currency. For the results within the euro area, the null hypothesis of random walk cannot be rejected for 3 of the 11 countries (Austria, Belgium, and Luxembourg) during the first sub-period (floating-rate regime). Mean reversion to PPP is supported for the other 8 EMU countries. Half-lives range from only 3 months to 15 months with an average half-life of 7.48 months. In contrast, the random walk hypothesis cannot be rejected for two (Japan and Switzerland) of the five non-EMU countries and PPP is supported for Canada, UK, and US during the first sub-period. The half-life ranges from 5 to 11 months with an average half-life of 7.71 months for the non-EMU group.

During the second sub-period with the target-zone arrangement regime, 7 of the 11 EMU countries within the euro area display mean reversion (Finland, France, Greece, Ireland, Italy, the Netherlands and Spain). As in Table 1, half-lives for this sub-period are longer than during the first sub-period, ranging from 9 to over 57 months with an average half-life of 26.91 months. In contrast, I again reject the null hypothesis for 3 of the 5 non-EMU countries. The half-lives range from 14 to 52 months with an average half-life of 29.07 months.

During the third sub-period (fixed-rate euro regime), which is the focus of this chapter, random walk hypothesis is rejected for only 4 of the 11 EMU countries (3 at the 1% level and 1 at the 5% level). These are the relatively smaller economies in the EMU (Finland, Greece, Luxembourg, and Spain). Mean reversion towards PPP (i.e., price convergence) is not supported for 7 of the 11 countries in the euro area, including Austria, Belgium, France, Ireland, Italy, Netherlands, and Portugal. These results are in

contrast to the results for the second sub-period during which twice as many countries exhibited statistically significant results at 1% level. While the coefficients for the third sub-period are generally lower than for the second sub-period, I fail to reject the null hypothesis for many more countries during this sub-period. The main reason is the higher standard error resulting from large divergence in EMU countries' domestic price levels without the benefit of any exchange rate fluctuations to offset them during this (fixed-rate euro regime) sub-period. The average half-life is only 5.54 months for the four countries displaying mean reversion. In contrast, I have 4 out of 5 rejections for the non-EMU control group during the third sub-period as opposed to 3 rejections during the second sub-period. The null hypothesis is strongly rejected for Canada, Japan, the UK and the US at the 1% level. Switzerland is the only exception for which PPP is not supported.[29] The half-life ranges from 4 to 10 months with an average half-life of 7.71 months.[30]

Even though the number of rejections for the third sub-period within the euro area is lower than for the second sub-period, the half-lives for these countries during the third sub-period are shorter than during the earlier two sub-periods. Only four countries show evidence in support of PPP (i.e., mean reversion) while the vast majority, though

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[29] From my estimation results with DM as the base currency, we observe that between non-EMU European countries, PPP holds for the UK while we obtain little evidence in support of PPP for Switzerland. The fact that UK is a member of the EU while Switzerland is not may explain the observation, recalling that UK has retained the freely floating pound sterling as its currency.

[30] Though my methodology is robust in sample size, one could be concerned that the 69 monthly observations for each country during the third sub-period may be influencing the observed lack of support for the PPP for the euro area countries. The reported 4 out of 5 rejections of the null hypothesis at 1% level for the control group during this sub-period should alleviate such concerns. In addition, the first sub-period has about the same number of monthly observations (72), but we are still able to reject the null hypothesis for twice as many countries (8 versus 4 for the third sub-period).

adjusting to a new regime, fail to demonstrate harmonized real sector prices and mean reversion. The average half-life is 7.48, 26.91, and 5.54 months for the EMU countries and 7.71, 29.07, and 7.71 months for the non-EMU countries during sub-periods 1, 2 and 3, respectively. Overall, the average half-life over the 3 sub-periods for the 16 countries analyzed is 7.54, 27.56, and 6.63 months.

In general, half-lives peak during the second sub-period whether using DM or USD as the base currency.[31] While significantly shorter than those reported in previous studies, the longer half-life estimates for the second sub-period (4/1979 – 4/1998) can be attributed to two reasons[32]. First, the USD experienced high fluctuation during the second sub-period, rising in 1980-1985 and sinking in 1985-1987. Second, the target-zone exchange rate regime of the European Monetary System prevailing during this sub-period may have constrained nominal exchange rate changes to fully offset fluctuations in relative prices. In the third sub-period with fixed exchange rates within the euro area, I observe PPP to deteriorate in the EMU countries (in terms of the number of countries for which the null cannot be rejected) using DM or USD. This suggests that the adoption of the euro has consequences for PPP both within the euro area as well as between EMU countries and the US. It is also worth noting that for those EMU countries in which PPP is supported during the third sub-period, the average half-life is shorter when evaluated using DM than USD. This suggests faster price harmonization within the currency bloc

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[31] The only exception is the results for the EMU countries with USD as the base currency where the average half-lives for the second and third sub-periods are very similar.

[32] My average half-life estimates are shorter than those reported in past research. This could be due to a more robust methodology. In addition, note that we do not include β*'s* which are not significantly different from one in calculating the average half-life. Including these ($\beta=1$, i.e., random walk) to estimate speed of mean reversion, as done by previous studies, makes no economic sense.

(the euro area) as opposed to between currency blocs (the euro area and the US) but only when PPP holds.

Note that with DM as the numeraire, I are not able to reject the unit root hypothesis at the 5% level during the first two sub-periods for the Benelux countries (consisting of Belgium, the Netherlands, and Luxembourg), which were currency partners of Germany during the first sub-period.[33] In addition, PPP does not hold for Austria, which along with the Benelux countries has long been closely linked to the German economy. These results contradict the findings of Bayomi and Eichengreen (1997) which suggested that Austria, the Benelux countries and Germany (along with Ireland and Switzerland) were the best candidates for an optimum currency area in Europe. Taken together, my results provide little support for PPP holding against DM for countries with close linkages with Germany (i.e., Austria and the Benelux countries) during the first two sub-periods examined.[34] Focusing on the third sub-period, I fail to support PPP for most countries (7 out of 11) in the common currency area (the euro zone) including the historical currency partners of Germany.[35] Clearly, I do not observe PPP holding better in EMU countries during the fixed-rate euro regime. My results do not provide evidence in support of PPP holding within a currency bloc (neither in the

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[33] Benelux along with Germany was called the DM zone between 1973 and 1979 (i.e., my first sub-period).
[34] Netherlands is the only exception among these four countries. PPP is only weakly supported at 10% level for Netherlands during the first two sub-periods.
[35] Luxembourg is the only exception.

previous DM zone nor in the recent euro zone). In contrast, I observe improvement in PPP holding over time for non-EMU countries.[36]

To further illustrate my results, I visually depict the timelines of three variables: price ratio $\left(P_t^* / P_t\right)$, nominal exchange rate $\left(S_t\right)$, and disparity from PPP $\left(d_t = ln\left(S_t P_t^* / P_t\right)\right)$. Figure 1 plots these variables for Greek Drachma and Figure 2 for Irish Pound, with DM as the numeraire for both. In Figure 1, I can see that nominal exchange rate $\left(S_t\right)$ falls while price ratio (P_t^* / P_t) rises over time. Both trends offset each other such that the real exchange rate appears to stay constant. In fact, I can see that PPP disparity (d_t) for Greece is fluctuating around -5.3 throughout the period examined. This is consistent with my empirical results rejecting the unit root hypothesis for Greece for all three sub-periods. It is noteworthy that while the nominal exchange rate (S_t) was converging after May 1998 and became fixed against euro (and therefore, DM) after January 2001, the price ratio (P_t^* / P_t) appears to rise at a decreasing rate and become stable after May 1998, and so does the PPP disparity (d_t), which apparently follows the trend of the price ratio during the third sub-period.

In Figure 2, I observe that unlike for Greece, PPP disparity (d_t) for Ireland does not converge to some level during the period examined.[37] Especially after May 1998, the disparity keeps widening. This is consistent with results reported in Table 2; the unit root

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[36] The number of rejections at 1% level increase from only 1 in the first sub-period to 2 in the second sub-period to 4 in the third sub-period (see Table 2).

[37] We do observe mean reversion during the first two sub-periods.

hypothesis for Ireland could not be rejected during the third sub-period. Figure 2 shows that during the first two sub-periods, while the nominal exchange rate (S_t) falls, the price ratio (P_t^* / P_t) rises, and these trends offset each other such that the PPP disparity (d_t) converges to some level during the first two sub-periods. This is consistent with my empirical results that rejected the unit root hypothesis for Ireland before the introduction of the euro. However, after May 1998 when the nominal exchange rate (S_t) was fixed, in contrast to Greece, the Irish price ratio (P_t^* / P_t) keeps rising without any offset possible from a fixed exchange rate.

In summary, comparing timelines for price ratio and real exchange rate in Figures 1 and 2, it is apparent that before the euro, changes in nominal exchange rate offset price ratio changes providing a buffer such that real exchange rate remained stable. After the euro, the burden to stabilize the real exchange rate fell entirely on adjustment in real sector prices because the nominal exchange rate became fixed. The increasing price level in Ireland relative to in Germany explains why PPP does not hold during the euro sub-period in Ireland as opposed to in Greece.

2. Structural Break Test Results

My results do not support the view that market and regulatory innovations associated with the monetary union and the adoption of a common currency have improved PPP and harmonized prices in the EMU countries. As a robustness test, I now employ another approach to verify whether changes associated with the EMU and euro had any impact

on the within the currency bloc PPP performance measured against the DM. The results of this analysis are reported in Tables 3 and 4.[38]

In Table 3, allowing for different (i.e., country specific) coefficients for the time dummy variables, results obtained from model 1 with two time dummies show that only 3 of 11 countries (Austria, Greece, and Italy) in the euro zone have significantly negative coefficients for the time dummy representing the third sub-period (fixed-rate euro regime) from May 1998 to January 2004 (γ_{i2}). Note that a negative coefficient of γ_{i2} implies a smaller β_i in panel C of Table 2, suggesting that changes associated with euro adoption improve PPP performance for Austria, Greece, and Italy (though Table 2 results show that this improvement for Austria and Italy was not sufficient to reject the random walk hypothesis). However, Ireland has a significantly positive coefficient for the same time dummy, implying that changes associated with the monetary union have worsened price harmonization for it. This is consistent with the Table 2 results that rejected the random walk hypothesis at 1% for Ireland in the first two sub-periods but not in the third sub-period where it has the highest β_i value. In contrast, for countries outside the euro zone, only UK has a significantly positive coefficient for the time dummy during the third sub-period. Turning to the results from model 2 with only one time dummy for the third sub-period, I obtain no significance across the EMU countries except Greece with a significantly negative coefficient.

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[38] In Tables 3 and 4, we report estimation results for only the dummy variables because my focus is to examine the impact of the euro adoption on PPP. In addition, models in Tables 3 and 4 are not tailored to test for the unit root hypothesis so we do not report the coefficients β_i and β.

Similar to Table 3, Table 4 reports the results of two models obtained by imposing the restriction of a common coefficient for all EMU countries and a common coefficient for all non-EMU countries. I observe no significant result regardless of the model tested and the country group. Hence, from Tables 3 and 4, I am not able to obtain any evidence in support of PPP performing better for countries that adopted the common currency. If changes associated with euro adoption do improve price convergence and harmonization in a fixed-rate environment, my results suggest that this has occurred in only a very small number of the EMU countries. This is consistent with what I observe in Table 2, which shows a considerable decrease in the number of random walk rejections from the second to the third sub-period within the euro zone.

3. Discussion

Rogoff (2001, p. 243) asserts "…virtually everyone knows by now, exchange rates fluctuate wildly in comparison with goods prices… shocks to real exchange rates damp out at a remarkably slow rate. Even the most optimistic estimates put the half-life of real exchange rate movements in years, not months." This assertion indeed reflects a commonly held view, frequently referred to as the "PPP puzzle" whose basis is the voluminous but conflicting empirical evidence on the validity of the PPP with USD as the numeraire. While many frictions in the market can fail PPP, weak power of statistical procedures can also fail to support it.

Using a more efficient and robust empirical procedure, I provide evidence showing existence of a strong mean reverting tendency in real exchange rates supporting

PPP since the advent of floating exchange rates. These results, reported in Table 1, hold for 10 of 12 EMU countries (all but Belgium and Luxembourg) and 2 non-EMU countries (Japan and Switzerland) during the first sub-period. They continue to hold for the same 10 countries in the euro area, the same two non-EMU countries along with the UK during the second sub-period. During the third sub-period, PPP is supported for the same 2 non-EMU countries but the EMU countries show much weaker evidence supporting PPP than during the first two sub-periods.[39] These results support PPP in general, and it holding between currency blocs in particular. My overall average half-life estimates for all sub-periods regarding how quickly shocks to PPP are absorbed range from 9 months to 2 years, which is substantially shorter than commonly believed 4 to 5 years.

Results obtained using DM as the base currency show that PPP performance did not improve with the establishment of the EMS in 1979 and seems to have deteriorated after the adoption of a common currency for the EMU countries, i.e., within the euro currency bloc.[40] With DM, PPP was supported for 8 of 11 countries (Finland, France, Greece, Ireland, Italy, the Netherlands, Portugal, and Spain) during the floating-rate first sub-period and for 7 of the 11 countries (Austria, Belgium, Luxembourg, and Portugal being the exceptions) during the target-zone arrangement second sub-period. However, since May 1998, mean reversion in real exchange rates was observed for only 4 relatively smaller economies out of the 11 euro zone countries (Finland, Greece,

[39] The number of rejections drops dramatically to 5 in the third sub-period from 10 during each of the first two sub-periods.
[40] In fact, they follow the pattern of the results obtained using USD as the base currency since 1973, i.e., PPP for the EMU countries worsens during the third sub-period.

Luxembourg, and Spain). Despite the very significant structural and regulatory reforms implemented to integrate their markets, absence of any evidence indicating PPP holding better in EMU countries after they adopted a common currency underscores the critical role of floating exchange rates in achieving harmonization of prices.[41]

Comparing results obtained using USD as the base currency (Table 1) with those using DM as the numeraire (Table 2), I find a similarity in PPP performance between the two. PPP performance worsens both within the euro currency bloc and between currency blocs (primarily between the euro area and the US) after the introduction of the euro. PPP is strongly supported with both USD (between currency blocs, including for the euro area countries) and DM during the first two sub-periods. However, since the introduction of the euro, while PPP performance did not change much among the non-EMU countries, PPP performance seems to have deteriorated in the EMU countries irrespective of the base currency. All EMU related changes like removal of barriers, increased transparency and harmonization of regulations were meant to increase market integration. Therefore, absence of any improvement in price convergence within the euro bloc can be attributed to the absence of the adjustment mechanism provided by floating exchange rates.

