



Department of Economics  
Lund University, Sweden

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Author: Daniel Ekeblom  
Instructor: Kristian Jönsson

## What is the Probability of a Recession in the United States?

## SUMMARY

The goal of this thesis is to answer the question *what is the probability that the U.S. economy will experience a recession and a concomitant financial crisis in the near future*. The question is answered through the use of a probit model, in which five explanatory variables, derived from previous research, are processed. The variables are Current Account to GDP, NYSE Composite Index, Domestic Credit, Domestic Investments, and the Yield Interest Rate Spread, where the three latter variables turn out to be statistically significant. The assumptions of heteroskedasticity and of normality are tested for in the model and cannot be rejected at any level of significance. The final model is fairly theory consistent.

The future probability of a recession is explored in three different scenarios, which comprise a partial analysis, a parallel to the 1987 Current Account reversal and a speculative future scenario with heavy inflationary pressures. The main conclusion is that the U.S. economy has begun some sort of adaptation to lower expectations of future real growth although it cannot be concluded that there exists an impending threat of recession. In fact, the economy appears surprisingly stable although the influence of foreign factors on the domestic probability of a recession cannot be estimated within the elaborated framework. The probability of a future financial crisis cannot be predicted based on the available theory and accessible data, nor can the point in time of a recession be determined.

**Keywords:** United States; Current Account reversal; Probit; U.S. recession; Inflation.

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# 1 Introduction

A concern for the state of the U.S. economy and implicitly the world economy has steadily been growing for some time. This concern originates from the financial predicament of the U.S. economy, i.e. the U.S. dependence on foreign capital to notably fuel domestic consumption. Opinions have been raised that the U.S. investment relationship with the rest of the world is likely to be untenable (IMF 2002; Mann 2002). The Current Account deficit amounts to approximately 6% of GDP on an annual basis and the net international investment position deficit is equivalent to approximately a quarter of the U.S. GDP (Bureau of Economic Analysis, 2006). In addition to this perceived predicament the U.S. experience low private savings rates and a budget deficit that probably will exceed at least 10% of GDP over the future 50 years (Congressional Budget Office, 2003). The situation is alleged to be – or soon to be – dire, based on various degrees of indications for the U.S. whose domestic consumption far outweighs domestic production.

The opinions mirroring a general outlook for the U.S. economy, and causing the debate, can be summarized by Levey and Brown (2005). The accumulation of foreign debt is unsustainable in the long term. At a certain point, i.e. when total net foreign liabilities have reached such a level that foreign investors are reluctant to invest further in the U.S. economy due to altered expectations on future earnings, the process of accumulating debt has to reverse. The reversal of the U.S. debt accumulation and consequently the Current Account deficit would, in an implausible scenario according to Levey and Brown (2005, p. 2), “*set off a panic, causing the dollar to tank, interest rates to skyrocket, and the U.S. economy to descend into crisis, dragging the rest of the world down with it*”. The purpose of the debate can be said to clarify whether such a scenario is probable and if so, to pinpoint the date when these events will occur. In the light of recent discussion, I pose the question *what is the probability that the U.S. economy will experience a recession and a concomitant financial crisis in the near future?*

In the second chapter I will account for previous research and the nature of the matter. The following subjects will be treated in two subchapters: the sustainability of the Current Account deficit and the closely related importance of the net international investment position; the nature of and the occurrence of financial crises and likely causes. The third chapter contains a presentation of the theory and the probit model elaborated in order to assist in answering the question. An account of the data motivated by previous research and a testing strategy of the model is also presented in the chapter. The fourth chapter accounts for

the results of the computation of the final model. Coefficients, significances, and marginal effects of the explanatory variables will be presented along with the measure-of-fit. In the fifth chapter the model is applied to various scenarios in order to explore the probability of recession for the U.S. economy. A conclusion will follow in the sixth chapter where I basically state that the probability for a U.S. recession is rather low under accompanying assumptions. A subchapter suggests interesting aspects which may make up future research.

## 2 Previous Research

The problem as formulated by Levey and Brown (2005) consists of two parts. First of all, the main sources of concern for the state of the U.S. economy would be the negative Net International Investment Position (from now on referred to as the NIIP) and the Current Account deficit, which are intimately interdependent<sup>1</sup>. Secondly, a chain of events that would supposedly lead to a situation where the “*Sudden unwillingness by investors abroad to continue adding to their already large dollar assets, in this scenario, would set off a panic,...*” (Levey, Brown, 2005 p. 2).

The concerns that a possibility for domestic imbalances exist in U.S. fundamentals are not new and previous research has dealt with these issues in numerous ways. In order to establish previous findings, conventional accords and disputes, I will account for the various positions on the U.S. Current Account deficit and the U.S. NIIP in subchapter 2.1. The recapitulation is supposed to shed light on the premier part of the issue with respect to the probability of a future recession. Secondly, I will make an account of previous research on financial crises in subchapter 2.2 in order to hopefully complete the composition of the entire issue. The chapter on Previous Research is deliberately concise because it spans a very large subject. It is purely intended to supply the reader of an orientation from which further inquiries may be made.

### 2.1 The U.S. Current Account and the U.S. NIIP

The issue of a sustainable Current Account deficit thus includes the aspect of a manageable NIIP<sup>2</sup>. The definition of sustainable Current Account deficit is well characterized by Mann (2002, p. 143): “...*the external imbalance generates no economic forces that change its trajectory*”. When the Current Account deficit is large it indicates a growing negative NIIP. If the financial costs – interest and dividends – sustaining the negative NIIP become

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<sup>1</sup> A negative NIIP implies that the U.S. is left with net foreign liabilities when U.S. assets possessed by foreigners (external liabilities) have been deducted from foreign assets owned by U.S. residents (external assets). The Current Account is correlated to the NIIP in the sense that a Current Account deficit implies a capital account surplus by definition, which in turn signifies that U.S. residents are either selling of U.S. assets to foreigners – implicitly reducing external assets - or borrowing foreign capital i.e. accumulating external liabilities.

<sup>2</sup> For a more elaborate description of different perspectives on the US Current Account deficit, see Mann (2002).

sufficiently large they will eventually cut into current consumption and investments, consequently reducing growth and making the present level unsustainable (Mann, 2002). However, a large negative NIIP does not have to be an ominous signal. The accumulation of foreign liabilities would not be possible if it were not for other countries' confidence in the U.S. economy (Cooper, 2001).

A large Current Account deficit does not necessarily result in a deteriorating NIIP over time. If the inflow of foreign capital generates productivity growth it will also increase the long term GDP growth. It is possible that a higher growth of real GDP facilitates the upholding of a negative NIIP without considerably affecting current consumption and investments (Miles-Ferreti, Razin, 1996). To establish a feasible level of foreign investments in the U.S. economy that global investors are ready to support is nonetheless hard based on the share of U.S. assets in the global investor's portfolio (Meade, Thomas, 1993; Ventura, 2001), and perhaps even inadequate as a measure of sustainability for that matter.

Some voices have suggested that the Current Account is misleading as a measure of the evolution of the NIIP. Obstfeld (2004, p. 564) claims that "*National portfolios are increasingly leveraged through the trade of claims on the home country for claims on foreigners, trades that need not entail any change in national wealth at the point securities change hands*". The real exchange of wealth could occur at some point later in time, after the switch of financial assets has taken place. The exchange of securities remains a formal accounting procedure, not necessarily analogous to an exchange of real values. Further, Obstfeld (2004) argues that attempts to exploit the Current Account-to-NIIP nexus by running increasingly larger deficits in order to instigate a Current Account reversal might result in a collapse of whatever statistical regularity that has existed in the past. It is basically the Lucas-critique<sup>3</sup> applied to another context.