Even though the "nominal" foreign exchange risk in the EMU countries is eliminated with the adoption of a common currency, these countries have seen large

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[41] It is worth noting that with DM, PPP has been holding well for the UK, a member of the EU but not EMU. The UK also has virtually no restrictions on cross-border flows of goods and capital with EMU countries, but the major difference is that it did not adopt the common currency and its currency pound sterling maintains a floating exchange rate against the euro. This may explain why PPP continues to hold in the third sub-period for the UK.

price level divergence since then. The economically meaningful "real" purchasing power risk among these countries seems to have increased (see Adler and Dumas (1983) for the role of PPP in international asset pricing and Shapiro (2003) for linkage between PPP disparity and real foreign exchange risk). According to Duisenberg (2000), the President of the European Central Bank (ECB), different price developments will not disappear in general across the EMU countries due to country-specific factors.[42] The ECB notes an increase in divergences in inflation in the euro area. For example, inflation in Ireland differs to a large degree from that for the remaining euro area as a whole. This is consistent with my finding that Ireland has the slowest mean reversion (i.e., highest coefficient of .979) among all EMU countries in the third sub-period.

My findings highlight the fact that adoption of a common currency is neither a panacea for real risk reduction nor will it insure market integration. This is because even with a common currency, there is still "real" inflation/consumption risk, which can exist due to different relative prices in different countries (as suggested by my results for the third sub-period), presence of non-tradable goods in consumption baskets and differences in consumer preferences (Hardouvelis et al. 2001) among other factors. In a well functioning floating-rate regime, changes in relative prices are offset by fluctuations in nominal exchange rates. As noted earlier, price adjustment to a shock in the goods markets is slow relative to the foreign exchange markets. It follows that mean reversion to PPP after a shock will be slow with fixed exchange rates or a common currency since

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[42] For details, see the speech delivered by Willem F. Duisenberg on September 6, 2000 (http://www.ecb.int/).

all adjustment must occur in the relatively sluggish real sector prices with no adjustment possible via exchange rates. Unless cross-border barriers are fully dismantled to allow free flow of all factors of production across countries at negligible cost and governments are willing to give up sovereign control of their countries monetary and fiscal policies, a common currency will not be a superior alternative to other exchange rate regimes. In fact, my results show that PPP in the euro area held much better before the introduction of the euro when floating-rate and target-zone arrangement regimes were prevailing. Elimination of barriers and increased regulatory and policy harmonization in the EMU during the euro sub-period make my results telling.

The following two quotes suggest that the establishment of the EMU and adoption of the euro may be more for political than economic reasons. The President of the European Central Bank, Willem F. Duisenberg, in his analysis of economic developments in the euro area said, "Over the past few months both pillars of the monetary policy strategy of the Eurosystem have indicated that upward risks to price stability have increased. … The challenge to turn the current expansion into a prolonged period of non-inflationary growth clearly requires further efforts in all policy areas. Reforms in the labour market will be a major factor contributing to sustained non-inflationary growth in the euro area. The current level of unemployment in the euro area, despite some decline, is still too high. In this respect, both appropriate wage settlements

and structural reforms will be important contributions to continued employment growth and to maintaining low inflation."[43]

The increasing relative price instability observed in the euro area implies that many member countries were not economically ready prior to the formation of the EMU. The fiscal and monetary convergence they achieved right before 1998 was not sustained after the euro. In fact, adopting a common currency seems a matter of political belief rather than economic analysis. Analyzing UK's dilemma in joining the EMU, the editor of The Observer, William Keegan[44], notes, "If there is one thing Dr Watkins' chattering classes are agreed on, it is that the decision about the euro will be 'political'. … Few people believe the outcome of the tests (about 'sustainable convergence', 'sufficient flexibility', the impact on investment, the impact on financial services, and the effect on employment) can be 'clear and unambiguous'. No. Almost everyone one meets believes this will be a very political decision." My results are consistent with these views.

F. Conclusion

I provide stronger evidence in favor of PPP compared to previous studies. Unlike past research, I find that PPP holds better between currency blocs than within a currency bloc. However, I obtain little evidence supporting PPP and price convergence in most EMU countries since the adoption of the euro. My results show that the euro area may not be

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[43] For details, see a speech delivered by Willem F. Duisenberg on June 20, 2000 (http://www.ecb.int/).
[44] For details, see "in my view: who wants to go down in history?" in the Observer by William Keegan (editor of The Observer) on January 5, 2003.

an optimum currency area, as claimed by some researchers and policy makers. The Maastricht Treaty required member countries to converge in monetary and fiscal policies prior to the euro. However, will this convergence sustain after the euro? Some member countries are likely to deviate from convergence criteria because they have a budget deficit, which can result in inflation that exceeds the target level. In addition, cross-border barriers such as labor immobility (sometimes due to regional cultural ties) prevalent in Europe can hinder economic integration as well. These problems may partially explain why PPP performance has not improved after the adoption of a common currency. Compared to previous experiments with the floating-rate and target-zone arrangement regimes, the common currency regime does not appear to be as successful in converging prices based upon my empirical evidence. My results highlight the importance of floating exchange rates despite the volatility inherent in them.

My findings suggest the need for further dismantling of barriers as well as more disciplined and harmonized policy implementation by the EMU governments. However, diverging market practices rooted in national traditions and historical experiences could also be contributing factors that require passage of time for the market to lose its memory. On the other hand, for a few EMU countries where PPP holds after the adoption of the euro, the speed of adjustment shows remarkable improvement. This observation leads us to believe that perhaps the EMU economies' price formation process is in transition. While it is clear that since the advent of a common currency, PPP performance has not improved, there are signs that after the transition stage, what may emerge is a more resilient and efficient market than before the monetary union.

Nevertheless, this is only possible if benefits of dismantled barriers, policy convergence, monetary and fiscal discipline, exchange rate risk elimination, reduced transaction costs and economic integration outweigh the benefits of a floating-rate system.

CHAPTER III

EFFECTS OF CORPORATE GOVERNANCE AND MONETARY UNION ON CORPORATE LIQUIDITY

This chapter investigates corporate liquidity (cash holdings of firms) from 15 European Union (EU) countries [12 Economic and Monetary Union (EMU) countries that adopted a common currency, euro, and 3 non-EMU countries] from 1993 to 2002 using a dynamic panel data model. My main contributions to the corporate liquidity literature are four-fold. First, many corporate governance variables, including shareholder rights, have been considered important determinants of corporate cash holdings. I provide evidence that creditor rights also affect corporate liquidity and show that their effect is more consistent than that of shareholder rights. Second, exploiting the recent formation of EMU, I show that such significant macro changes in international markets affect firm cash holdings. I find that debt and net working capital are better substitutes for cash in EMU countries than for non-EMU countries. I also find that adoption of a common currency reduces cash holdings in EMU countries. These findings suggest enhanced market integration in member countries resulting from their monetary union. Third, a variety of results obtained by us suggest that the agency theory plays an important role in explaining corporate liquidity. In particular, the agency view of corporate liquidity has stronger explanatory power for EMU firms, probably because of an enhanced capital

market integration that weakens the transaction and precautionary motives of holding cash. Fourth, I show that dealing with the endogeneity problem in corporate liquidity studies is important.

A. Introduction

Why do firms hold cash and what explains variations in their cash holdings? In general, firms hold corporate liquidity for transaction costs, precautionary and speculative motives.[45] More specifically, they use cash to conduct day-to-day operations such as paying employees, purchasing inputs, and paying dividends to stockholders. Firms will hold less cash if the transaction cost (e.g., cost of liquidating assets or raising capital) is lower and vice versa. In addition, they hold cash for the precautionary reason to invest in future profitable projects in case they have difficulty raising funds from the capital markets. The precautionary motive results from information asymmetry and the agency costs of debt (Opler et al. 1999), both of which can make it difficult to raise funds in capital markets. Information asymmetry arises because outsiders know less about the firm's operation than management, while agency costs of debt arise when the interests of the debt holders differ from those of the shareholders. The higher the level of information asymmetry and the agency costs of debt, the greater will be the precautionary motive. Further, management might hoard cash because of its personal

[45] Firms need cash for the speculative motive to take advantage of bargain purchases, but conventional wisdom is that liquidity held for speculative motive is relatively minor and negligible compared to that held due to transaction and precautionary motives.

risk aversion or because it wants to satisfy its own needs, e.g., consuming perquisites, termed the agency cost of managerial discretion (Opler et al. 1999).[46]

In this chapter, I contribute to the existing international corporate liquidity literature in many ways. Many valuation models treat cash as negative debt; the amount of cash held by the firm is simply subtracted from the value of debt outstanding in order to compute shareholders' equity in the firm (Acharya et al. 2005). This assumes perfect substitutability between cash and debt. On the other hand, no one assumes perfect substitutability between cash and equity. While the relationship between cash and debt may not be perfect, cash is much closer to debt than it is to equity.[47] Therefore, creditor rights should influence the cash holdings of firms more than shareholder rights. Recent international corporate liquidity studies have highlighted the importance of shareholder rights in a country as a determinant of its firms' cash holdings (Dittmar et al. 2003), but no one has evaluated the role of creditor rights. The first contribution of this chapter is to show that creditor rights are a significant determinant of corporate liquidity.

The creation of the European Union (EU) comprised of 15 countries, and within it the Economic and Monetary Union (EMU) of 12 countries that adopted a common currency, is considered one of the most important institutional innovations in international markets. It provides a unique opportunity to examine what happens to cash holdings of firms operating in an area where transactions occurring in multiple currencies are reduced to a single currency. Establishment of EMU culminating in a

[46] Agency costs also include costs incurred to minimize or eliminate the conflict between debt holders and equity holders or among different kinds of debt holders.
[47] Opler et al. (1999) note that most of the variables associated with high cash levels are also known to be associated with low leverage.

common currency should lead to a decrease in transaction costs in the EMU countries. If capital markets become more integrated within the EMU, it should make it easier for EMU firms to raise funds within the EMU and weaken their precautionary motive for holding cash. This should result in lower corporate liquidity in EMU countries in contrast to non-EMU countries that retained their national currencies. The test of this hypothesis is the second contribution of this chapter, and to my knowledge, the first examination of this issue. I also investigate how the institutional changes associated with the EMU have affected the sensitivity of corporate liquidity to its benchmark determinants (e.g., market-to-book ratio, net working capital, cash flow, etc.).

Finally, this chapter formally deals with the endogeneity problem associated with the determinants of corporate liquidity that has received little attention in the liquidity literature. While recent studies have started recognizing this problem, they do not account for it.[48] Since ignoring the presence of the endogeneity problem can lead to biased estimation, my study explicitly deals with this issue and shows that it matters. Furthermore, since the agency costs are embedded in each of the extant theories (i.e., tradeoff theory, financing hierarchy theory, and agency theory), the predictions of each theory about how corporate liquidity is affected by its determinants are inevitably intertwining. It is difficult to infer which theory outperforms others from the estimated coefficients of the corporate liquidity determinants. Instead of arguing which theory best

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[48] For example, Harford et al. (2005) note that corporate cash holdings and corporate governance can be jointly determined, recognizing that the endogeneity problem may arise when modeling the relation between these two variables. However, they also note the difficulty in accounting for the endogeneity problem using two-stage least squares (2SLS) because of lack of proper instrument variables. Though they recognize it, they do not account for it directly in their study.

explains corporate liquidity, this chapter evaluates the relevance of agency theory in explaining corporate liquidity. I examine the coefficients of the corporate governance variables, whose effects are more clearly predicted by the agency theory.

My data span 1993 to 2002. I analyze all 15 European Union (EU) countries, including 12 EMU countries with the euro as their common currency, and 3 non-EMU countries which have retained their numeraires, as a control group.[49] Many changes resulting from the formation of the EU were common to all 15 member states. Therefore, selecting the 3 non-EMU country firms as the control group isolates the unique effect of the monetary union resulting in the adoption of a common currency on corporate liquidity in the 12 EMU countries. Using the dynamic panel data model (Arellano and Bond 1991) and accounting for the endogeneity problem associated with the determinants of corporate liquidity, I examine corporate cash holdings using a large sample of non-US firms. In particular, I investigate how corporate governance variables and the monetary union affect corporate liquidity.

I show that firms in countries with strong creditor rights hold less cash regardless of the model specifications. Similarly, the effect of shareholder rights on cash is negative but it becomes ambiguous when creditor rights are included in the model. The consistently negative effect of creditor rights on cash reiterates that cash is closer to debt than equity and shows the importance of incorporating creditor rights in international

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[49] The 12 EMU countries are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain. The 3 non-EMU countries are Denmark, Sweden, and the United Kingdom (UK). The EU admitted 10 new countries to the Union on May 1, 2004 and these are not included in my analysis.

liquidity studies. In addition, the harmonization and the subsequent convergence of economic and monetary policies in the EMU appear to affect corporate liquidity. For example, net working capital and cash are more substitutable for firms in the EMU than in the non-EMU countries. I also observe a stronger negative relationship between cash and debt in EMU countries, implying that they are better substitutes for the EMU firms than for non-EMU firms. This could be the result of enhanced capital market integration accompanying the convergence in EMU country policies, which culminated in the adoption of a common currency (Croci 2004; Bris et al. 2004). I also obtain evidence that adopting a common currency reduces corporate liquidity in the EMU.

My results show the importance of formally dealing with endogeneity in corporate liquidity research. The effect of investment opportunities (proxied by market-to-book ratio) on cash holdings is positive when the endogeneity problem is ignored. However, it becomes significantly negative when endogeneity is accounted for. This is consistent with the agency view of corporate liquidity and consistent with the findings of Dittmar et al. (2003). My results suggest that the two country-specific corporate governance variables (i.e., shareholder rights and creditor rights) play an important role in determining corporate liquidity. Additionally, after controlling for country-specific corporate governance variables, firm-specific characteristics like market-to-book ratio, capital expenditure and insider ownership influence corporate liquidity in a way that provides further insights into how agency issues affect liquidity. In particular, from the results of the impact of investment opportunities on corporate liquidity, the agency

theory appears to explain cash holdings better for the EMU firms than for the non-EMU firms.

The remainder of this chapter is organized as follows. The next section presents literature review. Section C provides a brief discussion of the EMU. Section D provides the empirical model and my hypotheses development. Section E describes the data employed. Section F contains a discussion of my results and Section G concludes this chapter.

B. Literature Review

The early corporate liquidity literature focused on determining whether there is an optimal level of cash holdings (Opler et al. 1999). Three major theories have been utilized to explain corporate liquidity (i.e., cash and its equivalents): tradeoff theory, financing hierarchy theory and agency theory. The tradeoff theory predicts an optimal corporate liquidity resulting from firms balancing the marginal cost of corporate liquidity and marginal cost of shortage of corporate liquidity (Keynes 1936).[50] The financing hierarchy theory says that internal financing is preferred to external financing to fund new investments because internal financing is less costly. Firms will accumulate cash and repay debt when they have a surplus of internal funds; when they are short of internal funds, they issue debt to fund new investments. According to this view,

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[50] According to Opler et al. (1999), marginal cost of corporate liquidity involves the return that could be earned by investing the amount of cash holdings in other assets. Marginal cost of shortage of corporate liquidity incorporate potential bankruptcy cost. Cash holding and financial distress are negatively related.

corporate liquidity is determined by changes in internal funds and thus there is no optimal corporate liquidity (Myers and Majluf 1984; Shyam-Sunder and Myers 1999). The agency theory suggests that the management tends to hoard cash to gain discretionary power; therefore, there is no optimal corporate liquidity (Jensen 1986). The predictions of each theory regarding the effect of firm characteristics (e.g., size, cash flow, investment opportunity set, etc.) on corporate liquidity are mostly inconsistent. Since previous researchers (Kim et al. 1998; Opler et al. 1999; Myers 1984; Jensen 1986) have discussed the predictions of these theories in detail, I simply summarize the theoretical predictions of each theory in Appendix B without elaboration.