The U.S. NIIP may fluctuate with changes in the value of the present external assets and liabilities due to volatility in asset prices or exchange rates, which may cause an exaggerated concern for the state of the U.S. economy (Tille, 2003). In 2001, the U.S. net international debt leaped to approximately \$2.3 trillion, from half the level recorded in 1999. The increase reflected the additional borrowing undertaken by the U.S. to finance the rising Current Account deficit. Nevertheless, a third of the change was traced to the effect of a rising dollar on the value of U.S. external assets. Although being purely nominal adjustments in the U.S. NIIP, they do not prevent the occurrence of real effects on economic activity if unknown to

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<sup>3</sup> See Lucas (1976) for an exposition.

the public (Barro, 1976). In the case where the market does not have complete information on the matter, future expectations will be conceived on false grounds and the purely nominal adjustments will result in real effects.

Furthermore, the Euro was introduced in 1999 and this event altered the financial conditions for the U.S. economy. The lack of integration of the European financial markets made it more costly for international investors to obtain European exposure in the matter of risk management. The slower growth in the euro area most certainly added to the unwillingness of investors to hold the euro. Consequently, capital inflows to Europe were lower than they otherwise might be, and these events prevented the euro from appreciating even further *via-a-vis* the dollar (BIS, 2002; IMF 2001).

Empirical findings strongly suggest that the U.S. income elasticity for imports of goods and services is significantly greater than the foreign income elasticity for U.S. exports of goods and services. These findings are consistent over different periods, data, and econometric techniques (Houthakker, Magee, 1969; Cline, 1989; Hooper, Johnson, Marquez, 1998; Wren-Lewis, Driver, 1998). They also entail a continuously expanding Current Account deficit if the U.S. economy and the rest of the world grow at an equivalent pace, unless the dollar persistently depreciates (Krugman, 1985; Krugman, Baldwin, 1987; Obstfeld, Rogoff, 2000). A study by the IMF (2004) finds nearly identical output growth rates for the U.S. and its export-weighted partners from the 1990s and forth. The dollar has not depreciated as the present state of the Current Account would suggest and the historical trend appreciation most likely mirrors the unrivalled U.S. productivity growth in reference to other major industrialized economies (Marston, 1987; Tille et al, 2001; Alquist, Chinn, 2002).

The 'true' value of the dollar is subject to much controversy. Some proponents claim that a rather abrupt depreciation of the dollar which in turn facilitates the diminution of the Current Account deficit is a likely scenario in the near future. According to Blanchard et al (2005) the dollar is bound to depreciate, but the pace of the depreciation is conditional on the degree of substitutability between U.S. assets and foreign assets. The current slow rate of depreciation thus suggests that assets lack substitutability. Poor development of financial markets in Asia and the need to accumulate international collateral implies an increasing relative demand for U.S. assets. Chinese investors, currently limited by capital controls, constitute a latent demand for U.S. assets, which may further alter the conditions for currency equilibrium when unleashed (Dooley et al, 2004; Caballero et al, 2005).

A seminal analogy to the Bretton Woods system was introduced by Dooley, Folkerts-Landau and Garber in 2003 (Dooley et al, 2003). The appearance of a fixed exchange rate

periphery in Asia (China, Taiwan, HK, Singapore, Japan, Korea, and Malaysia) has once again established the U.S. as the centre in a Bretton-Woods similar international monetary system. The strategy of the Asian countries is to stimulate growth through the exports supported by an undervalued fixed exchange rate and capital controls. The accumulation of reserve assets serve as an increasing financial claim on the centre country, implicitly strengthening the dollar. The economic growth thus allows the periphery to graduate to the centre for an extensive period of time, as the countries of Europe once did under the original Bretton-Woods system.

Albeit relevant for the elucidation of the dollars strength and the U.S. Current Account deficit, the Bretton-Woods analogy constitutes yet another disputed explanation to the emergence of the U.S. Current Account deficit. Even the original Bretton-Woods system was controversial and much criticized. Once again actualized, Triffin's Dilemma stated that if the U.S. seized to run a balance of payments deficit, the international community would lose its largest source of additions to reserves (Triffin, 1960). The ensuing shortage of liquidity could cause instability in the world economy through its contractionary effect. But if the U.S. would continue to fuel world economic growth through its balance of payments deficit, the excessive U.S. deficits would reduce confidence in the value of the dollar, and it would risk being refused as the global reserve currency. Bretton-Woods could break down, leading to instability on a global scale.

Eichengreen (2004) and Roubini and Setser (2005) argue that current state of affairs is not sustainable. There are several reasons for such unravelling of events, but the mutual critique lies in structural differences: the world has changed a great deal the last thirty years and it is simply not possible to talk of a revived Bretton-Woods. Roubini and Setser (2005) also stresses that the sheer size of the U.S. Current Account deficit is intractable. The side effects – such as unsuccessful sterilization operations and a possible loss on investments – of Asian central banks' attempts to fund it will bring about an end of the revived Bretton-Woods. Obstfeld and Rogoff (2004) argue that the current conjuncture of the U.S. economy resembles the early 1970s, when the Bretton Woods system collapsed.

Empirical evidence suggests that the long term Current Account/GDP ratio is statistically stationary (Taylor, 2002). A large Current Account deficit may be expected to decline in comparison to its long term mean, whereas a small Current Account deficit is a candidate for possible growth. Freund (2000) identifies a 5% Current Account/GDP threshold beyond which Current Account reversals typically occur. Main characteristics of a reversal are a significant slowdown in output growth, a 10–20% real depreciation of the domestic

currency, a subsequent increase in real export growth, a decline in Domestic Investments, a small reduction of the budget deficit and some levelling off in the NIIP.

Debelle and Galati (2005) have completed a study of Current Account adjustments in industrialized countries and their findings are in line with previous research. Current Account reversals were typically associated with a sizeable slowdown in domestic growth, investments, and large exchange rate depreciation. These findings are also corroborated by Edwards (2004). Credit growth had a propensity to increase before and to peak one year after the Current Account adjustment. The inflation profile – inflation typically declined by several percentage points – presumably signalled the presence and a following resolution of macroeconomic imbalances. Debelle and Galati (2005) argue that causality is not explained by these types of econometric studies and that the question whether Current Account adjustments are exogenous or endogenous to these development remains unanswered. A plausible explanation of their own is that Current Account reversals in such episodes reveal the expansion and resolution of national economic imbalances.

The multiple perspectives on the Current Account deficit as such reflect the complexity of the matter, and that few conventional positions remain. There is some accord on the size of the U.S. Current Account deficit and the U.S. NIIP: they are unusually large and a probability exists – yet undefined – that they will regress. However, the pace of the reversal is subject to debate. A number of indicators, such as the Current Account to GDP ratio, output growth, exports, domestic investments, and the value of the dollar possibly presage Current Account reversals. But even a relatively large Current Account deficit provides no definite indication of the probability of a reversal, nor of the stability of the domestic economy.

## **2.2 Financial Crises**

Financial crises occur regularly and cyclically (Kindleberger, 1996), and they seldom occur in combination with healthy economic fundamentals (Kaminsky, Reinhart, 1999; Borio, Lowe, 2002). There have been made several definitions of a financial crisis throughout the history of financial research and several key components have been identified, but I favour the somewhat simplistic definition by Bordo et al (2001, p. 55): “...*episodes of financial-market volatility marked by significant problems of illiquidity and insolvency of financial-market participants and/or by official intervention to contain such consequences*”. Bordo et al (2001, p. 55) further divide financial crises into banking crisis – “...*financial distress resulting in the erosion of most or all of aggregate banking system capital*” - and currency crisis – “...*a*

*forced change in parity, abandonment of a pegged exchange rate, or an international rescue”.*

The explanation that financial globalization is a leading cause for the occurrence of currency crises lacks support (Bordo et al, 2001). A lesser frequency of currency crises in the pre-1913 and post-1972 periods, when capital controls were absent and capital mobility prevalent, disputes the view that financial globalization has created instability in foreign exchange markets. Tight regulations of domestic and international capital markets suppressed banking crises almost completely in the 1950s and 1960s, whereas capital controls were deficient in suppressing currency crises. Furthermore, data indicates that currency crises tend to be an emerging-market problem in particular.

Attempts have been made to quantify the loss of a financial crisis. The output loss, calculated as the sum of the differences from the commencement of the crisis to the recovery between pre-crisis trend growth and actual growth, is roughly ten percentage points larger in recessions with crises than in recessions without them both since 1973 and before 1913 (Bordo et al, 2001). The cost of currency crises does not appear to be determined by the domestic budget balance, financial system, or exchange rate regime, but the Current Account deficit does seem to matter. The cost is greater when the Current Account deficit deepens significantly in the preceding period for post-1972 period. Currency crises also become more costly in conjunction with banking-sector problems (Kaminsky, Reinhart, 1999). These calculations might overstate the loss because pre-crisis growth tends to be unsustainably high, making it less appropriate for comparison (Mulder, Rocha, 2000). Furthermore, not all crises identified by Bordo et al (2001) are correlated with loss of output. Since crises often occur in recessions, it could be that computed output losses are merely normal contractionary effects. According to Boyd et al (2005) there is a non negligible possibility that banking crises engender no loss of economic output in highly developed economies. This particular finding renders it supposedly even more difficult to econometrically relate loss of output during financial crises to explanatory variables.

Banking crises tend to correlate with liquidity support for insolvent banks and the nature of the exchange rate regime. The reason for open-ended liquidity support to increase the cost of crises is evident. Public liquidity support to banks that is not conditional on restructuring and recapitalization permit insolvent institutions to opt for gratuitous resurrection. They

facilitate the continued flow of capital to loss-making borrowers and allow owners and managers to engage in stealing company property<sup>4</sup> (Akerlof, Romer, 1993).

Banking crises tend to build up over time and to be the result of deteriorating economic fundamentals (Borio, Lowe, 2002). Banking crises associated with significant loss of output often occur in conjunction with the exposure of several institutions to a number of risk factors. A common scenario in which banking crises occur is an expanding economy with increasing prices on assets such as real estate and equity, where risk is perceived to decline and external financing becomes cheaper. Therefore, the build-up of financial imbalances should be possible to discern in the appreciation of the real exchange rate, capital inflows, and the potential build-up of concomitant foreign exchange mismatches. An important note is that banking crises normally propagates through deteriorating asset quality<sup>5</sup>. Borio and Lowe (2002) identify three core variables which are perceived to indicate the presence of such imbalances: the ratio of private sector credit to GDP, equity prices deflated by the price level, and the real effective exchange rate. To capture the cumulative processes indicating the level of financial distress, they compute the deviations of core variables from a Hodrick-Prescott trend. If the indicators exceed some critical threshold, then financial imbalances are assumed to be emerging and signalling the risk of ensuing financial distress. The variables, i.e. the cumulative deviations from the trend, allow for variable forecasting horizons. A good indicator would consequentially have a low noise-to signal ratio, predicting a high fraction of the crises that occur but not turn on too often implicitly signalling crises that do not materialise. The exchange rate indicator might be more valid in emerging market economies. These tend to rely more on external finance and they often have fixed exchange rate regimes. Borio and Lowe (2002) find that the credit level and asset price combination is a superior indicator to the credit level and exchange rate alternative, and if the equity price gap is included then the exchange rate does not apparently add useful information. Studies on rapid credit growth suggest the higher the growth rate is in a business cycle upswing the more decisive is the contraction in the downswing (Gavin, Hausmann, 1996). Credit escalation is also a reliable indicator of subsequent banking crises (Caprio et al, 1994).

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<sup>4</sup> The behaviour is also a symptom of the Soft Budget Constraint syndrome (Kornai et al, 2003)

<sup>5</sup> This is a partial symptom of a credit crunch where too small a share of equities to detain the consequence of bankruptcy instigates the propagation process. For a further exposition on credit crunches, see (Bernanke, Lowe, 1991; Yuan, Zimmerman, 1999).

Due to the heterogeneous nature of crises it is unlikely that attempts to statistically relate them to fundamentals will have high explanatory power (Eichengreen et al, 1995). This view could be interpreted as if there is a psychological or an unquantifiable component to a crisis. The idea that international capital markets are a source of market discipline is flawed their arbitrary and erratic history (Eichengreen, 2000). A herding behaviour amongst international investors can be rational when information is scarce. Agents then infer information from the actions of other agents and therefore behave similarly (Calvo, Mendoza, 1997). Incomplete, or asymmetric, information is a prerequisite for such a scenario where ill-informed investors infer that a security is of a different quality than previously assumed from the decisions of other investors. They act collectively – by buying or selling -amplifying price movements and precipitating crises. Financial globalization is contributing to herding and thereby financial volatility as the increase in the menu of available assets floods international investors with investment alternatives without necessary complementary information. The result is an increase in tendency for incomplete-information problems. Whether these problems are causal or symptomatic of investors' behaviours is hard to identify. There are examples when international investors who willingly overlook weaknesses in domestic policy environments until they are abruptly revealed cause overreaction and panic amongst creditors, which may result in a disproportionately severe financial crisis for the country (Calvo, Mendoza, 1996).

According to Mishkin (1996b, p. 10) asymmetric information theory define a financial crisis as: “...*a nonlinear disruption to financial markets in which adverse selection and moral hazard problems become much worse, so that financial markets are unable to channel funds efficiently to those who have the most productive investment opportunities*”. In the case of imperfect knowledge of borrower quality, the problem of adverse selection can occur. Incomplete information prevents lenders from evaluating credit quality. As a result, they will pay a single price for a security that reflects the average quality of firms issuing securities. High quality firms above fair market value will refuse to sell securities at the given price but the low quality firms will wish to sell securities because they know that the price of their securities is greater than their value. A biased low credit quality funding will materialize since projects whose net present value is lower than the opportunity cost of funds will be financed. Such liberalized capital markets will not deliver an efficient allocation of resources (Eichengreen et al, 1998).

A relevant phenomenon in leveraged buy-outs amongst other activities is the occurrence of moral hazard. Borrowers wish to invest in relatively risky projects from which they will

prosper if it succeeds but the lender bears most of the loss if it fails, whereas lenders want to limit the riskiness of the project. Moral hazard occurs when the borrowers alter their behaviour after the transaction has taken place, i.e. make even riskier decisions in order to maximize profits. Lenders, anticipating this type of behaviour, will be reluctant to make loans and levels of investment become suboptimal (Eichengreen et al, 1998). Thus the resulting increase in moral hazard and adverse selection implies that lending decreases, producing a decline in investment and aggregate economic activity.

An increase in the risk premium – equivalent to an increase in interest rates – may worsen adverse selection problems for lenders, because the borrowers that are most willing to pay high interest rates are those willing to assume the most risk (Mishkin, 1996b). The resulting increase in moral hazard and adverse selection in the presence of asymmetric information implies that lending goes down, producing a decline in investment and aggregate economic activity. Foreign interest rates also contribute significantly when predicting currency crises, but then mainly in fixed exchange rate regimes (Frankel, Rose, 1996).

The theories of moral hazard and adverse selection have been proven fairly correct by empirical findings (Mishkin, 1996b). U.S. financial crises have to a large extent begun with a rise in interest rates frequently resulting from a rise in interest rates in the London market, a stock market crash, and an increase in uncertainty after the start of a recession. Failures of major financial and non financial firms have also added to the increase in risk premium. The increase in uncertainty, the rise in interest rates, and the stock market crash added to the severity of adverse selection problems in credit markets, whereas the decline in net worth originating from the stock market crash increased moral hazard problems. The increase in spread between interest rates on low and high quality bonds reflecting the increase in adverse selection and moral hazard problems made it less attractive for lenders to lend, resulting in a decline in investment and aggregate economic activity.