Past studies analyze the determinants of corporate liquidity to see which theory is supported by empirical evidence. The benchmark determinants of corporate liquidity include market-to-book ratio, firm size, cash flow, net working capital, leverage, industry-specific cash flow variability, capital expenditure, dividend, shareholder rights, and managerial ownership (Opler et al. 1999). Recent corporate liquidity literature can be categorized into the following three categories: (1) studies using US data (Kim et al. 1998, Opler et al. 1999, Faulkender 2004, Harford et al. 2005), (2) single-country studies using non-US data (Pinkowitz and Williamson 2001, Ozkan and Ozkan 2004) and (3) studies using multi-country data (Dittmar et al. 2003, Pinkowitz et al. 2003, Kalcheva and Lins 2004, Ferreira and Vilela 2004). All of these studies attempt to identify the determinants of corporate liquidity and/or the theory that explains corporate liquidity better. Since the three theories' predictions of the relationship between corporate liquidity and its determinants are not mutually exclusive (see Appendix B), it is difficult

to empirically support one theory over the others unambiguously. All studies (including this one) suffer from this. The agency theory is relatively less prone to this problem since it provides unique predictions on the relationship between corporate liquidity and corporate governance variables like ownership structure and the degree of investor protection (see Appendix B).

Kim et al. (1998) explored corporate liquidity in the US industrial firms and found a positive relationship between optimal corporate liquidity and cost of external financing. Firms with lower returns and higher volatility of earnings on physical assets (relative to liquid assets) tended to have higher corporate liquidity. They also observe a positive relation between corporate liquidity and measures of future economic conditions. Unlike them, Opler et al. (1999) attempt to determine the relative merit of alternative theories to explain corporate liquidity in the US. Their results support the tradeoff theory over the other two. Pinkowitz and Williamson (2001) study corporate liquidity in Japan and find a positive relationship between corporate liquidity and bank power. Ozkan and Ozkan (2004) examine corporate liquidity in the UK. One of their findings is the nonlinear relationship between corporate liquidity and managerial ownership.

In general, the extant literature does not clearly reveal which theory plays a dominant role in explaining corporate liquidity. There are several reasons for this. As noted earlier, these theories do not yield mutually exclusive predictions regarding the relationship between cash holdings and their determinants, agency costs are involved in each of the three theories, and the use of inappropriate methodology may have contributed to the inconclusive results. However, the predictions of the agency theory

regarding relationship between corporate liquidity and the corporate governance variables affecting agency costs do lend themselves to relatively unambiguous testing. Most studies examining corporate liquidity and corporate governance are conducted in a single country environment (e.g., Opler et al. 1999; Kim et al. 1998; Pinkowitz and Williamson 2001; Ozkan and Ozkan 2004). Only recently have researchers started paying attention to this issue from a multi-country perspective. This vantage point allows conducting richer tests for the agency theory explanation of cash holdings since multi-country data has wide variation of country-specific characteristics, i.e., corporate governance variables at the country level.

Following Dennis and McConnell's (2003) observation that simply replicating the research that has been conducted using the U.S. data in other countries without considering the impact of country-specific corporate governance variables will suffer from a misspecification problem, Dittmar et al. (2003) include shareholder rights in their study. Using cross-sectional data for only one year (1998) from 45 countries, they find shareholder rights the most important determinant of corporate liquidity. Firms hold less cash in countries with higher shareholder rights, which Dittmar et al. (2003) interpret as evidence supporting the agency theory. In countries with high shareholder rights, other determinants of corporate liquidity become less important. Kalcheva and Lins (2004) examine corporate liquidity in 31 countries and find that cash holdings are higher in firms with more severe agency problems. They also find stronger positive relationship between cash holdings and effective managerial control when shareholder rights are weaker. Like Dittmar et al. (2003), they also use only one-year cross-sectional data (for

1996). The use of cross-sectional data for just one year rather than panel data by these studies precludes identifying the dynamic nature of the cash holding decision.

However, cash is a much closer substitute for debt (Acharya et al. 2005) than for equity. Since debt holders are predominantly concerned about creditor rights, it follows that creditor rights should have a more systematic effect on corporate cash holdings than shareholder rights. Lenders in countries with higher creditor rights are exposed to lower risks and will be more willing to lend to firms than in countries with low creditor rights. Accordingly, firms will hold less cash in countries where creditors enjoy better protection since it is easier to borrow in their capital markets. Ferreira and Vilela (2004) examine cash holdings in EMU countries and observe a negative effect of both creditor rights and shareholder rights on corporate liquidity. However, they obtain results using a static model and ignore the problem of endogeneity in their variables. My study formally deals with these issues and furthermore, exploits the unique event of EMU formation to obtain further insights into what determines corporate liquidity.

It is well recognized that the economic and political environment in which a firm operates influences its use of factor inputs. Innovations in its environment can affect the more fundamental determinants of corporate liquidity, i.e., the nature of real and financial asset markets in which a firm transacts and which gives rise to corporate cash flows as well as risks borne by the firm. The establishment of EMU and the adoption of a common currency, the euro, is one of the most significant recent institutional innovations in international markets. This event provides us a unique opportunity to shed further light on the determinants of corporate liquidity. The harmonization process

associated with the EMU resulted in free movement of capital between member states, convergence in fiscal and monetary policies, and price transparency within the EMU as a direct consequence of adopting the common currency. This also alleviated the need to exchange national currencies and therefore eliminated currency risk from all transactions within the EMU. These dramatic changes should affect corporate liquidity as well as its sensitivity to its underlying determinants in the EMU. Firms in my test sample and the control sample belong to the EU. Therefore, both samples are affected by similar regulatory and structural changes associated with the EU except that the 12-nation EMU group converged in economic and monetary policies and adopted a common currency. Using a dummy variable to distinguish the EMU group, my research design allows us to isolate the unique effect of the EMU on corporate liquidity.

This chapter contributes to the liquidity literature in many ways. First, I provide evidence that creditor rights are a better proxy for investor protection than shareholder rights in studies attempting to explain corporate liquidity. Second, I extend the international liquidity literature by analyzing the 15 European countries over a unique ten-year span from 1993 to 2002 and reveal how a monetary union affects corporate liquidity. Third, I carefully account for the endogeneity problem associated with the determinants of corporate liquidity and show that it matters. Lastly, I obtain evidence that suggests that agency issues play an important role in explaining cash holdings of firms.

C. The Structural Change: EMU and Euro

European countries have been trying to form a united Europe since more than half a century ago. Shortly after the Second World War, several Treaties have been signed to achieve this goal. The Treaty of Paris was signed in 1951 to set up European Coal and Steel Community (ECSC). In 1957, the Treaty of Rome was signed to set up the European Economic Community (EEC) and the European Atomic Energy Community (Euratom). Subsequently, the Single European Act was signed in 1986, the Treaty on European Union was signed in 1992 and the European Union (EU) came into being. All these steps were taken to enhance political and economic integration among the member countries.

The creation of the Economic and Monetary Union (EMU) and the euro was the culmination of this lengthy economic and political process and considered by many scholars as the most significant institutional innovations to occur in international markets. In March 1979, the European Monetary System (EMS) was established to foster monetary stabilization. However, the exchange rate regime adopted at that time proved to be inadequate and finally led to speculative currency attacks in 1992-1993. In 1992, the Maastricht Treaty was signed to promote monetary stabilization and form the Economic and Monetary Union (EMU).[51] The Treaty specified a gradual adjustment process to a union with countries converging in monetary and fiscal policies to some

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[51] According to the glossary provided by http://europa.eu.int, "Economic and Monetary Union (EMU) is the name given to the process of harmonizing the economic and monetary policies of the member states of the Union with a view to the introduction of a single currency, the euro." In this chapter, in addition to the above definition, EMU also means the union of 12 countries, depending on the context.

desired level, and ultimately forming an EMU and adopting a common currency. The fixed bilateral foreign exchange rates of the 12 EMU countries against the Deutsche Mark were established in 1998 leading to the euro in 1999, which became the sole legal tender of the 12 EMU countries in 2002.[52]

My second research question is to determine whether EMU (i.e., broadly speaking, the process of harmonizing economic and monetary policies of the member states) has a unique effect on corporate liquidity. Reforms such as deregulation and reduced barriers to factor mobility have been common to all 15 EU countries, but only 12 countries converged in fiscal and monetary policies and finally adopted the common currency; the remaining three have retained their national currencies. By using firms belonging to these three countries as the control group, I can isolate the unique effect of EMU on corporate liquidity in my test sample. In addition, the last stage of EMU features the adoption of a common currency, which eliminates exchange rate risk, currency conversion costs and the need to maintain cash in different currencies (which existed prior to the euro) by firms of one EMU country operating in another. Adoption of the common currency and converging economic and monetary policies should reduce product and capital market imperfections and enhance market integration in the common currency area. For these reasons, I expect the test sample EMU firms to hold less cash after adopting the common currency than firms in the non-EMU control group.

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[52] For information about the fixed bilateral foreign exchange rates of the 12 EMU countries against the Deutsche Mark, please visit http://europa.eu.int/scadplus/leg/en/lvb/l25017.htm;http://www.portugal.org/information/economic4/info_1l.html

D. The Model and Hypothesis Development

In this section, I first describe my methodology and empirical model obtained from my theoretical model in Appendix C. Then I explain how each variable is expected to affect corporate liquidity based on my theoretical model predictions.

1. Empirical Model

Virtually all previous studies utilize ordinary least squares (OLS) regression to analyze corporate liquidity. Following these studies, I also employed OLS. However, the simple OLS regressions fail to consider the endogeneity problem (Harvey et al. 2004; Ozkan and Ozkan 2004), which very likely exists when dealing with financial variables in the balance sheet and income statement because they are simultaneously determined. Variables used in previous corporate liquidity studies as well as this chapter are likely to be simultaneously determined as well (Agrawal and Knoeber 1996). Ignoring the endogeneity problem will cause the estimators to be biased.

Though I perform simple OLS regressions to provide a basis for comparison with the results of previous studies, I employ the dynamic panel data model for my analysis, which allows us to overcome the endogeneity problem (Arellano and Bond 1991).[53]

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[53] First, panel data model rather than the OLS is fit for my data, which is both cross sectional and time series. Second, rather than using the static model, we chose the dynamic one. There is always a question about whether to choose fixed or random effects for the static panel data model. With the dynamic panel data model, however, it becomes irrelevant whether the true model has fixed or random effects. The reason is that individual effects will be purged by first differencing, which is the first step in estimating the dynamic model, irrespective of fixed or random effects exist. Further, unlike static corporate cash holdings models that implicitly assume instantaneous adjustment to a desired cash level in response to a random

This model has been used in recent finance and economics literature (e.g., Hayashi and Inoue 1991; Blundell et al. 1992; Bond and Meghir 1994; Judson and Owen 1999; Ozkan and Ozkan 2004). I used STATA 8 to estimate the dynamic panel data model. Building on Anderson and Hsiao (1981, 1982), Arellano and Bond (1991) used the GMM framework developed by Hansen (1982) to identify valid instruments from lagged levels of the dependent variable and the independent variables, including predetermined and endogenous variables. They also showed how to put together these lagged levels and differences of the strictly exogenous variables to form an instrument matrix. This dynamic panel data model allows us to account for endogeneity problem by using levels lagged two or more periods of some endogenous variable as valid instrumental variables to obtain consistent estimators (Arellano and Bond 1991). The following model is used to estimate effects of the determinants of corporate liquidity.

$$y_{it} = \delta y_{i,t-1} + \beta x_{it} + \gamma z_{it} + u_{it},$$

where the error term u_{it} is specified as a two-way error component model:

$$u_{it} = \mu_i + \lambda_t + \nu_{it},\ i = 1,\ldots,2738,\ t = 1,\ldots,T_i,$$

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shock, we assume that cash adjustment is costly and immediate adjustment is not likely. It follows that the appropriate model should include a lag of corporate cash holdings as one of the determinants (Ozkan and Ozkan 2004).

where μ_i denotes a firm-specific effect and λ_t denotes a year-specific effect[54,55,56]; subscript *i* denotes the i^{th} firm and *t* denotes the t^{th} year.[57] y_{it}, corporate liquidity, is the natural log of the ratio of cash and its equivalents to total assets. x_{it} is a set of endogenous variables, including benchmark determinants for corporate liquidity such as market-to-book ratio, size, net working capital/assets, cash flow/assets, capital expenditure/assets, leverage, and dividend payouts/earnings. z_{it} is a set of exogenous variables, including firm-specific variable such as insider ownership and country-specific variables such as shareholder rights and creditor rights.[58] It also includes dummy variables like the EMU dummy and the euro dummy. The model was estimated by a first-difference transformation. The first- and second-order autocorrelations in the first differenced residuals are reported. Since I applied two-step estimation, I am more concerned with the second-order autocorrelation because its presence implies that the estimates are inconsistent. The Sargan test was also conducted to test for over-identification restrictions by testing whether the residuals and instruments are independent.

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[54] Each firm *i* has its unique number of years T_i because some firms in my sample have unbalanced data.
[55] Even though the firms that we are interested in come from the same category (i.e., industrial), there are always time-invariant firm-specific effects because firms are likely to be heterogeneous. We use as many variables as possible to account for the firm-specific nature, but we also introduced this firm-specific dummy variable to capture any remaining firm-specific effects.
[56] Time (or year) dummies are also created to represent year-specific effect from 1993 to 2002. There can be some economic events associated with a specific year during the time span (1993-2002) of my data. For example, in response to the currency crisis of 1993, some EU countries might have taken some specific steps to meet the convergence criteria in certain years after 1993. This necessitates the inclusion of time dummy variables in the model to capture those shocks associated with particular year(s).
[57] See Ozkan and Ozkan (2004) for an application of this methodology to corporate liquidity.
[58] Unlike Dittmar et al. (2003), we use levels of shareholder rights and creditor rights as constructed by La Porta et al. (1998) instead of creating dichotomous dummy variables. Levels allow for using more information than dichotomous dummy variables.

2. The Lagged Dependent Variable

One unique feature of my estimation model is the inclusion of lagged corporate liquidity as a regressor or a determinant of corporate liquidity. I hypothesize that immediate adjustment is not possible due to the presence of transaction and adjustment costs, so the model should involve a lag of corporate liquidity as a determinant. Such adjustment lags are becoming well recognized in recent capital structure literature (Fisher et. al 1989; Fama and French 2002; Frank and Goyal 2003; Roberts and Leary 2005). My null hypothesis is that the coefficient for the lag of corporate liquidity is zero against the alternative that the coefficient is not equal to zero.