Different aspects of financial crisis have been accounted for hitherto, but I would like complement the chapter with a study by Estrella and Mishkin (1998) who have investigated possible indicators of future recessions in the U.S. economy. They used a probit model to quantify the predictive power of the variables examined with respect to future recessions. They found that stock prices and the yield curve in particular were useful. Spreads between rates of different maturities were interpreted as expectations of future rates and stock prices as expected discounted values of future dividend payments. In this manner they incorporate views in terms of the future profitability of the firm and future interest or discounting rates. They let larger spreads and higher stock prices indicate higher levels of future economic

activity and implicitly higher real economic growth. The steepness of the yield curve gives the impression to be a correct forecaster of real activity. They also claim that it is possible for current monetary policy to significantly influence both the yield curve spread and real activity over the next several quarters. An increase in the short rate is likely to flatten the yield curve as well as slowing real growth in the near term.

This chapter represents an abridgement of the plethora of previous research which is meant to account for the main various positions related to the issue of the U.S. Current Account position and the probability of a related crisis. The main findings substantiate the assertion that crisis occur in conjunction with: unhealthy economic fundamentals; large Current Account deficits; recessions and loss of output; fixed exchange rate regimes; credit growth; asset price growth; rise in interest rates; and stock market crashes. There is some dispute over the view that financial globalization provokes herding, financial volatility and hence financial crisis but there is no definite concord.

Although the positions are divided I conclude from the present state of the U.S. Current Account deficit and from previous research that there is a possibility that domestic imbalances in U.S. fundamentals exist. These might be an indication of an elevated threat to the stability of the economy and a related potential domestic crisis and therefore I find it reasonable to search for portentous signs in deteriorating domestic fundamentals. The previously defined indicators will serve as a guideline for further econometric inquiries, except for the real exchange rate indicator. I will apply the framework of a probit model in order to quantify the probability of a domestic recession in the U.S. economy. Along the lines of previous findings, I deem it too difficult to solely predict the future probability of a financial crisis on the basis of historical data. It is precarious to define a crisis as a specific event confined to a specific moment in time. The crisis itself is often marked by a short period of volatile prices and illiquidity, while the repercussions may span several years, and therefore the focus of the probit model will lie on quantifying a probability for a domestic recession and not a domestic financial crisis. However, the probability of an occurrence of a financial crisis cannot be excluded from the probability of recession generated by the model.

### 3 Empirical methodology

Previous research has established a number of indicators to be possible predictors of future domestic recession. I will use these indicators within a probit-framework in order to conceive a model that is capable of predicting future recessions. This in-sample model will serve as a basis for several out-of-sample speculative future scenarios, in which the probability of a recession will be accounted for. In subchapter 3.1 a presentation of the probit-model will follow along with specification issues, out-of-sample characteristics and testing strategy for the probit model. In subchapter 3.2 the dependent and explanatory variables are presented along with their treatment, and excluded variables are also accounted for.

#### 3.1 The Probit Model

I apply a standard probit model in order to quantify the predictive power of the variables examined with respect to a future recession (Verbeek, 2004, p. 190-192). In the probit model, the dependent variable assumes either the value of one or zero — in this context it represents whether the economy is or is not in a recession. The model assumes a linear additive relationship:

$$y_i^* = \beta' x_i + \varepsilon_i .$$

$y_i^*$  is a dependent unobservable variable which determines the occurrence of a recession for observation  $i$ ,  $\varepsilon_i$  is a normally distributed error term,  $\beta$  is a vector of coefficients including a constant, and  $x_i$  is a vector of values of the independent variables,. The observable variable  $y_i$  functions as a recession indicator and it is related to the model by

$$y_i = \begin{cases} 1, & \text{if } y_i^* \text{ is above } 0 \\ 0, & \text{otherwise} \end{cases} .$$

The probit model states the probability that  $y_t$  assumes the value 1 to be

$$P(y_i = 1) = P(y_i^* > 0) = P(\beta' x_i + \varepsilon_i > 0) = P(-\varepsilon_i \leq \beta' x_i) = F(\beta' x_i) .$$

F represents the cumulative normal distribution function<sup>6</sup> of  $-\varepsilon_i$ . The model is estimated by maximum likelihood, with the likelihood function defined as

$$L(\beta) = \prod_{y_i=1} F(\beta' x_i) \prod_{y_i=0} [1 - F(\beta' x_i)].$$

The first order conditions of the likelihood function are nonlinear so obtaining estimates for the coefficients are done through an iterative process.

The respective marginal effects of each explanatory variable in a probit model are interpreted through their partial derivatives given the probability that  $y_i$  equals one:

$$\frac{\partial P(y_i = 1)}{\partial x_{i,k}} = f(-\beta' x_i) \beta_{i,k}$$

$f$  represents the standard normal probability density function and its value depends on all the regressors in  $x$ . The partial derivative, which depends on the slope of the probit function and the size of the parameter  $\beta_i$  shows the effect of an increase in  $x_i$  on  $p$ . The marginal effect of an explanatory variable will assume the sign of the estimated parameter  $\hat{\beta}_i$ , since the probability density function is always positive. Large values of the expression  $-\beta' x_i$  will have a small effect on the probability of recession since the probability density function has low values in the tails, which in turn reflects the low marginal effects the cumulative distribution function has in its tails. Values of  $-\beta' x_i$  such that the probability density function assumes a high value and  $F(\beta' x_i)$  is close to 0.5, has the most impact on the probability of recession. A computed marginal effect is thus only valid in a narrow sample of observations. A computed mean of marginal effects become rather uninformative.

There are other binary choice models which could be applied, such as a linear probability model or a logit model. In the linear probability model the probability is set to either 1 or 0 if the function  $(\beta' x_i)$  exceeds a lower or upper threshold, although it is rarely

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<sup>6</sup>  $F(x) = \int_{-\infty}^x \frac{1}{\sqrt{2\pi}} \exp\left\{-\frac{1}{2}t^2\right\} dt$

used in empirical work. The probit and logit model typically yield very similar results in empirical work, if one corrects for the difference in scaling.

### 3.1.1 Specification Issues

Non-normality or heteroskedasticity of the error terms will cause the likelihood function to be incorrectly specified, which implies that the distributional assumption of  $y_i$  given  $x_i$  is incorrect. In such case, the maximum likelihood estimator will be inconsistent (Verbeek, 2004, p. 200). There is reason to suspect that such circumstances exist since all of the explanatory variables are in some way correlated to the dependent variable. The most obvious case is that the level of investments, an explanatory variable, constitutes an element in the definition of the GDP which is related to the value of the dependent variable. The error terms of the sample are assumed to be normally and independently distributed, with a mean of zero and variance  $\sigma^2$ .

$$\varepsilon_i \sim NID(0, \sigma^2)$$

I will test for normality in the error term which also corresponds to a test for omitted variables. The test is derived from the similar test in Verbeek (2004, p. 201). The test checks the distribution for skewness – i.e. symmetry of the distribution – and excess kurtosis – i.e. the amount of pointedness of the distribution.

$$P(y_i = 1) = F\{\beta' x_i + \gamma_1 (\beta' x_i)^2 + \gamma_2 (\beta' x_i)^3\}$$

In the case where the distribution suffers from skewness,  $\gamma_1$  will not assume a value of zero, whereas if the distribution suffers from kurtosis,  $\gamma_2$  will not assume a value of zero. The test for normality consists of a test of significance where the p-value must be inferior to the significance level  $\alpha$  for the null hypothesis to be rejected.

$$H_{K,0} : \gamma_2 = 0 \quad \text{No Kurtosis}$$

$$H_{K,1} : \gamma_2 \neq 0 \quad \text{Kurtosis}$$

$H_{S,0} : \gamma_1 = 0$  *No Skewness*

$H_{S,1} : \gamma_1 \neq 0$  *Skewness*

Equivalently, when the p-value is superior to any conventional level of significance ( $\alpha$  of 0.0.1, 0.05 0.1) the null hypothesis – i.e. the possibility that  $\gamma_1$  and  $\gamma_2$  have a zero impact on  $P(y_i = 1)$  – cannot be rejected and they are considered to be statistically insignificant.