3. Effect of the Euro on Corporate Liquidity

Next, I examine whether the structural change resulting from the establishment of the EMU and the adoption of a common currency has affected corporate liquidity. If the EMU markets become more integrated due to the convergence process and the introduction of the euro, the opportunity cost of holding cash should be higher as transactions and relative values become more transparent and the need to convert currencies reduces. Consequently, managers will perceive holding cash to be more costly with the introduction of the euro. Based on equation 4 (see Appendix C), corporate liquidity should decline in response to an increase in the opportunity cost. In addition, the cost of capital should go down to the extent that financial markets become more

integrated in the EMU.[59] According to equation 5 (see Appendix C), corporate liquidity should decline in response to a decrease in the cost of capital. Due to these reasons, the EMU firms should see a decline in corporate liquidity relative to non-EMU firms.

To test this hypothesis, I examined the partial effect of the euro on corporate liquidity by performing multivariate analysis and controlling for other determinants of corporate liquidity. I examined whether the EMU firms decreased their corporate liquidity, *ceteris paribus,* in a statistically significant manner during the euro period.[60]

4. Effect of EMU on Sensitivity of Corporate Liquidity to Its Determinants

EMU may change the way some variables (determinants of corporate liquidity, X_1 and X_2) affect corporate liquidity. For example, firms tend to hoard cash from cash flow because raising external funds from the capital markets is costly. Therefore, previous studies typically observe a positive effect of cash flow on corporate liquidity. This effect should be weaker for the EMU firms if EMU countries' capital markets become more integrated. In other words, corporate liquidity in the EMU countries will then be less sensitive to cash flow compared to the non-EMU countries. Similarly, EMU might have also

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[59] Bris et al. (2004) provides empirical evidence consistent with this.

[60] The test examined whether the coefficient for D98* D_{EMU} is significant after 1998. D98 takes on a value of 1 if the year is 1998 or after and 0 otherwise; D_{EMU} takes on a value of 1 if the country belongs to the EMU and 0 otherwise. The European Council approved the entry of the 11 countries in to the EMU on May 2 1998. Bilateral exchange rates between 11 EMU countries were fixed on May 3, 1998 (http://europa.eu.int/scadplus/leg/en/lvb/l25017.htm;http://www.portugal.org/information/economic4/info_1l.html). My null hypothesis is that the coefficient on D98* D_{EMU} is zero while the alternative hypothesis is that the coefficient is negative. The year 1998 is the time when participating countries were ready for the establishment of the EMU. Hence, we chose 1998 as the breaking year even though the euro was formally created on January 1, 1999. Bris et al. (2004) provides evidence that the structural break occurred in 1998.

changed the effect of other determinants of corporate liquidity. To test this hypothesis, I created interaction variables by multiplying some determinants by a dummy (i.e., *d* in equation (6)) representing EMU. Then I examined the coefficients for those interaction variables to see if they are statistically different from zero.

E. Data

I use firm-specific annual financial data from Compact D Worldscope (CD Version of March 2003).[61,62] To ensure that my sample was comprised of firms with data available during pre-euro period, I identified all firms from the 15 EU countries with data available at least up to year 1999. I retrieved data for all such non-financial firms from 15 EU countries, including 12 EMU as well as 3 non-EMU countries.[63,64] I selected these 3 non-EMU countries as the control group because they have been in the EU with the 12 EMU countries during my sample period, but they have not adopted a common

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[61] The only exception is the ownership data (closely held shares as percentage of total outstanding stocks, i.e., fraction of closely held shares outstanding). These were obtained from Global Researcher's Worldscope from 1993 to 1998 only. We took an average of ownership data for each firm over this period and used it in my analysis given that there is little or no change in ownership.

[62] The use of this data in international corporate liquidity literature is standard. While accounting differences across countries exist, Worldscope data analysts minimize this by adopting specific procedures. For example, they define each data item precisely in a standard way. To increase comparability, any reported data items different from their definitions are standardized. If there is any variation in formats, Worldscope conform the different formats into their standard industry templates. They also apply other standardization procedures to reconcile various reported data items reported due to different accounting systems, countries, industries and languages (Worldscope Database Data Definitions Guide 2000).

[63] We also exclude non-financial firms belonging to the division of public administration with 2-digit SIC code ranging from 91 through 99 because they are government-related and may be quite different from the private firms in terms of corporate liquidity.

[64] The EMU group consists of Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain. The non-EMU group includes Denmark, Sweden, and the UK.

currency. The data span 10 years from 1993 to 2002. Appendix D defines the raw data obtained from Worldscope. These data were manipulated to obtain empirical variables used in this chapter. A brief description of how these variables were derived follows. All variables used are ratios other than the natural log of size, i.e., total assets.

My key variable is corporate liquidity, which I define as the ratio of cash and its equivalents to total assets (CH/TA). My selection of determinants follows previous research. I use the market-to-book ratio as the proxy for investment opportunities and computed it as the book value of total assets less the book value of equity plus the market value of equity divided by total assets. Size is proxied by total assets. Net working capital proxies an additional liquid asset, which previous research has found a substitute for corporate liquidity. I measure net working capital (NWC) as total current assets less cash less total current liabilities. Firm's profitability is proxied by cash flow, which is defined as earnings before interest and taxes, depreciation and amortization (EBITDA), less interest, taxes, and common dividends.

Capital expenditure/assets proxies potential investment opportunities (Kacheva and Lins 2004) and is measured as additions to fixed assets as a fraction of total assets (Kexp). Leverage (Lev) (total debt as a fraction of total assets) is included because it has been considered a key determinant of corporate liquidity, and the financing hierarchy theory gives a clear prediction of its (negative) effect on corporate liquidity. Dividend payout is common stock dividends as a fraction of earnings, and I use it as a corporate

governance variable affecting agency costs as is insider ownership. It is measured as shares held by insiders as a fraction of common shares outstanding.[65]

Country-specific data include shareholder rights and creditor rights. Both shareholder rights and creditor rights come from measures constructed by La Porta et al. (1998). They constructed indices to proxy shareholder rights and creditor rights, ranging from 0 to 6 and 0 to 4, respectively. Higher (lower) index value means higher (lower) shareholder or creditor rights. These indices are used to proxy the degree of investor protection in a country.

As is common with international data, a careful examination of all data revealed some outliers. To ensure that each observation (firm-year) makes economic sense, I retained observations that satisfy the following criteria:

$$0 \le \frac{CH}{TA} \le 1, 0 \le Lev \le 1, -1 \le \frac{NWC}{TA} \le 1, Kexp \le 1, \text{ and } 0 \le \frac{FA}{TA} \le 1.$$[66]

After applying the above data screening procedures, the remaining sample comprises 2,683 firms and 10,438 firm-year observations. On average, each firm has 3.9 years of data. My estimator is appropriate for this unbalanced panel.

Table 5 provides descriptive statistics of corporate liquidity across 15 countries, which further break down into 2 sub-groups, the 12 EMU and 3 non-EMU countries. The average corporate liquidity across 15 countries is 11.1%, ranging from 3.0% (Luxembourg) to 15.8% (Denmark). Among the EMU countries, France has the highest

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[65] Insiders include directors, officers and their immediate families as well as individuals who hold 5% or more of the outstanding shares (Worldscope Database Data Definitions Guide 2000).

[66] FA/TA denotes the ratio of fixed assets to total assets. It is not included as the determinant for corporate liquidity in my study, but is used to ensure that firms included in my study have data that makes sense.

Table 5
Descriptive statistics for corporate liquidity, 1993-2002

This table presents summary statistics of each country's mean, percentiles (p25, p50, and p75), standard deviation, and number of observations (firm-years). It also presents summary statistics for the EMU, non-EMU, and the total samples. The sample includes firms belonging to 12 EMU countries and 3 non-EMU countries which are members of the EU from Compact D Worldscope, 1993-2002. Corporate liquidity is the ratio of cash holdings to total assets.

Country	*mean*	*P25*	*p50*	*p75*	*standard deviation*	*no. observations*
Austria	0.133	0.034	0.079	0.166	0.157	563
Belgium	0.135	0.043	0.078	0.176	0.137	645
Finland	0.136	0.041	0.081	0.177	0.147	777
France	0.141	0.038	0.090	0.188	0.149	3,674
Germany	0.078	0.002	0.014	0.068	0.154	1,229
Greece	0.090	0.007	0.021	0.063	0.180	33
Ireland	0.063	0.005	0.012	0.058	0.104	104
Italy	0.044	0.004	0.018	0.048	0.075	265
Luxembourg	0.030	0.001	0.001	0.007	0.097	15
Netherlands	0.039	0.001	0.005	0.030	0.095	173
Portugal	0.035	0.000	0.012	0.049	0.068	43
Spain	0.050	0.003	0.017	0.039	0.085	70
EMU	0.120	0.023	0.066	0.162	0.149	7,591
Denmark	0.158	0.040	0.103	0.229	0.165	992
Sweden	0.117	0.012	0.047	0.160	0.158	104
UK	0.044	0.000	0.007	0.040	0.094	1,751
Non-EMU	0.086	0.003	0.027	0.110	0.137	2,847
Total	0.111	0.014	0.055	0.149	0.146	10,438

average corporate liquidity (14.1%) while Luxembourg has the lowest (3.0%). Among the non-EMU countries, Denmark has the highest corporate liquidity (15.8%) while the UK has the lowest (4.4%). The median tells a similar story. Overall, Denmark has the highest median corporate liquidity (10.3%) while Luxembourg still has the lowest (0.1%). Among the EMU countries, France has the highest median corporate liquidity (9.0%) while Luxembourg has the lowest (0.1%). Among the non-EMU countries, Denmark has the highest median corporate liquidity (10.3%) while the UK has the lowest (0.7%). My summary statistics are similar to those provided by Ferreira and Vilela (2004).

Focusing on the summary statistics for two sub-groups, the EMU firms have higher mean corporate liquidity (12.0%) than for the non-EMU firms (8.6%). In addition, median corporate liquidity for the EMU (6.6%) is also higher than that for the non-EMU (2.7%). Hence, it appears that over the whole test period, corporate liquidity in the EMU firms is higher than in non-EMU firms.

Table 6 provides the averages for various determinants of corporate liquidity by country over the test period. Overall, the EMU firms have lower market-to-book ratio as well as dividend and higher net working capital, cash flow, leverage, size, and capital expenditure than the non-EMU firms. It is worth noting that non-EMU firms enjoy better shareholder rights and creditor rights than EMU firms. In addition, insider ownership is lower in the non-EMU firms than in the EMU firms.

Table 6
Averages for determinants of corporate liquidity by country, 1993-2002

This table provides averages for the determinants of corporate liquidity by country. Market-to-book ratio is defined as the book value of total assets less the book value of equity plus the market value of equity divided by total assets. Net working capital is defined as total current assets less cash less total current liabilities. Cash flow is earnings before interest and taxes, depreciation and amortization (EBITDA), less interest, taxes, and common dividends. Leverage is total debt as a fraction of total assets. Shareholder rights and creditor rights are summary measures of shareholder and creditor protection, ranging from 0 to 6 and 0 to 4, respectively. Both variables are derived from La Porta et al. (1998). Ownership represents shares held by insiders as a fraction of common shares outstanding. Size is the natural log of total assets. Capital expenditure/assets is additions to fixed assets over total assets. Dividend is common dividends as a fraction of earnings. The values for EMU, non-EMU and total samples are weighted averages.

Country	*Market-to-book ratio*	*Net working capital/ assets*	*Cash flow/ assets*	*Leverage*	*Shareholder rights*	*Creditor rights*	*Ownership*	*Size*	*Capital expenditure/ assets*	*Dividend*
Austria	1.061	0.058	0.071	0.248	2	3	0.591	12.018	0.073	0.276
Belgium	1.389	0.028	0.084	0.248	0	2	0.573	12.165	0.080	0.234
Finland	1.603	0.084	0.088	0.261	3	1	0.419	12.085	0.083	0.285
France	1.332	0.052	0.065	0.216	3	0	0.586	11.706	0.061	0.190
Germany	1.561	0.079	0.037	0.198	1	3	0.639	11.327	0.082	0.211
Greece	1.549	0.073	0.100	0.187	2	1	0.699	11.000	0.046	0.432
Ireland	1.436	0.039	0.025	0.174	4	1	0.376	11.065	0.075	0.123
Italy	1.198	-0.070	0.028	0.249	1	2	0.545	12.292	0.051	0.220
Luxembourg	0.985	0.018	-0.023	0.343	.	.	0.846	12.104	0.127	0.009
Netherlands	1.439	-0.006	0.040	0.225	2	2	0.506	11.371	0.064	0.158
Portugal	0.699	-0.127	0.052	0.227	3	1	0.511	11.617	0.070	0.277
Spain	0.974	-0.132	0.038	0.225	4	2	0.383	11.737	0.044	0.193
EMU	1.374	0.050	0.062	0.224	2.3	1.1	0.563	11.747	0.069	0.213
Denmark	1.259	0.075	0.081	0.256	2	3	0.242	11.595	0.064	0.187
Sweden	2.010	-0.208	0.057	0.149	3	2	0.352	10.372	0.058	0.150
UK	2.328	-0.038	0.019	0.164	5	4	0.330	10.756	0.065	0.237
Non-EMU	1.950	-0.005	0.043	0.196	3.9	3.6	0.300	11.034	0.065	0.216
Total	1.539	0.035	0.056	0.216	2.7	1.8	0.482	11.553	0.068	0.214

F. Empirical Results

I obtained the correlation matrix between corporate liquidity and its determinants before performing multivariate analysis.[67] I found that the determinants of corporate liquidity indeed correlate with corporate liquidity. My correlation results suggest the need to include them for estimation.[68] Next, I present results from static regressions including pooled OLS cross-country regressions and between-effect panel data regressions first and then dynamic panel data estimation results.

1. Static Regressions

Table 7 consists of three panels. Panel A presents the simple OLS results, which are comparable to the estimation results reported in previous liquidity studies. Panel B presents the results of between-effect panel data regressions. Panel C shows the results of between-effect panel data regressions including the EMU dummy. There are six models in each panel.[69] In each panel, models 1 through 3 use the full sample while models 4 through 6 use only observations with insider ownership data available. Approximately 25% of my observations have missing insider ownership data, which is

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[67] We do not report these results for space consideration, but will provide them upon request.

[68] We obtained the directed acyclic graphs (DAG) representation software from David Bessler (Bessler and Yang 2003) that provides a structure of causality among corporate liquidity and its determinants. According to DAG representation, corporate liquidity has three direct causes, i.e., leverage, net working capital, and creditor rights, suggesting that corporate liquidity is a function of these three variables. This observation is consistent with my empirical results that these three variables have significant effects on corporate liquidity (see Tables 3 through 6 for details). In addition, the graph also shows four causal roots such as market-to-book ratio, capital expenditure and dividend payout, all of which turn out to be influential in my regression results. It is interesting to note that unlike the creditor rights, the DAG representation does not identify shareholder rights as a causal variable.

[69] In all models, industry dummies were included to capture industry-specific effects.