I will test the final model for heteroskedasticity, although it is not necessary to eliminate for the forecasting capability of the model. If the ML-estimator does not suffer from heteroskedasticity it may be informative to study the estimated coefficients. The test is accounted for in Verbeek (2004, p.200). Assume that the variance of the error term depends on an exogenous variable,  $z_i$ , such that

$$V(\varepsilon_i) = h(z_i' \theta).$$

The variable  $z_i$  is a subset of  $x_i$  since the model describes the probability of  $y_i = 1$  for a given series of  $x_i$ ; the variables determining the variance of the error term should be in this conditioning set as well. In this case,  $z_i$  is equivalent to  $x_i^2$ .  $h$  represents a function of the form  $h > 0$ ,  $h(0) = 1$ , where the derivative is separated from zero,  $h'(0) \neq 0$ . The test hypothesis consists of evaluating the significance of  $\theta$ . If  $\theta$  assumes a value of zero, the function  $h$  assumes a value of 1 and consequently the variance of the error term,  $V(\varepsilon_i)$ , is constant as is the case of homoskedasticity. If the value of  $\theta$  is not equal to zero, the variable  $z_i$  will have an impact on  $V(\varepsilon_i)$  and the case of heteroskedasticity will prevail. The test does not depend on the form of the function  $h$ , only on upon the variables  $z_i$  that affect the variance.

The LM-test<sup>7</sup> consists of an auxiliary linear regression which is computed from a series of ones regressed upon  $\hat{\varepsilon}_i^G \cdot x_i$  and  $(\hat{\varepsilon}_i^G \cdot \hat{\beta}' x_i) z_i$ . To test the null hypothesis, compute the test statistic by taking the uncentred  $R^2$  times  $N$  which is Chi-squared with  $J$  degrees of freedom,  $J$  in this case being the dimension of  $z_i$ .  $\varepsilon_i^G$  is the generalized residual of the probit model and  $z_i$  should not include a constant due to the normalization. If the p-values of the estimated parameters are such that the null hypothesis cannot be rejected at any conventional

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<sup>7</sup> See (Verbeek, 2004, p. 165) for an exposition on LM-tests.

level of significance, they imply that  $\theta$  is not statistically significant for the variance of the error term, and consequently the null of homoskedasticity cannot be rejected.

$H_0 : \theta = 0$  *Homoskedasticity*

$H_1 : \theta \neq 0$  *Heteroskedasticity*

### **3.1.2 Out-of-sample Prediction**

Although the estimator may be biased, it will not pose a serious problem as long as the predictions of the model are satisfactory. The ML estimator cannot be shown to be unbiased for finite samples (Verbeek, 2004, p. 165), but it will be compensated if the model is able to perform well with respect to forecasting recessions in sample. The model is conceived in order to generate out-of-sample predictions of future recessions within a period of up to 12 quarters. The predictions will be based on speculative evolutions of explanatory variables. It is possible to make predictions even further in time, but I have no means of verifying their validity and therefore I arbitrarily settle for 12 quarters, a period representing the near future. The model will inevitably suffer from lower power when predicting future recessions, due to the out-of-sample characteristic. This behaviour may be induced by the fact that the function  $F(\beta' x_t)$ , once estimated in-sample, is no longer produces correct probabilities when applied to the new set of out-of-sample speculative series.

In reference to out-of-sample testing, Killian and Taylor (2003) have stated that out-of-sample testing based on splitting the sample suffers from loss of information and hence lower power in small samples. Consequently, an out-of-sample test performed on half the sample may fail to detect predictability that exists in a population, while the in-sample test of the entire population correctly will detect it. These findings imply that an out-of-sample test based on sample splitting applied to this particular model may be flawed. There is no way of telling whether the power of the prediction is adequate or not when the model is applied to various speculative scenarios.

### 3.1.3 Testing Strategy

The strategy is to test an initial probit model based on all the explanatory variables. In a first sequence of computations, the dependent variable will differ in four initial settings while the explanatory variables remain the same. In the following sequences the model will each time be re-estimated with one explanatory variable less. Thus, in the second sequence seven computations, one explanatory variable excluded in every computation, will be made as there are eight explanatory variables in total. In the third sequence, six computations will be made as one explanatory variable is excluded in each computation from the model with the best measure-of-fit from the second sequence. The goal is to create a final parsimonious model that satisfies the appropriate condition which is comprised of a measure-of-fit indicator.

The measure-of-fit of the regression is derived from a cross-tabulation of actual and predicted outcomes. The table compares correct to incorrect predictions where a correct prediction for a recession ( $y_t = 1$ ) is represented by an estimated value ( $\hat{y}_t$ ) surpassing  $1/2$ . Technically, the estimated probability that  $y_t = 1$  is given by  $F(\hat{\beta}'x_t)$ . It is conventional to predict that  $y_t = 1$  if  $F(\hat{\beta}'x_t) > 1/2$ , and since  $F(0) = 1/2$  for symmetric distributions with a mean of 0, it is equivalent to  $\beta'x_t > 0$ . I will stick to convention and consequently predictions will be made according to following formulas

$$\hat{y}_t = 1 \quad \text{if } \hat{\beta}'x_t > 0$$

$$\hat{y}_t = 0 \quad \text{if } \hat{\beta}'x_t \leq 0$$

		$\hat{y}_t$		
		0	1	Total
$y_t$	0	$n_{00}$	$n_{01}$	$N_0$
	1	$n_{10}$	$n_{11}$	$N_1$
Total		$n_0$	$n_1$	$N$

Table 3.1: Cross-tabulation table of actual and predicted outcomes.

In Table 3.1,  $n_{11}$  denotes the number of times the model predicts a 1 when the actual outcome is 1 (a correct prediction), and  $n_{10}$  denotes the number of times the model erroneously predicts a zero. Likewise,  $n_{01}$  denotes the number of times the model predicts a 1 when the actual

outcome is 0, and  $n_{00}$  denotes the number of times the model predicts a 0 when the actual outcome is 0. The measure-of-fit measure,  $R_p^2$ , is constructed from calculating the mean of the two ratios  $n_{00}/N_0$  and  $n_{11}/N_1$ .

$$R_p^2 = \frac{1}{2} \left( \frac{n_{00}}{N_0} + \frac{n_{11}}{N_1} \right)$$

The regression with the highest measure-of-fit will be deemed to be the most appropriate one for modelling future recessions. The measure-of-fit represents the average amount of correctly predicted in-sample observations.

### 3.2 Data

The series are based on observations from 1982 to 2005 and the estimates are derived from quarterly data as it guarantees compatibility of all series. All economic data has been retrieved from the official websites of the Bureau of Economic Analysis (2006), the Department of Labor (2006), the Federal Reserve (2006), and the NYSE Group (2006). The quality of data is presumed to be fairly valid, the U.S. public authorities being rather transparent. Source references for the constructed variables are accounted for in Appendix A.

Some series have been transformed into logarithmic values such that the parameter denotes relative change instead of absolute change. The rationale for such a transformation is that a relative change in an explanatory variable in reference to a dependent variable is often more informative than a change in the absolute value of the explanatory variable. This is a technique widely applied when calculating elasticities. In a probit model, which uses a dummy as a dependent variable by default, it is not possible to calculate informative elasticities.

The choice of data is motivated by several factors. When performing a probit regression it is preferable to obtain a large number of observations since the maximum likelihood estimator is asymptotically normally distributed. A relatively large sample is required in order to establish the normality of the estimator, which is a key property. The period between 1982 and 2005 spans 96 observations on a quarterly basis. The reason for not going further back in time when choosing a population is motivated by the implementation of monetarism during the early 1980s. Paul Volcker, chairman of the board of governors of the Federal Reserve

system, focused on credibly restraining the supply of liquidity to end the period of ‘great inflation’ (Federal Reserve Bank of Minneapolis, 2006). From then on, the awareness of the hazard of excess liquidity profoundly altered the way monetary policy was conducted on a global scale. Data for the spread series is also not accessible prior to 1982.

### 3.2.1 Dependent Variables

The dependent variable,  $y_{t,i}$ , is set to 1 if the economy is in *recession* in quarter  $t$  and to zero otherwise. Recession, as defined in this context, occurs when real GDP growth for a specific quarter is less than a beforehand defined threshold,  $\tau_i$ . The index  $i$  denotes which of the  $\tau_i$  values the  $y_i$  series refers to. I have chosen four different values of  $\tau_i$  in order to generate  $y_1$ ,  $y_2$ ,  $y_3$ , and  $y_4$ . The real GDP series has been computed from a nominal seasonally adjusted GDP series deflated by a price deflator series, provided by the Bureau of Economic Analysis (2006).

$$y_{t,i} = 1 \quad \text{if } GDP_t^{real} \leq \tau_i$$

For  $y_1$ ,  $\tau_1$  is set to 0, i.e.  $y_{t,1} = 1$  when real GDP growth is less than 0%, and  $y_{t,1} = 0$  when real GDP exhibits positive growth. The threshold is motivated from the classical definition of a recession, according to which an economy experiences loss of output for two consecutive quarters. However, in  $y_1$  a recession date is not conditioned by a consecutive quarter of negative real GDP growth.

In  $y_1$  there are only 7 out of 96 observations that assume a value of 1 and classify as quarterly recession dates. It might be that these observations will not suffice for an initial regression to be meaningful. Therefore, I will increase  $\tau$  in  $y_2$ ,  $y_3$ , and  $y_4$ .  $\tau_i$  is set to 0.0025, 0.0050 and to 0.0079 for  $y_2$ ,  $y_3$ , and  $y_4$  respectively. In  $y_2$  12 out of 96 observations assume a value of 1, in  $y_3$  24 out of 96 observations classify as a 1 and in  $y_4$  44 out of 96 observations assume a value of 1.  $\tau_2$  represents the case where the economy slows

down to an approximate<sup>8</sup> annual real growth rate of 1%,  $\tau_3$  represents an approximate annual real growth rate of 2%, whereas  $\tau_4$  represents the case where the real GDP growth rate is below its mean for the period 1982 to 2005<sup>9</sup>.

### **3.2.2 Explanatory Variables**

The explanatory variables for the initial regression have been chosen from the findings of previous research. An account for the motive and the treatment of each variable will follow under respective subchapter.

#### **3.2.2.1 Asset Price**

Domestic financial imbalances usually arise in conjunction with noticeable asset price growth (Borio, Lowe, 2002). The Asset Price series is intended to reflect the presence of such imbalances and thus be an indicator of a possible financial crisis and/or recession. The seasonally unadjusted data represents the total assets of U.S. households and non profit organizations denominated in million dollars (Federal Reserve, 2006). The series has been deflated by a GDP price deflator series with the base year 2000 (Bureau of Economic Analysis, 2006), and then transformed into logarithmic values.

#### **3.2.2.2 Current Account to GDP**

Current Account reversals are typically associated with a sizeable slowdown in domestic growth and investments (DeBelle, Galati, 2005; Freund, 2000). This observation implies that a growing Current Account deficit correlates to an increase in GDP growth and conversely that a declining Current Account deficit correlates to a decrease in GDP, after the reversal has taken place. The Current Account to GDP series is intended to reflect this behaviour and to be an indicator of a possible recession. The series has been computed from

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<sup>8</sup> The quarterly growth rate of 0.25% represents 1.003% on an annual term due to the compound effect ( $1.0025^4 \approx 1.003$ ). However, I deem the last decimal to have a negligible effect on the outcome.

<sup>9</sup> The growth rate of real GDP for the period 1982q1 to 2005q4 has been computed from the first differences of the log of the real GDP. The mean of the growth rate includes the first difference of 1981q4 to 1982q1 and it is calculated 0.79% per quarter. If the first difference of 1981q4 to 1982q1 is excluded, the mean will be equivalent to 0.81% per quarter.

current prices of both the Current Account and the GDP, where the latter constitutes the denominator of the equation, and it is denoted in percentages (Bureau of Economic Analysis, 2006). Due to the valuation effects of various currencies on the Current Account, real values have not been implemented in the series. The Current Account numerator is computed on a quarterly basis whereas the GDP denominator is computed on an annual basis.

### **3.2.2.3 Domestic Credit**

Credit growth has a propensity to increase before and to peak one year after a Current Account reversal (Debelle, Galati, 2005) and credit escalation is also a reliable indicator of subsequent banking crises (Caprio et al, 1994). The Domestic Credit series is intended to be an indicator of a possible financial crisis and/or recession. The seasonally unadjusted data represents the total consumer credit liability of U.S. households and non profit organizations denominated in million dollars (Federal Reserve, 2006). The series has been deflated by a GDP price deflator series with the base year 2000 (Bureau of Economic Analysis, 2006), and then transformed into logarithmic values.

### **3.2.2.4 Domestic Investments**

Current Account reversals are typically associated with a sizeable slowdown in domestic growth and investments (Debelle, Galati, 2005; Freund, 2000). The Domestic Investments series is intended to be an indicator of a possible recession along with the Current Account to GDP series. The data represents seasonally adjusted gross domestic investments denominated in billion dollars deflated by a Domestic Investments deflator series into real prices with the base year 2000 (Bureau of Economic Analysis, 2006), and then transformed into logarithmic values.

### **3.2.2.5 NYSE**

Stock prices have some predictive power with respect to future recessions (Estrella, Mishkin, 1998). High stock prices indicate high levels of future economic activity and implicitly an elevated real economic growth. If stock prices are low, then expectations of future economic activity will accordingly be low. The NYSE series is intended to be an indicator of real economic growth and implicitly an indicator of a possible recession. The

series is composed of computed quarterly averages from the composite index of daily closing prices (NYSE Group, 2006), and then transformed into logarithmic values.

#### **3.2.2.6 NYSE STD**

A financial crisis is usually recognised by an episode of financial-market volatility (Bordo et al, 2001). The NYSE STD series is intended to reflect such volatility, where a high value of standard deviation reflects increased volatility, and thereby heightened risk of financial distress and financial crisis. The NYSE STD series is computed from the NYSE series. Each observation represents the standard deviation of the four preceding quarterly observations in the NYSE series.

#### **3.2.2.7 Interest Rate Spread**

The yield curve is particularly useful when predicting future recessions and the steepness of the yield curve gives the impression to be a correct forecaster of real activity. An increase in the short rate is likely to flatten the yield curve and to reduce real growth in the near term (Estrella, Mishkin, 1998). The Interest Rate Spread series is intended to reflect this behaviour and to be an indicator of a possible recession. The series is denoted in percentages where each quarterly observation represents the average of the adhering monthly computed differences of a 3 month maturity U.S. Treasury security deducted from a 10 year maturity U.S. Treasury security (Federal Reserve, 2006).