Table 7
Static regressions, 1993-2002

Panel A presents pooled OLS cross-country regression results and panel B presents between-effect panel data regression results; panel C presents results of between-effect panel data regression with the EMU dummy (D_{EMU}) included. The dependent variable for all models is the natural log of the ratio of cash and its equivalents to total assets (Cash). Market-to-book ratio is defined as the book value of total assets less the book value of equity plus the market value of equity divided by total assets. Size is the natural log of total assets. Net working capital is defined as total current assets less cash less total current liabilities. Cash flow is earnings before interest and taxes, depreciation and amortization (EBITDA), less interest, taxes, and common dividends. Capital expenditure/assets is additions to fixed assets over total assets. Leverage is total debt as a fraction of total assets. Dividend is common dividends as a fraction of earnings. Shareholder rights and creditor rights are summary measures of shareholder and creditor protection, ranging from 0 to 6 and 0 to 4, respectively. Both variables are derived from La Porta et al. (1998). Ownership represents shares held by insiders as a fraction of common shares outstanding. Ownership squared represents the square of ownership. D_{EMU} takes on 1 if a firm belongs to EMU and 0 otherwise. In all models, industry dummies were included to capture industry-specific effects. *N* represents the number of observations (firm-years); n stands for the number of firms. The numbers in the parentheses are t-statistics. ***, ** and * indicate coefficient is significant at the 1%, 5% and 10% level, respectively.

(A) Pooled OLS cross-country regressions, 1993-2002

Independent variable	Full sample			Firms with ownership data available		
	1	2	3	4	5	6
Market-to-book ratio	0.013 (1.52)	0.017* (2.10)	0.025*** (3.15)	0.049*** (3.67)	0.046*** (3.46)	0.046*** (3.47)
Size	0.305*** (19.57)	0.247*** (16.22)	0.216*** (14.35)	0.234*** (12.9)	0.204*** (11.28)	0.205*** (11.32)
Net working capital/assets	-0.626*** (-5.15)	-0.692 *** (-5.94)	-0.933*** (-8.11)	-0.931*** (-6.84)	-0.899*** (-6.71)	-0.889*** (-6.63)
Cash flow/assets	2.877*** (11.92)	2.569*** (11.03)	2.385*** (10.45)	4.748*** (15.18)	4.580*** (14.85)	4.577*** (14.84)
Capital expenditure/assets	-2.626*** (-6.52)	-1.643*** (-4.24)	-2.072*** (-5.44)	-2.574*** (-5.32)	-2.674*** (-5.61)	-2.643*** (-5.54)
Leverage	-2.673*** (-16.23)	-2.640*** (-16.69)	-2.877*** (-18.5)	-2.637*** (-13.85)	-2.710*** (-14.44)	-2.685*** (-14.28)
Dividend	-0.398*** (-3.63)	-0.122 (-1.15)	-0.070 (-0.67)	0.039 (0.31)	0.088 (0.71)	0.090 (0.72)
Shareholder rights	-0.338*** (-17.78)		-0.298*** (-16.55)	-0.227*** (-10.33)	-0.295*** (-13.16)	-0.292*** (-13.00)
Creditor rights		-0.476*** (-28.92)	-0.455*** (-28.12)	-0.409*** (-20.39)	-0.490*** (-23.42)	-0.492*** (-23.49)

Table 7 Continued (A) Pooled OLS cross-country regressions, 1993-2002

Independent variable	Full sample			Firms with ownership data available		
	1	2	3	4	5	6
Ownership					-1.583*** (-11.8)	-2.398*** (-5.06)
Ownership squared						0.892*[70] (1.79)
Constant	-5.015*** (-14.41)	-4.579*** (-13.8)	-3.329*** (-9.98)	-4.662*** (0.31)	-3.091*** (-9.16)	-3.000*** (-8.79)
N	6386	6386	6386	4576	4576	4576
Adjusted R^2	0.170	0.230	0.262	0.2649	0.287	0.287

[70] The p-value for ownership squared in model 6 is 0.073, which enables us to reject the null hypothesis at 10% level that the corresponding coefficient is zero and accept the alternative one-sided hypothesis that the coefficient is greater than zero.

Table 7 Continued (B) Between-effect panel data regressions, 1993-2002

Independent variable	Full sample			Firms with ownership data available		
	1	2	3	4	5	6
Market-to-book ratio	0.007 (0.59)	0.010 (0.95)	0.013 (1.24)	0.072** (2.80)	0.068** (2.64)	0.068** (2.63)
Size	0.352*** (11.02)	0.334*** (11.09)	0.286*** (9.49)	0.334*** (8.37)	0.310*** (7.70)	0.309*** (7.68)
Net working capital/assets	-1.009*** (-5.02)	-0.956*** (-5.07)	-1.245*** (-6.60)	-1.302*** (-5.41)	-1.231*** (-5.13)	-1.228*** (-5.12)
Cash flow/assets	1.481*** (3.64)	1.150*** (2.96)	1.149*** (3.01)	5.002*** (7.76)	4.945*** (7.72)	4.931*** (7.69)
Capital expenditure/assets	-2.414*** (-3.29)	-1.114 (-1.60)	-1.628** (-2.36)	-2.101 (-1.90)	-2.185* (-1.98)	-2.169* (-1.97)
Leverage	-3.324*** (-10.27)	-3.478*** (-11.30)	-3.657*** (-12.05)	-3.167*** (-7.61)	-3.201*** (-7.74)	-3.182*** (-7.65)
Dividend	-0.497* (-2.13)	-0.156 (-0.70)	-0.099 (-0.45)	0.360 (1.20)	0.423 (1.42)	0.430 (1.44)
Shareholder rights	-0.400*** (-11.97)		-0.266*** (-8.24)	-0.165*** (-3.82)	-0.221*** (-4.87)	-0.220*** (-4.82)
Creditor rights		-0.572*** (-19.00)	-0.509*** (-16.66)	-0.424*** (-9.51)	-0.471*** (-10.23)	-0.473*** (-10.24)
Ownership					-1.109*** (-3.80)	-1.619 (-1.61)
Ownership squared						0.556 (0.53)
Constant	-5.603*** (-10.74)	-5.445*** (-11.41)	-4.122*** (-8.31)	-6.233*** (-9.20)	-5.126*** (-6.98)	-5.051*** (-6.75)
N	6386	6386	6386	4576	4576	4576
n	1960	1960	1960	1158	1158	1158
R^2	0.197	0.273	0.297	0.304	0.313	0.313

Table 7 Continued (C) Between-effect panel data regressions with the EMU dummy, 1993-2002

Independent variable	Full sample			Firms with ownership data available		
	1	2	3	4	5	6
Market-to-book ratio	0.009 (0.84)	0.010 (0.98)	0.013 (1.24)	0.070** (2.77)	0.068** (2.70)	0.068** (2.70)
Size	0.322*** (10.18)	0.328*** (10.76)	0.292*** (9.79)	0.343*** (8.76)	0.330*** (8.31)	0.330*** (8.30)
Net working capital/assets	-1.143*** (-5.75)	-0.994*** (-5.20)	-1.190*** (-6.38)	-1.265*** (-5.37)	-1.233*** (-5.23)	-1.233*** (-5.23)
Cash flow/assets	1.518*** (3.79)	1.176*** (3.03)	0.933** (2.47)	4.553*** (7.18)	4.561*** (7.20)	4.561*** (7.19)
Capital expenditure/assets	-2.181*** (-3.01)	-1.182 (-1.69)	-1.534** (-2.25)	-1.845 (-1.70)	-1.906 (-1.76)	-1.906 (-1.76)
Leverage	-3.410*** (-10.70)	-3.490*** (-11.34)	-3.712*** (-12.38)	-3.117*** (-7.65)	-3.137*** (-7.71)	-3.138*** (-7.67)
Dividend	-0.433 (-1.88)	-0.164 (-0.73)	0.018 (0.08)	0.581* (1.97)	0.593* (2.01)	0.593* (2.01)
Shareholder rights	-0.164*** (-3.71)		-0.506*** (-10.86)	-0.458*** (-7.76)	-0.462*** (-7.83)	-0.462*** (-7.78)
Creditor rights		-0.534*** (-12.28)	-0.766*** (-16.19)	-0.759*** (-11.83)	-0.755*** (-11.77)	-0.755*** (-11.76)
D_{EMU}	1.130*** (7.98)	0.178 (1.21)	-1.470*** (-7.05)	-1.859*** (-7.12)	-1.710*** (-6.25)	-1.711*** (-6.22)
Ownership					-0.536 (-1.78)	-0.519 (-0.52)
Ownership squared						-0.018 (-0.02)
Constant	-6.728*** (-12.64)	-5.569*** (-11.41)	-1.911*** (-3.28)	-3.516*** (-4.59)	-3.198*** (-4.07)	-3.200*** (-4.03)
N	6386	6386	6386	4576	4576	4576
n	1960	1960	1960	1158	1158	1158
R^2	0.2225	0.2734	0.315	0.3334	0.3353	0.3353

needed in my subsequent tests. To ensure that no bias is created by ignoring those observations with missing insider ownership data, I conduct tests on the full sample as well as the sample with insider ownership data available. As shown in Table 7 results discussed below, the coefficients of corporate liquidity determinants are similar for both these samples. Hence, in my subsequent analysis, I can focus on the sample with the insider ownership data available.

a. Pooled OLS Cross-Country Regression Results

In general, my estimation results are consistent with those obtained by previous studies in terms of the signs associated with determinants of corporate liquidity. Market-to-book ratio has a positive effect on corporate liquidity in all models. Size has a positive effect on corporate liquidity. Net working capital has a negative effect on corporate liquidity, confirming that net working capital and corporate liquidity are substitutes. Cash flow has a positive sign, suggesting that firms with high cash flow tend to have higher cash levels for the precautionary purpose. Consistent with Dittmar et al. (2003) as well as Kalcheva and Lins (2004), capital expenditure has a negative effect. According to Kalcheva and Lins (2004), this negative effect suggests that corporate liquidity increases if potential investment opportunities (proxied by capital expenditure) decline. Leverage proves to be negatively related to corporate liquidity, supporting the view that debt and cash are substitutes. I observe an insignificant effect of dividend payouts in all models except model 1.

Corporate governance variables turn out to be important determinants. Strong shareholder rights appear to reduce corporate liquidity, consistent with Dittmar et al.'s (2003) as well as Ferreira and Vilela's (2004) findings; strong creditor rights appear to reduce corporate liquidity, consistent with Ferreira and Vilela's (2004) findings. In addition, in models 5 and 6, I observe that higher insider ownership leads to lower corporate liquidity, substantiating the view that when insiders own more shares, they prefer to hold less cash because their interests are more in line with other shareholders. My OLS results from model 5 assume a simple linear relationship between insider ownership and corporate liquidity while the results from model 6 provide some evidence supporting a nonlinear relationship between ownership and liquidity.[71] This finding is interesting since it implies that cash holdings decline as insider ownership increases, i.e., managers' interests align with shareholders'; however, beyond a certain ownership level, cash holdings increase with insider ownership. Using Morck et al.'s (1998) reasoning, managers are entrenched beyond a particular ownership level and maintain high cash holdings for consuming perquisites.

b. Between-Effect Panel Data Regression Results

Since the nature of my data is both time-series and cross sectional, estimation with the panel data model is more appropriate. However, because I have variables that vary

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[71] The p-value for ownership squared in model 6 is 0.073, which enables us to reject the null hypothesis at 10% level that the corresponding coefficient is zero and accept the alternative one-sided hypothesis that the coefficient is greater than zero.

across firms or countries but are constant over time (i.e., shareholder rights, creditor rights and insider ownership), the fixed effect panel data model is inappropriate for them. I instead use between-effect panel data model. This model averages each variable over time for each firm. The results so obtained are reported in Table 7 panel B and are similar to those obtained using OLS and reported in panel A. They confirm the negative impact of shareholder rights and creditor rights on cash holdings. Insider ownership has a negative impact on corporate liquidity as shown in model 5 results but no effects when ownership squared is introduced in model 6 which itself becomes insignificant.

In addition, I also performed between-effect panel data regressions by including an additional variable, i.e., the EMU dummy (Table 7 (C)). I introduce the EMU dummy because one of my goals in this chapter is to examine whether EMU firms distinguish themselves from non-EMU firms in corporate liquidity. In general, the effects of each determinant stay the same. For example, my key variables like shareholder rights and creditor rights continue to exert a negative impact on corporate liquidity. Insider ownership has the predicted sign, but the effect is not significant. Except for models 1 and 2, the EMU dummy has a negative impact on corporate liquidity, suggesting the EMU firms generally have lower corporate liquidity as opposed to non-EMU firms, *ceteris paribus*.

Table 8
Dynamic panel data regressions, 1993-2002

The dependent variable for all models is the natural log of the ratio of cash and its equivalents to total assets (Cash). Lagged cash denotes Cash one year before. Market-to-book ratio is defined as the book value of total assets less the book value of equity plus the market value of equity divided by total assets. Size is the natural log of total assets. Net working capital is defined as total current assets less cash less total current liabilities. Cash flow is earnings before interest and taxes, depreciation and amortization (EBITDA), less interest, taxes, and common dividends. Capital expenditure/assets is additions to fixed assets over total assets. Leverage is total debt as a fraction of total assets. Dividend is common dividends as a fraction of earnings. Model 1 is the benchmark. Model 2 includes year dummy variables for the period 1993-2002. Model 3 includes year dummy variables and considers the endogeneity problem. Panel A presents regression results based on all data available. Panel B provides robustness check by using observations without missing ownership data.

N represents the number of observations (firm-years) while *n* indicates the number of firms. Correlation 1 and 2 are test statistics for first and second order autocorrelations in residuals, respectively, distributed as standard normal N(0,1) under the null of no serial correlation. Sargan test is a test of over-identifying restrictions, distributed as chi-square under the null of instrument validity. Z-statistics are reported in parentheses. ***, ** and * indicate the coefficient is significant at the 1%, 5% and 10% level, respectively.