#### **3.2.2.8 Unemployment**

The above included variables have all been fetched from previous research. In the hypothetical case where these explanatory variables are of a low significance with respect to predicting the future, I have included a variable of my own choice; the unemployment rate. Unemployment is traditionally considered to be an indicator of real activity. A low rate of unemployment often indicates high economic activity and equally a high rate of unemployment indicates low economic activity i.e. a sign of recession. The Unemployment series is intended to reflect this behaviour and to be an indicator of a possible recession. The data is denoted in percentages (Department of Labor, 2006).

### 3.2.3 Excluded Variables

Some variables have been excluded since they are in one aspect or another dependent on one or several explanatory variables, or since they do not add any crucial information to the different future scenarios. I will account for the most obvious.

#### 3.2.3.1 The Exchange Rate and the Exchange Rate Regime

The exclusion of the exchange rate and the exchange rate regime as explanatory variables is not an undisputed choice to justify for several reasons. The Current Account is commonly perceived to be closely affiliated with the currency. A large Current Account deficit is an omen of an overvalued currency which is about to depreciate in the future, whether it's near or long term (Blanchard et al, 2005). Do notice that no explanation of causality is given in this particular relationship.

Such a relationship could classify as an argument in favour of including the exchange rate in the model. If a real depreciation of the dollar is to take place then the Current Account deficit is expected to decline. The motivation for exclusion of the exchange rate lies within this very argument; It is hard to predict when a real exchange rate will depreciate and equally hard to determine its proper value. A real exchange rate ( $S$ ) is constructed by multiplying the nominal exchange rate ( $E$ ) by the foreign price level ( $P^*$ ) and dividing by the domestic price level ( $P$ ).

$$S = \frac{EP^*}{P}$$

For the foreign price level to be informative it has to be constructed as a weighted index of the foreign price levels of the trading partners of the U.S. These data are not easily acquired, especially from Asian and European countries such as China and Russia, formerly under communist rule. China today is a major trading partner to the U.S., representing approximately a quarter of total U.S. net imports (Bureau of Economic Analysis, 2006), and the effect of the Chinese price index on the real exchange rate is presumably large. A foreign index can be computed in order to help predict the future value of the real exchange rate, but it cannot be included in the test computations as an explanatory variable due to the lack of historic data.

Since the focus of this model will be on predicting future recessions, I deem it unwieldy to also predict the future value of the dollar. Research confirms the view that it is continually difficult for econometric models to beat the forecasts of random walks for exchange rates, especially in the short term (Kilian, Taylor, 2003). This recognized problem also verifies that the scientific society does not yet have sufficient understanding of the factors propelling the adjustments of a currency's value.

A currency's value is determined in reference to other currencies, which in turn are also difficultly valued. The value of a currency is intimately associated with the exchange rate regime. The value of a currency can be artificially determined through the use of a fixed exchange rate regime or a dirty float<sup>10</sup>, or it can be set on the open market without any intervention at all, in which case it is known as a floating exchange rate regime. In the case of the dollar, being a world currency, its value is often determined through other countries exchange rate regimes. Several Asian and South American countries have pegged their exchange rate to the dollar in one way or another. Against these currencies, the dollar will implicitly become fixed although it technically remains a free float currency and it will suffer the effects of a fixed exchange rate regime, whereas it is free to float against other currencies such as the euro, the sterling, and the Suisse franc. For the sample period of 1982 to 2005, the euro has a relatively short period of formal existence. Prior to the euro, the ECU was the internal accounting unit of the European Monetary Union but it was not an equivalent to the euro. These factors have in common that they render the exchange rate regime as an explanatory variable rather ineffective.

### **3.2.3.2 The NIIP**

Since one of the major sources of concern for the state of the U.S. economy is the NIIP, according to Levey and Brown (2005), it would be fair to include the NIIP as an explanatory variable. Since it is closely correlated to the Current Account – the aggregate of the separate amounts of the Current Account over time constitutes the NIIP – I will not do so. The actual Current Account is included and previous research has not found the NIIP to be of significant importance in predicting future recessions.

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<sup>10</sup> A dirty float is equivalent to open market interventions effectuated by the Central Bank in order to keep the currency's value within a pre-defined range set by the Central Bank.

There is also some dispute over the quality of the official data emitted by U.S. authorities. Data from the Bank for International Settlements (BIS) show considerably larger dollar reserve holdings and reserve purchases than the U.S. data does. The discrepancy shows that the U.S. data are based on transactions reported by domestic financial institutions. Accordingly, they overlook holdings of dollar securities for foreign central banks by foreign private financial institutions, and the transactions of dollar securities between foreign central banks and foreign brokers. Central banks worldwide report data on offshore dollar reserve purchases and holdings to the BIS (Higgins, Klitgaard, 2004).

### **3.2.3.3 Productivity**

A widespread notion is that the U.S. “...*is continually extending its lead in the innovation and application of new technology...*” (Levey, Brown, 2005, p. 2). This development would not only favour the U.S. economy making it even more competitive, but it would also strengthen investor credibility. The extended lead in technology and implicitly profit-increasing factor productivity would result in more investors eager to lend the U.S. new capital, and thus augmenting sustainability of the Current Account deficit. Such a characteristic of the economy would allow for a greater Current Account deficit than otherwise.

To obtain a valid measure of factor productivity is however not an easy task. A conventional approach is the use of the Solow residual (Solow, 1957). This particular measure attributes changes in output on one side to changes in the stock of capital and labour on the other side. The discrepancy between the two is known as the Solow residual. A number of problems arise when one scrutinises the definition of GDP ( $Y = C + I + G + Ex - Imp$ ). It is obvious that the variance in the GDP measure may be a result of activities that are not directly correlated to domestic productivity, notably exports and imports. In the case of the U.S. the true measure of productivity when calculated as a Solow-residual is prone to be obscured by the relatively large amount of imports. Even economic fluctuations will affect GDP although factor productivity should remain unaltered. Technological progress and affiliated factor productivity do not fall into oblivion due to sudden recession. In these cases it is not clear what the discrepancy, or the Solow-residual actually is a measure of. Other measures of productivity basically suffer the same deficiencies.

Productivity is also difficult to measure in term of growth profits from technological progress due to the complex nature and the fact that the benefits take time to exploit. In the

case of the magnificent invention known as Internet and related applications such as Local Area Networks (LAN), the present gain, or future gains, in factor productivity is hard to quantify. There is no doubt that the Internet and related applications has improved productivity the last 15 years as they reduce transactional costs, but to what extent is not easily established. To measure and quantify soft values such as productivity gains of workers' experience with Internet, or organizational structure and software- and hardware-implementation of LAN-applications is awkward. As our societies grow more complex, it is reasonable to expect further progress in technological development related to the tertiary sector, which brings me to predicting the future.

Productivity related to technological progress remains difficult to forecast. Great inventions do not emerge with precise regularity. Further, predicting the development of productivity for a near future, such as 12 quarters, seems to be of little use. For productivity to have a significant impact on real growth it is probably necessary to consider a greater time horizon and I will assume it to be constant. Therefore, I will not include such an explanatory variable in the model.

#### **3.2.3.4 The Federal Reserve's Discount Rate (DWPCR)**

The discount rate affects liquidity, inflation, interest rates and consequentially real economic activity (Romer, 2006). The Federal Reserve's Discount rate thus affects the probability of a recession and it could be useful with an explanatory variable accounting for the effects of the discount rate. The Board of Governors of the Federal Reserve System replaced the discount rate with the Discount Window Primary Credit Rate (DWPCR) on January 9 2003 (Federal Reserve Release, 2002). The former discount rate was a below-market rate whereas the DWPCR is a market-based rate. Therefore it will not be possible to create a time series from 1980 to 2005 without a break and hence a bias in the data will occur.