	(A) Full sample			(B) Firms with ownership data available		
Independent variable	Basic regression	Regression including year dummies	Regression including year dummies and accounting for endogeneity	Basic regression	Regression including year dummies	Regression including year dummies and accounting for endogeneity
	1	2	3	1	2	3
Lagged cash	0.401*** (4.39)	0.390*** (4.34)	0.112*** (8.87)	0.296 *** (3.13)	0.228** (2.55)	0.038*** (3.16)
Market-to-book ratio	0.042** (2.66)	0.040** (2.54)	-0.021* (-2.12)	0.061*** (2.86)	0.039 (1.66)	-0.023* (-2.15)
Size	0.290*** (2.87)	0.378*** (3.04)	0.462*** (9.38)	0.279** (2.47)	0.447*** (3.14)	0.598*** (11.92)
Net working capital/assets	-1.404*** (-4.41)	-1.365*** (-4.30)	-2.766*** (-22.66)	-1.379*** (-4.09)	-1.386*** (-4.16)	-3.160*** (-26.73)
Cash flow/assets	0.628 (1.44)	0.491 (1.09)	1.046*** (5.09)	0.541 (1.06)	0.409 (0.80)	0.483** (2.48)
Capital expenditure/assets	-1.611** (-2.83)	-1.791*** (-3.18)	-0.457* (-2.20)	-1.379** (-2.71)	-1.683*** (-3.34)	-0.942*** (-4.86)
Leverage	-1.126*** (-3.07)	-1.153*** (-2.93)	-2.322*** (-16.65)	-1.062** (-2.61)	-1.236** (-2.81)	-2.776*** (-18.81)
Dividend	-0.112 (-1.18)	-0.156 (-1.67)	0.186** (2.29)	-0.222* (-2.14)	-0.255** (-2.52)	-0.245*** (-2.88)
Constant	0.033*** (0.01)	0.047*** (0.02)	0.095*** (11.91)	0.039*** (3.10)	0.064*** (3.88)	0.113*** (16.24)

Table 8 Continued

Independent variable	(A) Full sample			(B) Firms with ownership data available		
	Basic regression	Regression including year dummies	Regression including year dummies and accounting for endogeneity	Basic regression	Regression including year dummies	Regression including year dummies and accounting for endogeneity
	1	2	3	1	2	3
N	2689	2689	2689	2164	2164	2164
n	785	785	785	615	615	615
Correlation 1	-5.09	-4.98	-5.45	-4.11	-3.73	-4.60
Correlation 2	-1.75	-1.68	-1.99	-1.49	-1.50	-1.36
Sargan test (df)[72]	47.17 (35)	46.29 (35)	286.1 (280)	46.88 (35)	47.57 (35)	260.89 (280)

2. Dynamic Panel Data Estimation

In general, my estimation results from the simple OLS and between-effect panel data regressions are consistent with previous findings. I now discuss the results obtained from the dynamic panel data model, which are the focus of this chapter. Table 8 provides the basic estimation results derived from models comparable to those in Table 7 while Table 9 estimation extends Table 8 analysis by additionally examining how corporate liquidity is affected by other governance variables at both country and firm levels like shareholder

[72] Our Sargan test results suggest that we reject the null hypothesis that residuals and instruments are independent for models 1 and 2 at 10% level but fail to reject it for model 3, suggesting model 3 with year dummies included and endogeneity problem considered is an appropriate specification. Thus, model 3 in Table 4 serves as the benchmark for dynamic panel data estimation in the following tables.

Table 9
Dynamic panel data regressions accounting for endogeneity with corporate governance variables, 1993-2002

The dependent variable for all models is the natural log of the ratio of cash and its equivalents to total assets (Cash). Lagged cash denotes Cash one year before. Market-to-book ratio is defined as the book value of total assets less the book value of equity plus the market value of equity divided by total assets. Size is the natural log of total assets. Net working capital is defined as total current assets less cash less total current liabilities. Cash flow is earnings before interest and taxes, depreciation and amortization (EBITDA), less interest, taxes, and common dividends. Capital expenditure/assets is additions to fixed assets over total assets. Leverage is total debt as a fraction of total assets. Dividend is common dividends as a fraction of earnings. Shareholder rights and creditor rights are summary measures of shareholder and creditor protection, ranging from 0 to 6 and 0 to 4, respectively. Both variables are derived from La Porta et al. (1998). Ownership represents shares held by insiders as a fraction of common shares outstanding. Ownership squared represents the square of ownership. D98 takes on a value of 1 if the year is 1998 or later and 0 otherwise. D_{EMU} takes on 1 if a firm belongs to EMU and 0 otherwise. The year dummy variables for the period 1993-2002 are included for all models but their coefficients are not shown in the table.

N represents the number of observations (firm-years) while *n* indicates the number of firms. Correlation 1 and 2 are test statistics for first and second order autocorrelations in residuals, respectively, distributed as standard normal N(0,1) under the null of no serial correlation. Sargan test is a test of over-identifying restrictions, distributed as chi-square under the null of instrument validity. Z-statistics are reported in parentheses. ***, ** and * indicate the coefficient is significant at the 1%, 5% and 10% level, respectively.

Independent variable	Full sample	Firms with ownership data available		
	1	2	3	4
Lagged cash	0.105*** (7.64)	0.032** (2.69)	0.033** (2.74)	0.037*** (3.13)
Market-to-book ratio	-0.024** (-2.42)	-0.031*** (-2.99)	-0.036*** (-3.50)	-0.037*** (-3.45)
Size	0.479*** (11.48)	0.608*** (12.21)	0.615*** (12.29)	0.580*** (10.73)
Net working capital/assets	-2.728*** (-22.07)	-3.232*** (-27.56)	-3.257*** (-27.65)	-3.261*** (-25.92)
Cash flow/assets	1.086*** (4.88)	0.489** (2.52)	0.414* (2.16)	0.386 (1.93)
Capital expenditure/assets	-0.413* (-1.96)	-0.854*** (-4.41)	-0.861*** (-4.35)	-0.818*** (-3.96)
Leverage	-2.167*** (-14.64)	-2.779*** (-18.94)	-2.766*** (-18.91)	-2.628*** (-15.13)
Dividend	0.190** (2.35)	-0.271*** (-3.12)	-0.321*** (-3.65)	-0.329*** (-3.83)
D98* D_{EMU}	-0.178*** (-3.01)	-0.288*** (-4.62)	-0.265*** (-4.19)	-0.248*** (-3.42)
D98*Shareholder rights	0.015 (0.68)	0.005 (0.22)	0.003 (0.13)	0.016 (0.73)

Table 9 Continued

Independent variable	Full sample	Firms with ownership data available		
	1	2	3	4
D98*Creditor rights	-0.066*** (-3.05)	-0.099*** (-4.34)	-0.097*** (-4.11)	-0.096*** (-3.80)
D98*ownership			-0.046 (-0.54)	-0.746* (-2.15)
D98*ownership squared				0.750* (2.00)
Constant	0.075*** (5.17)	0.073*** (4.94)	0.071*** (4.54)	0.058*** (3.38)
N	2685	2164	2164	2164
n	784	615	615	615
Correlation 1	-5.30	-4.55	-4.57	-4.54
Correlation 2	-2.11	-1.42	-1.41	-1.46
Sargan test (df)[73]	287.61 (280)	258.80 (280)	258.95 (280)	259.01 (280)

rights, creditor rights and insider ownership. Table 10 presents results derived by interacting the EMU dummy and the determinants of corporate liquidity to see if the creation of EMU has changed the way the determinants affect corporate liquidity during the test period.

I start with Table 8, which reports dynamic panel data model results to provide a comparison with OLS model results of Table 7.[74] Table 8 consists of panels A and B. Panel A presents the estimation results using the full sample. Panel B provides a

[73] Our Sargan test results suggest that we fail to reject the null hypothesis of residuals and instruments being independent throughout all models in Tables 5 and 6.

[74] Table 4 does not include static variables such as shareholder rights, creditor rights and insider ownership because these static variables will take a value of zero after the first differencing, the first step of dynamic panel estimation.

Table 10
Dynamic panel data regressions accounting for endogeneity, 1993-2002
Impact of EMU on sensitivity of corporate liquidity to its determinants

This table introduces interaction variables to measure any unique effects due to the introduction of the euro, D98, on the coefficients of the determinants of corporate liquidity. The dependent variable for all models is the natural log of the ratio of cash and its equivalents to total assets (Cash). Lagged cash denotes Cash one year before. Market-to-book ratio is defined as the book value of total assets less the book value of equity plus the market value of equity divided by total assets. Size is the natural log of total assets. Net working capital is defined as total current assets less cash less total current liabilities. Cash flow is earnings before interest and taxes, depreciation and amortization (EBITDA), less interest, taxes, and common dividends. Capital expenditure/assets is additions to fixed assets over total assets. Leverage is total debt as a fraction of total assets. Dividend is common dividends as a fraction of earnings. Shareholder rights and creditor rights are summary measures of shareholder and creditor protection, ranging from 0 to 6 and 0 to 4, respectively. Both variables are derived from La Porta et al. (1998). Ownership represents shares held by insiders as a fraction of common shares outstanding. Ownership squared represents the square of ownership. D98 takes on 1 if the year is 1998 or after 1998 and 0 otherwise. D_{EMU} takes on 1 if a firm belongs to EMU and 0 otherwise. The year dummy variables for the period 1993-2002 are included for all models but their coefficients are not shown in the table. Only observations with ownership data available were used for estimation.

N represents the number of observations (firm-years) while *n* indicates the number of firms. Correlation 1 and 2 are test statistics for first and second order autocorrelations in residuals, respectively, distributed as standard normal N(0,1) under the null of no serial correlation. Sargan test is a test of over-identifying restrictions, distributed as chi-square under the null of instrument validity. Z-statistics are reported in parentheses. ***, ** and * indicate the coefficient is significant at the 1%, 5% and 10% level, respectively.

Independent variable	Basic Model	Model including shareholder rights and creditor rights	Model including shareholder rights, creditor rights and ownership
	1	2	3
Lagged cash	0.042*** (13.56)	0.031*** (9.67)	0.034*** (10.61)
D_{EMU} *Lagged cash	0.002 (0.28)	0.011 (1.36)	0.009 (1.10)
Market-to-book ratio	0.012*** (3.10)	0.018*** (4.82)	0.023*** (5.26)
D_{EMU} *Market-to-book ratio	-0.066*** (-13.67)	-0.079*** (-15.47)	-0.090*** (-18.53)
Size	0.885*** (0.021)	0.859*** (38.34)	0.860*** (36.71)
Net working capital/assets	-1.373*** (-28.60)	-1.149*** (-26.19)	-1.174*** (-22.86)
D_{EMU} *Net working capital/assets	-0.846*** (-8.44)	-1.065*** (-11.6)	-1.003*** (-10.08)
Cash flow/assets	3.249*** (27.71)	3.428*** (31.06)	3.424*** (32.52)

Table 10 Continued

Independent variable	Basic Model	Model including shareholder rights and creditor rights	Model including shareholder rights, creditor rights and ownership
	1	2	3
D_{EMU} *Cash flow/assets	-2.965*** (-19.08)	-3.299*** (-20.6)	-3.462*** (-22.54)
Capital expenditure/assets	-1.325*** (0.080)	-1.366*** (-20.96)	-1.373*** (-19.86)
Leverage	-2.315*** (-42.13)	-2.267*** (-40.43)	-2.226*** (-40.30)
D_{EMU} *Leverage	-0.549*** (-3.90)	-0.635*** (-4.83)	-0.703*** (-5.42)
Dividend	-0.137*** (0.025)	-0.124*** (-7.30)	-0.208*** (-8.57)
D98*Shareholder rights		0.191*** (13.88)	0.241*** (16.23)
D98* D_{EMU} *Shareholder rights		-0.253*** (-8.95)	-0.315*** (-10.46)
D98*Creditor rights		-0.235*** (-9.29)	-0.339*** (-12.37)
D98* D_{EMU} *Creditor rights		0.135*** (8.26)	0.225*** (13.65)
D98*ownership			-1.584*** (-9.02)
D98*ownership squared			1.307*** (6.12)
Constant	0.132*** (0.002)	0.098*** (13.84)	0.036*** (0.008)
N	2164	2164	2164
n	615	615	615
Correlation 1	-4.62	-4.60	-4.61
Correlation 2	-1.43	-1.48	-1.49
Sargan test (df)	392.97 (455)	394.44 (455)	386.94 (455)

robustness check to panel A by including only those observations for which insider ownership data is available. In both panels, models 1 and 2 treat the determinants of corporate liquidity as exogenous while model 3 treats them as endogenous by using all their lagged values as instruments of each determinant. Focusing on panel A, in model 1, which serves as the benchmark, the signs are identical to those observed in Table 7

except that the coefficient for cash flow/assets is insignificant. Model 2 includes year dummies and the results obtained are very similar to those of model 1. When I account for the endogeneity problem as well as time effects in model 3, the most noticeable change is that the sign of market-to-book ratio changes from positive to negative. This finding of a negative relationship between cash holdings and market-to-book ratio is different from the results of Dittmar et al. (2003) as well as Ferreira and Vilela (2004), which were obtained using OLS. Based upon their results, Dittmar et al. (2003) and Ferreira and Vilela (2004) had concluded that managers hold high cash balances in anticipation of high future investment opportunities. My endogeneity-adjusted results lead to the opposite inference. They suggest that managers are inclined to hold more cash in response to poor investment opportunities as predicted by the agency theory. In addition, accounting for endogeneity, profitability as proxied by cash flow/assets has a significantly positive sign as observed in Table 7, confirming the precautionary motive for holding cash. The above two findings in model 3 as well as others are also observed in results reported in panel B, obtained using only observations with insider ownership data available. The only difference is that dividend exhibits a consistent negative effect in all models of panel B as compared to Panel A, where dividend shows a significant positive effect only in model 3.

In models 1 through 3 of both panels, I observe a significant positive coefficient for the lagged dependent variable, meaning that corporate liquidity one year before has significant explanatory power. This suggests that adjustment in cash holdings is costly such that instantaneous adjustment is not possible. In addition, my Sargan test results

show that I reject the null hypothesis that residuals and instruments are independent for models 1 and 2 at 10% level, but I fail to reject the null hypothesis for model 3, suggesting that model 3 with year dummies included and endogeneity problem accounted for is the appropriate specification. Thus, model 3 in Table 8 serves as the basis for my dynamic panel data models whose results are reported in Tables 5 and 6.

Table 9 is an extension of Table 8 and includes interaction variables whose construction is defined below. As noted earlier, my three governance variables vary across firms or countries but are constant over time, i.e., they are static variables. Since dynamic panel data analysis entails first differences, static variables take a value of zero and get eliminated from the analysis. To include these static variables in my analysis, I convert them to dynamic variables by interacting them with the euro dummy, D98. This procedure makes the interacted value of the static variables zero for each year before 1998 and non-zero in 1998 and subsequent years, i.e., this new variable is not constant over time and therefore can be incorporated in the dynamic panel data analysis. Given its construction, the first differences of this variable will be non-zero in only one year, 1998. Hence, results obtained for these variables should be interpreted in this context. I apply the same procedure to the EMU dummy variable, D_{EMU}. The first difference of its interaction variable will equal 1 in 1998 for EMU firms only and 0 for all other years and for all non-EMU firms.[75]

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[75] Assume the coefficient for the EMU dummy is β. Given that $y_{1998} - y_{1997} = \cdots + \beta D_{EMU} + \cdots$, $(y_{1998} - y_{1997})$ will change by β if $D_{EMU} = 1$, i.e., if a firm belongs to the EMU. Further assume

There are four models in Table 9. Model 1 uses the full sample as a robustness check while model 2 uses only those firms with insider ownership data available. All models include the EMU dummy, shareholder rights and creditor rights. Models 3 and 4 introduce insider ownership as an additional determinant of corporate liquidity. More specifically, model 3 assumes a linear relationship between insider ownership and corporate liquidity while model 4 assumes a non-linear relationship between the two.

In general, the results in Table 9 are consistent with those in model 3 of Table 8. For example, corporate liquidity in year $t-1$ continues to exert a significant influence on corporate liquidity in year t. Market-to-book ratio has a consistently significant negative effect, consistent with the prediction of the agency theory. Size has a positive impact on corporate liquidity. Net working capital is a substitute for corporate liquidity as predicted. The positive sign of cash flow suggests that management tends to retain more cash when cash flow is higher, consistent with findings of Dittmar et al. (2003). Capital expenditure has a negative impact on corporate liquidity. The negative coefficient for leverage suggests that debt and cash are substitutes. As observed in Table 8, in Table 9, the effect of dividend is positive in model 1 using the full sample, but negative for models 2 through 4 using the sample with insider ownership data available.

Next, I discuss the effects of the EMU dummy, shareholder rights, creditor rights and insider ownership on cash holdings. As mentioned earlier, their coefficients are based upon observations for year 1998 but are obtained using a much more robust

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y_{1997} is constant. Then we will have $\Delta y_{1998} = \beta$ if $D_{EMU} = 1$. The same logic applies to shareholder rights, creditor rights and insider ownership.

methodology than OLS and after adjusting for any endogeneity problems in the other determinants of corporate liquidity. The coefficient for the EMU dummy is significantly negative in all models, suggesting that the EMU firms see a reduction in corporate liquidity during the transition to the euro in 1998 compared to the non-EMU firms, *ceteris paribus*. This is consistent with the negative coefficient of the EMU dummy observed in the between-regression results (Table 7 (C)). Unlike previous studies, shareholder rights do not show a significant effect on corporate liquidity. Stronger creditor rights continue to have a significantly negative effect on corporate liquidity. From the results in model 4, I continue to observe a non-linear relationship between insider ownership and corporate liquidity.

a. Impact of EMU on Sensitivity of Corporate Liquidity to Its Determinants

I now discuss results estimated by interacting determinants of corporate liquidity and the EMU dummy variable to discern the unique effect of the monetary union by examining how EMU has changed the sensitivity of corporate liquidity to its determinants (Table 10). In particular, I are interested in estimating the coefficients of the D_{EMU} interaction variables associated with market-to-book ratio, net working capital, cash flow, capital expenditure and leverage.

The coefficient for market-to-book ratio is significantly positive by itself but significantly negative for its corresponding interaction variable. This implies that the effect of market-to-book ratio on corporate liquidity is positive for the non-EMU firms but negative for the EMU firms, suggesting that the generally negative effect of market-

to-book ratio observed in Table 9 is predominated by the negative effect observed here for the EMU firms. Since the agency theory predicts a negative effect of market-to-book ratio, it appears that the agency theory explanation of corporate liquidity applies more strongly to the EMU firms.

Size has a positive impact on corporate liquidity for both EMU and non-EMU firms. I find net working capital to be a substitute for corporate liquidity for the non-EMU firms. The significant negative coefficient for the corresponding D_{EMU} interaction variable suggests that net working capital is more substitutable for cash in EMU than in non-EMU countries. This suggests that the establishment of the EMU has strengthened the substitution effect of net working capital for the EMU firms, i.e., their net working capital can be more readily converted into cash for reasons related to the formation of the monetary union.

Cash flow has a positive impact on corporate liquidity for the non-EMU firms. The coefficient for the corresponding interaction variable for EMU firms is significantly negative. If I sum up the coefficient for cash flow and its corresponding interaction variable, I still obtain positive coefficient for cash flow in the first two models but slightly negative in the third model. The reduction in the sensitivity to cash flow suggests that EMU firms have a weaker precautionary motive for holding cash. In other words, the EMU firms keep relatively less cash as compared to the non-EMU firms in response to an increase in cash flow.

The coefficient for capital expenditure is significantly negative in all models, consistent with the findings of previous research. I had also observed significantly

negative coefficient for this variable all through Tables 3, 4 and 5. All this suggests that investment opportunities as proxied by capital expenditure have a negative effect on corporate liquidity. In addition, compared to market-to-book ratio, capital expenditure appears to be a better proxy for investment opportunities because its effect on corporate liquidity is not subject to the model specifications in my study. After controlling for other corporate governance variables, the negative effect of investment opportunities on corporate liquidity suggests that the management tends to hold more cash in response to poor investment opportunities. This observation is consistent with the prediction of the agency theory.

The effect of leverage is significantly negative for the non-EMU firms. Given the significant negative effect of its corresponding interaction variable, establishing the EMU appears to strengthen the substitution effect between debt and cash for the EMU firms. This may be due to or signal an enhanced integration of capital markets in the EMU countries. Overall, my results show that cash and debt are substitutes. In fact, given that cash and debt are primary financing sources for investments, factors affecting debt should affect cash in an opposite way. As pointed out by Opler et al. (1999), "variables that make debt costly for a firm are variables that make cash advantageous". Firms with higher investment opportunities (as proxied by market-to-book ratio) should have lower debt financing cost and thus borrow more (Myers 1977; Chen and Zhao 2005). According to the above reasoning, the positive relationship between investment opportunities and leverage implies a negative relationship between investment opportunities and cash, which is generally what I observe in Tables 3 through 6.

Regarding dividend, I observe a significantly negative coefficient for all firms. The observed inverse relationship between dividend and corporate liquidity supports the notion that less financially constrained firms, i.e., firms paying higher dividend, hold less cash (Almeida et al. 2004).

Moving from the basic model 1 to the next two models, which include other corporate governance variables, I observe some interesting results. During the transition to the monetary union, non-EMU firms had a positive impact of shareholder rights on corporate liquidity. The D_{EMU} interaction variable for shareholder rights has a significant negative coefficient in both models 2 and 3. As a result, the net effect of shareholder rights for EMU firms is negative and consistent with results in Table 7. The opposite effect of shareholder rights on cash holdings of EMU and non-EMU firms suggests that shareholder rights are an inconsistent determinant of corporate liquidity. On the other hand, creditor rights have a negative impact on corporate liquidity for non-EMU firms. The effect of the corresponding interaction variable is positive in both models. However, if I sum up these two coefficients in each model, the net result is still negative, meaning that EMU firms see a negative but weaker effect of creditor rights on corporate liquidity for non-EMU firms. The net effect of creditor rights on corporate liquidity for both groups of firms is negative. Lastly, I continue to observe a non-linear relationship between insider ownership and corporate liquidity.

In summary, my results corroborate the importance of country-specific corporate governance variables (i.e., key factors affecting agency costs) in determining corporate liquidity. The observation of a consistently negative impact of creditor rights on cash

holdings for all countries (as opposed to shareholder rights) suggests that creditor rights play a more dominant role in determining corporate cash holdings. In addition, the fact that I observe a consistent negative effect of creditor rights as opposed to an inconsistent effect of shareholder rights on corporate liquidity reiterates the fact that cash and debt are closer in terms of substitutability than cash and equity. Hence, ignoring creditor rights and focusing on shareholder rights, as is common in existing literature on multi-country corporate liquidity, is inappropriate.

The observation of a significant negative coefficient for the EMU dummy in Table 9, revealing that in multivariate setting, the transition to a monetary union is associated with a significant reduction in corporate liquidity in the EMU firms than in non-EMU firms. This may be a positive sign for those countries that have joined the monetary union and adopted a common currency. If other factors that affect corporate liquidity are losing their impact over time, corporate liquidity may fall eventually in these EMU firms due to all measures taken along with the establishment of EMU and the adoption of a common currency. In addition, from the results associated with interaction variables involving the EMU dummy, it appears that for EMU firms, cash and debt are more substitutable, and so are cash and net working capital. The precautionary motive for holding cash has become weaker for the EMU firms than for non-EMU firms.

My finding of a nonlinear relationship between cash holdings and ownership are consistent with the agency theory explanation. Corporate liquidity falls as insider ownership rises when the ownership is low. However, beyond a point, corporate cash holdings start rising as insider ownership increases and the management become more

entrenched.[76] Finally, past corporate liquidity appears to enter the managerial decision-making about cash management given that the coefficient on the lag of corporate liquidity is significantly different from zero in Tables 8 through 10. This suggests that liquidity adjustment is costly and immediate adjustment is not possible, suggesting the need to include the lagged corporate liquidity variable as a determinant of corporate liquidity in future studies.

3. Theoretical Implications

As was noted earlier, it is difficult to make unambiguous statements about which of the three theories (i.e., tradeoff, financing hierarchy and agency) best explains corporate liquidity, as they do not lead to mutually exclusive predictions. Not withstanding this, my results do shed more light on this issue. The observation that creditor rights and shareholder rights as well as insider ownership exert influence on corporate liquidity suggests that, corporate liquidity is significantly affected by the agency theory variables. The negative effect of investment opportunities as proxied by market-to-book ratio in some cases and capital expenditure in all cases is in line with the prediction of the agency theory, according to which managers tend to hold more cash when the investment opportunities are poor.

The creation of a monetary union and a common currency has uniquely affected the corporate liquidity of firms in that union. This can be seen from how this economic

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[76] Morck et al. (1988) observe a nonlinear relationship between insider ownership and firm value (instead of corporate liquidity in my paper) and use a similar agency theory explanation for their results.

event has affected corporate liquidity itself as well as the coefficients of its determining factors. I show that introducing the euro has partially reduced corporate liquidity for the EMU firms. This finding can further be explained by the following reasons: One, the immediate result of adopting the common currency is transparency and lower transaction costs, which should make cash and other liquid assets more substitutable and lower the demand for corporate liquidity. Two, capital markets in the EMU countries have become more integrated with the introduction of the euro, which catalyzes other reforms to enhance the capital market integration (Bris et al. 2004; Askari and Chaterjee 2005). It follows that firms should have easier access to capital markets and therefore reduce their tendency to hoard "non-earning" cash. In fact, I also find that EMU strengthened the negative effects of net working capital and debt during the entire period 1993-2002, suggesting higher substitutability between net working capital and cash and lower demand for cash as a financing source for "liquidity shortfalls" of the EMU firms in the entire test period. Additionally, EMU weakens the precautionary motive for holding cash given that EMU has a negative effect on sensitivity of corporate liquidity to cash flow.

G. Conclusion

Many determinants of corporate liquidity have been identified in the literature. More recently, shareholder rights have been shown to affect corporate liquidity. I argue that since cash is closer to debt than equity, creditor rights should also affect cash holdings. My results suggest that country-specific corporate governance variables, in particular, creditor rights, play an important role in explaining corporate liquidity. Creditor rights

have a consistent negative impact on corporate liquidity for all 15 EU countries analyzed in this chapter. In contrast, the influence of shareholder rights depends on whether a country belongs to the EMU or not. In light of my results, creditor rights should not be ignored in future international corporate liquidity research. In addition, after controlling for country-specific corporate governance variables, firm-specific characteristics like market-to-book ratio, capital expenditure and insider ownership influence corporate liquidity in a way that supports the agency theory explanation of cash holdings.

The recent formation of the Economic and Monetary Union and adoption of a common currency, considered by many as the most significant innovation in international markets, provided us a unique opportunity to study the effect of such macro changes on firm level data. I find that the adoption of a common currency influences corporate liquidity in many ways. The apparent consequences of the whole harmonization process include reduced transaction costs and more integrated capital markets for the countries participating in the monetary union as compared to the non-EMU countries that chose not to. Indeed, I find that cash and debt are better substitutes for EMU firms, consistent with a more integrated capital markets in the member states. I also provide evidence that net working capital and cash are better substitutes for EMU firms, implying that reduced transaction costs make net working capital more readily convertible into cash for EMU firms than for non-EMU firms. Moreover, the propensity to retain cash from cash flow is lower for EMU firms probably due to easier access to capital markets and thus reduced demand for cash as a financing source for future investments. Further, my results suggest that EMU firms see a potential reduction in

corporate liquidity during the transition to a monetary union and the adoption of a common currency.

Finally, by contrasting the results of OLS with those of the dynamic panel data model, I show that dealing with the endogeneity problem associated with the determinants of corporate liquidity methodologically is important. Unlike previous studies, I observe a negative effect of investment opportunities as proxied by market-to-book ratio on corporate liquidity after accounting for the endogeneity problem. In conjunction with my other results, this finding supports the agency theory explanation of cash holdings. In addition, I show that cash adjustment is costly and an instantaneous adjustment is not likely for all 15 EU countries, suggesting that empirical models for corporate liquidity should include the lag of corporate liquidity as a determinant.

CHAPTER IV

CONCLUSION

The establishment of Economic and Monetary Union (EMU) culminating in the adoption of the euro has received much global attention in international finance. This dissertation studies the potential effects of this macro change on purchasing power parity (PPP) and corporate cash holdings.

The second chapter studies the euro and PPP, providing stronger evidence in favor of PPP compared to previous studies. Unlike results of previous studies, I find that PPP holds better between currency blocs than within a currency bloc. However, I obtain little evidence supporting PPP and price convergence in most EMU countries since the adoption of the euro. My results show that the euro area may not be an optimum currency area as claimed by some researchers and policy makers. The Maastricht Treaty required member countries to converge in monetary and fiscal policies prior to the euro. However, will this convergence continue after the euro's adoption? Some member countries are likely to deviate from the convergence criteria because they have excessive budget deficits, which can result in inflation that exceeds the target level. In addition, cross-border barriers such as labor immobility (sometimes due to regional cultural ties) prevalent in Europe can hinder economic integration as well. These problems may partially explain why PPP performance has not improved after the adoption of a common currency. Compared to previous experiments with the floating-rate and target-

zone arrangement regimes, the common currency regime does not appear to be as successful in converging prices based upon my empirical evidence. My results suggest the importance of floating exchange rates despite the volatility inherent in them.

My findings suggest the need for further dismantling of barriers as well as more disciplined and harmonized policy implementation by the EMU governments. However, diverging market practices rooted in national traditions and historical experiences could also be contributing factors that require passage of time for the market to lose its memory. On the other hand, for a few EMU countries where PPP holds after the adoption of the euro, the speed of adjustment shows remarkable improvement, suggesting that perhaps the EMU economies' price formation process is in transition. While it is clear that since the advent of a common currency, PPP performance has not improved, there are signs that after the transition stage, what may emerge is a more resilient and efficient market than before the monetary union. Nevertheless, this is only possible if benefits of dismantled barriers, policy convergence, monetary and fiscal discipline, exchange rate risk elimination, reduced transaction costs and economic integration outweigh the benefits of a floating-rate regime.

Chapter III examines the effects of corporate governance and monetary union on corporate liquidity. Many determinants of corporate liquidity have been identified in the literature. More recently, shareholder rights have been shown to affect corporate liquidity. I argue that since cash is closer to debt than equity, creditor rights should also affect cash holdings. My results suggest that country-specific corporate governance variables, in particular, creditor rights, play an important role in explaining corporate

liquidity. Creditor rights have a consistent negative impact on corporate liquidity for all 15 EU countries analyzed in this chapter. In contrast, the influence of shareholder rights depends on whether a country belongs to the EMU or not. In light of my results, creditor rights should not be ignored in future international corporate liquidity research. In addition, after controlling for country-specific corporate governance variables, firm-specific characteristics like market-to-book ratio, capital expenditure and insider ownership influence corporate liquidity in a way that supports the agency theory explanation of cash holdings.

The recent formation of the Economic and Monetary Union (EMU) and adoption of a common currency provided us a unique opportunity to study the effect of such macro changes on firm level data. I find that the adoption of a common currency influences corporate liquidity in the following ways. The apparent consequences of the whole harmonization process include reduced transaction costs and more integrated capital markets for the countries participating in the monetary union as compared to the non-EMU countries that chose not to. Indeed, I find that cash and debt are better substitutes for EMU firms, consistent with a more integrated capital markets in the member states. I also provide evidence that net working capital and cash are better substitutes for EMU firms, implying that reduced transaction costs make net working capital more readily convertible into cash for EMU firms than for non-EMU firms. Moreover, the propensity to retain cash from cash flow is lower for EMU firms probably due to easier access to capital markets and thus reduced demand for cash as a financing source for future investments. Further, my results suggest that EMU firms see a potential

reduction in corporate liquidity during the transition to a monetary union and the adoption of a common currency.

Finally, by contrasting the results of OLS with those of the dynamic panel data model, I show that dealing with the endogeneity problem associated with the determinants of corporate liquidity methodologically is important. Unlike previous studies, I observe a negative effect of investment opportunities as proxied by market-to-book ratio on corporate liquidity after accounting for the endogeneity problem. In conjunction with my other results, this finding supports the agency theory view of corporate cash holdings. In addition, I show that cash adjustment is costly and an instantaneous adjustment is not likely for all 15 EU countries, suggesting that empirical models for corporate liquidity should include the lag of corporate liquidity as a determinant.

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APPENDIX A

CRITICAL VALUES FOR PPP

Simulation Model: $d_{i,t} = \alpha_i + d_{i,t-1} + u_{i,t}$

(A) Critical values for PPP used in Table 1

	1973:1-1979:3			1979:4-1998:4			1998:5-2004:1		
Country	1%	5%	10%	1%	5%	10%	1%	5%	10%
Austria	-5.495	-4.626	-4.152	-5.743	-4.773	-4.225	-5.845	-4.724	-4.250
Belgium	-9.267	-7.760	-6.974	-9.702	-8.026	-7.201	-6.220	-5.270	-4.626
Finland	-2.984	-2.419	-2.091	-1.529	-1.246	-1.117	-4.570	-3.804	-3.347
France	-2.312	-1.909	-1.695	-3.038	-2.510	-2.252	-6.216	-5.053	-4.473
Germany	-4.864	-4.020	-3.591	-6.153	-5.044	-4.498	-4.768	-3.904	-3.454
Greece	-1.429	-1.165	-1.014	-1.638	-1.307	-1.134	-1.176	-0.852	-0.657
Ireland	-2.787	-2.298	-2.003	-2.038	-1.655	-1.475	-4.270	-3.488	-3.110
Italy	-2.028	-1.626	-1.409	-1.869	-1.544	-1.354	-6.710	-5.664	-5.083
Luxembourg	-9.397	-7.665	-6.890	-9.983	-8.274	-7.370	-3.619	-2.843	-2.482
Netherlands	-4.053	-3.319	-2.868	-1.362	-1.095	-0.955	-3.635	-2.890	-2.518
Portugal	-1.456	-1.151	-1.011	-1.920	-1.522	-1.335	-3.981	-3.106	-2.679
Spain	-1.511	-1.213	-1.071	-2.129	-1.705	-1.486	-3.786	-3.028	-2.678
Canada	-2.376	-1.950	-1.743	-1.875	-1.562	-1.382	-1.537	-1.140	-0.964
Japan	-1.622	-1.317	-1.147	-0.984	-0.806	-0.711	-1.521	-1.157	-0.906
Switzerland	-2.734	-2.072	-1.784	-2.583	-2.053	-1.797	-2.000	-1.571	-1.334
UK	-3.110	-2.577	-2.323	-1.548	-1.232	-1.074	-1.569	-1.213	-1.012

(B) Critical values for PPP used in Table 2

	1973:1-1979:3			1979:4-1998:4			1998:5-2004:1		
Country	1%	5%	10%	1%	5%	10%	1%	5%	10%
Austria	-4.719	-3.959	-3.585	-5.041	-4.084	-3.619	-6.074	-5.091	-4.562
Belgium	-9.407	-7.856	-7.090	-10.445	-8.571	-7.643	-5.474	-4.552	-4.046
Finland	-2.975	-2.416	-2.122	-1.652	-1.351	-1.189	-4.798	-3.908	-3.496
France	-2.132	-1.753	-1.573	-3.155	-2.627	-2.349	-5.840	-4.785	-4.300
Greece	-1.554	-1.246	-1.076	-1.406	-1.116	-0.991	-2.571	-1.925	-1.561
Ireland	-2.912	-2.369	-2.066	-2.087	-1.734	-1.525	-4.264	-3.456	-3.033
Italy	-2.192	-1.769	-1.548	-1.905	-1.581	-1.392	-7.670	-6.418	-5.705
Luxembourg	-9.444	-7.717	-6.959	-10.328	-8.595	-7.678	-2.594	-2.099	-1.818
Netherlands	-4.132	-3.273	-2.856	-1.286	-1.061	-0.928	-3.602	-2.936	-2.562
Portugal	-1.620	-1.291	-1.101	-1.959	-1.585	-1.403	-3.973	-3.272	-2.852
Spain	-1.795	-1.427	-1.207	-2.242	-1.808	-1.586	-4.017	-3.275	-2.879
Canada	-3.456	-2.866	-2.527	-2.535	-2.132	-1.901	-1.936	-1.487	-1.212
Japan	-1.681	-1.357	-1.174	-1.107	-0.892	-0.785	-1.193	-0.879	-0.723
Switzerland	-2.556	-2.002	-1.705	-2.489	-2.023	-1.751	-3.298	-2.529	-2.130
UK	-3.045	-2.520	-2.264	-1.618	-1.321	-1.157	-1.530	-1.146	-0.953
US	-3.904	-3.242	-2.886	-2.631	-2.157	-1.921	-2.019	-1.605	-1.348

Notes: Statistics are defined as $t = \dfrac{\hat{\beta}_i - 1}{se(\hat{\beta}_i)}$, which was derived using the approach similar to Abuaf and Jorion (1990). With the Frisch-Waugh-Lovell (FWL) theorem (Baltagi 1998), I were able to generate $\hat{\beta}_i$ without imposing the value of α. The number of iterations is 5000. The one-sided critical values were generated at 1%, 5%, and 10 % levels based on the empirical distribution of t-test statistics.

APPENDIX B

SUMMARY OF THEORETICAL PREDICTIONS[77]

Variable	Theory		
	Tradeoff	Financing hierarchy	Agency
Investment opportunities	+	+	-
Size	-	+	+
Liquid asset substitutes	-		
Profitability	-	+	
Leverage	+/-	-	-
Dividend payout	-		
Investor protection			-
Insider ownership			-
Insider ownership squared			+

[77] The blank indicates that the theory fails to predict the effect.

APPENDIX C

THEORETICAL MODEL

I assume that firms hold cash as a buffer to replenish a shortage of operating cash flow. In a given period, I assume that each firm, *i*, receives a cash flow distributed uniformly with upper, and lower bounds, *M* and *–M*.[78] The management of each firm holds precautionary cash with an opportunity cost of r_1. Since income is taxed at the rate τ, the after tax opportunity cost is $r_1(1-\tau) = r_1^{\tau}$. Next, each firm has a threshold cash flow *F*, which is the least amount that a firm requires to service the suppliers of capital.[79] If the firm receives cash flow less than *F*, it might be able to use the cash withheld to pay for the shortage of cash flow. However, if the amount of cash withheld is not enough to cover the shortage of cash flow, firms must turn to capital markets to meet their operational needs and incur a cost r_2. Since interest is tax (τ) deductible, the after-tax cost of capital (r_2^{τ}) is a function of tax rate and leverage:

$$r_2^{\tau} = l \cdot k_d(1-\tau) + (1-l) \cdot k_e = r_2(l,\tau),$$

where *l* stands for leverage (i.e., the ratio of debt to total assets) $(l \in (0,1))$, k_d denotes cost of debt and k_e denotes cost of equity (Brealey and Myers 2003). Before each period starts, there are three scenarios facing a firm holding the amount of cash *C*.

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[78] This is a result of normalization so that on average each firm's normalized operating cash flow (cash flow hereafter) is zero. Baum et al. (2004) follows a similar procedure.

[79] If realized cash flow exceeds *F*, we assume firms return the extra amount to the investors.

First, realized cash flow is higher than *F*, so the cost borne by the firm is the opportunity cost of holding cash, $cost_1 = C_i r_1^{\tau}$ with probability $p_1 = \frac{M-t}{2M}$.

Second, realized cash flow is lower than *F* and the cash withheld is enough to cover cash flow shortage. In this case, in addition to the opportunity cost of holding cash, the firm incurs replenishing cost. The cost for this scenario is

$cost_2 = C_i r_1^{\tau} + \frac{C_i}{2}$ with probability $p_2 = \frac{C_i}{2M}$.

Third, realized cash flow is lower than *F*, and the cash held is not enough to cover the shortage of cash flow. It follows that the firm must borrow money from capital markets at a cost r_2^{τ}. The total cost for this scenario is

$cost_3 = C_i r_1^{\tau} + C_i + \frac{M+t-C_i}{2} \cdot (1 + r_2^{\tau})$ with probability $p_3 = \frac{M+t-C_i}{2M}$.

Therefore, before a given period starts, the management of the firm desires to minimize the expected total cost of holding cash,

$$
\begin{aligned}
&E(cost) \\
&= p_1 \cdot cost_1 + p_2 \cdot cost_2 + p_3 \cdot cost_3 \\
&= \frac{M-t}{2M} \cdot C_i r_1^{\tau} + \frac{C_i}{2M} \cdot \left(C_i r_1^{\tau} + \frac{C_i}{2} \right) \\
&+ \frac{M+t-C_i}{2M} \cdot \left[C_i r_1^{\tau} + C_i + \frac{M+t-C_i}{2} \cdot (1 + r_2^{\tau}) \right]
\end{aligned} \tag{1}
$$

Taking the first order condition, I derive the equation for the optimal cash,

$$C_i^* = \frac{-2Mr_1^{\tau}}{r_2^{\tau}} + (M+t) \ . \tag{3}$$

The following are relevant comparative statics derived from equation (3):

$$\frac{\partial C_i^*}{\partial r_1^\tau} = -\frac{2M}{r_2^\tau} < 0\,; \tag{4}$$

$$\frac{\partial C_i^*}{\partial r_2^\tau} = \frac{2Mr_1^\tau}{r_2^{\tau 2}} > 0\,. \tag{5}$$

From equation (4), I observe that optimal corporate liquidity goes down as the opportunity cost (r_1^τ) of holding cash goes up. Results from equation (5) imply that optimal corporate liquidity goes up as the cost of raising capital (r_2^τ) rises.

Assume that r_1 and r_2 are functions of economic variables:

$$r_1 = f(X_1)\,;\; r_2 = g(X_2)\,,$$

where X_1 denotes a vector of variables that affect r_1 while X_2 denotes a vector of variables that affect r_2; both X_1 and X_2 represent determinants of corporate liquidity. Since my test period incorporates a potential structural change (creation of EMU and introduction of euro), I introduce a dummy variable (d) to capture the effect of a structural change (like elimination of currency conversion costs and exchange rate risk associated with within-EMU transactions, enhanced market integration, etc.) on corporate liquidity and sensitivity of corporate liquidity to its determinants. Hence, the ideal function for optimal cash holdings should take the following form:

$$C_i = h(r_1^\tau, r_2^\tau, d) = h(f(X_1, \tau), g(X_2, \tau), d) = h(X_1, X_2, \tau, d)\,, \tag{6}$$

where *d* takes on 0 if the year is pre euro (1993-1997) and 1 for euro year (1998-2002).[80]

In summary, my model has the feature of the tradeoff theory in the sense that I derive the optimal cash holdings by minimizing the expected total cost of holding cash. In addition, by assuming that the management uses cash first to replenish cash flow shortage, and only then raises funds from capital markets in the form of debt, only when running short of cash flow, my model also contains features of the financing hierarchy theory.

Empirically, researchers do not use opportunity cost (r_1) and cost of capital (r_2) directly as determinants of corporate liquidity. Instead, they use various variables such as market-to-book ratio, total assets, net working capital, cash flow, capital expenditure, leverage and dividend payouts as determinants of latent variables r_1 and r_2 and therefore empirical proxies for corporate liquidity, to shed light on the validity of the three theories mentioned earlier. I follow the same procedure by including those determinants as well as new ones in my estimation model.

---

[80] Determinants of corporate liquidity, X_1 and X_2, depend on the dummy *d*. As discussed later, we created interaction variables by multiplying determinants by *d* to capture the effect of the euro on the sensitivity of corporate liquidity to its determinants.

APPENDIX D

DESCRIPTION OF RAW DATA FROM COMPACT D WORLDSCOPE

Variable	*Worldscope Definition*
Capital expenditures % total assets (Kexp)	Additions to fixed assets/total assets*100
Cash (000s) (CH)	Money available for use in the normal operations of the company; the most liquid assets in a company; including cash on hand, undeposited checks, cash in banks, checks in transit, cash in escrow, restricted cash, money orders, letters of credit, demand deposits (non-interest bearing), mortgage bond proceeds held in escrow, drafts, post office checking/GIRO accounts, post office savings accounts, central bank deposits, bullion, bullion in transit, cashiers checks, credit card sales.
Common equity ($000s) (CE)	Common equity*fiscal year end exchange rate of the country the company is domiciled in (US$)
Depreciation and amortization (000s) (DA)	Depreciation represents the process of allocating the cost of depreciable assets to the accounting periods covered during its expected useful life to a business. Amortization relates to cost allocation for intangible assets such as patents and leasehold improvements, trademarks, bookplates, tools and film cost.
Dividend payout (% earnings) – total dollar (Div)	Common dividends (cash)/(net income before preferred dividends-preferred dividend requirement)*100
Earnings before interest and taxes (000s) (EBIT)	Earnings of a company before interest expense and income taxes
Income taxes (000s) (IT)	All income taxes levied on the income of a company by federal, state and foreign governments
Interest expense on debt (000s) (IE)	Service charge for the use of capital before the reduction for interest capitalized
Market capitalization ($000s) (MC)	Total market value of the company based on year end price and number of shares outstanding converted to US dollars using the year end exchange rate
Net income (000s) (NI)	Income after all operating and non-operating income and expense, reserves, income taxes, minority interest and extraordinary items
Net property, plant and equipment (FA)	Gross property, plant and equipment less accumulated reserves for depreciation, depletion and amortization
Total assets ($000s) (TA_USD)	Total assets of the company converted to US dollars using the fiscal year end exchange rate
Total assets (000s) (TA)	Sum of total current assets, long term receivables, investment in unconsolidated subsidiaries, other investments, net property plant and equipment and other assets
Total current assets (000s) (TCA)	Cash and other assets that are reasonably expected to be realized in cash, sold or consumed within one year or one operating cycle
Total current liabilities (000s) (TCL)	Debt or other obligations that the company expects to satisfy within one year
Total debt % total assets (Lev)	(short term debt & current portion of long term debt + long term debt)/total assets*100

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