Furthermore, the effects of the DWPCR are implicitly mirrored by the Interest Rate Spread series (see 3.2.2.6). As the DWPCR rise, so will the interest rates on the 3 month U.S. Treasury securities. An auxiliary regression where the Fed Discount Rate series is regressed upon the 3 month U.S. Treasury securities series (T-bill 3 months) reveals that the two are

collinear from the  $R^2$  of 0.94 (Figure 3.1)<sup>11</sup>. Therefore, I will not include such an explanatory variable.

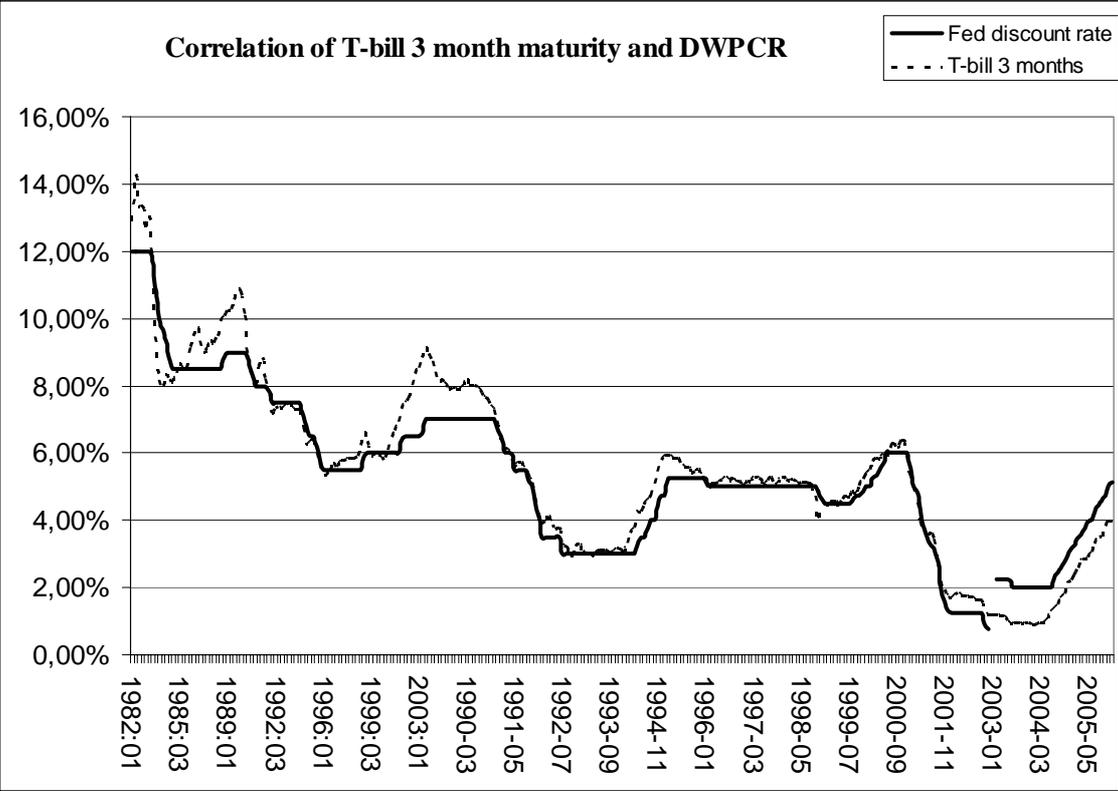


Figure 3.1: Correlation of the 3 month U.S. Treasury security and the Discount Window Primary Credit Rate

<sup>11</sup> An explanation for the rationale of the auxiliary regression is found in Chapter 4. For an exposition on the definition and the implication of collinearity, see Hill et al (2001).

## 4 Result

The first sequence of computations is made as all explanatory variables are regressed on the four dependent variables, respectively. The results are accounted for in Table 4.2. In the first column entitled *Model*, the model that is being tested is specified. In the second column entitled  $R_{p,i}^2$ , the model's measure-of-fit is accounted for. The index  $i$  represents the number of the estimated regression. In the third and fourth column,  $\gamma_1$  and  $\gamma_2$  are accounted for through their p-value respectively. Among the explanatory variables in the models below are the following denotations applied (Table 4.1).

$y_i$	Dependent variable of series $i$ .
$\beta_i$	Coefficient; $\beta_1$ represents an intercept.
$\varepsilon$	Error term.
$a$	Asset Price.
$ca$	Current Account to GDP.
$cr$	Domestic Credit.
$i$	Domestic Investments.
$ny$	NYSE.
$nys$	NYSE STD.
$sp$	Interest Rate Spread.
$un$	Unemployment.

Table 4.1: Denotations of explanatory variables

Nr	Model	$R_{p,i}^2$	$\gamma_1$	$\gamma_2$
1	$y_1 = \beta_1 + \beta_2 a + \beta_3 ca + \beta_4 cr + \beta_5 i + \beta_6 ny + \beta_7 nys + \beta_8 sp + \beta_9 un + \varepsilon$	0.500	0.00	0.00
2	$y_2 = \beta_1 + \beta_2 a + \beta_3 ca + \beta_4 cr + \beta_5 i + \beta_6 ny + \beta_7 nys + \beta_8 sp + \beta_9 un + \varepsilon$	0.571	0.22	0.23
3	$y_3 = \beta_1 + \beta_2 a + \beta_3 ca + \beta_4 cr + \beta_5 i + \beta_6 ny + \beta_7 nys + \beta_8 sp + \beta_9 un + \varepsilon$	0.562	0.37	0.21
4	$y_4 = \beta_1 + \beta_2 a + \beta_3 ca + \beta_4 cr + \beta_5 i + \beta_6 ny + \beta_7 nys + \beta_8 sp + \beta_9 un + \varepsilon$	0.723	0.53	0.37

Table 4.2: First sequence of computations

In Table 4.2 it is clear that model nr 4 is the most appropriate for forecasting recessions with respect to the measure-of-fit. The  $R_{p,4}^2$  assumes a value of 0.723 which is equal to stating that model nr 4 is predicting an average of 72.3% of the in-sample observations correctly. Normality of the data is not attained in the first regression where the binary series of  $y_1'$  is defined as

$$y_1' = \begin{cases} 1, & \text{if real growth} \leq \tau = 0 \\ 0, & \text{if real growth} > \tau = 0 \end{cases}$$

The p-values for  $\gamma_1$  and  $\gamma_2$  do not indicate skewness nor kurtosis for the rest of the regressions.

The next step will be to render the model even more parsimonious by re-estimating it with less explanatory variables. A second sequence is made as the model is re-estimated without one of the explanatory variables in every regression (Table 4.3).

Nr	Model	$R_p^2$	$\gamma_1$	$\gamma_2$
5	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'i + \beta_5'ny + \beta_6'nys + \beta_7'sp + \beta_8'un + \varepsilon$	0.724	0.59	0.34
6	$y_4 = \beta_1' + \beta_2'a + \beta_3'cr + \beta_4'i + \beta_5'ny + \beta_6'nys + \beta_7'sp + \beta_8'un + \varepsilon$	0.724	0.73	0.35
7	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'i + \beta_5'ny + \beta_6'nys + \beta_7'sp + \beta_8'un + \varepsilon$	0.685	0.17	0.20
8	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'ny + \beta_6'nys + \beta_7'sp + \beta_8'un + \varepsilon$	0.649	0.63	0.52
9	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'i + \beta_6'nys + \beta_7'sp + \beta_8'un + \varepsilon$	0.724	0.53	0.37
10	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'i + \beta_6'ny + \beta_7'sp + \beta_8'un + \varepsilon$	0.756	0.99	0.50
11	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'i + \beta_6'ny + \beta_7'nys + \beta_8'un + \varepsilon$	0.649	0.96	0.05
12	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'i + \beta_6'ny + \beta_7'nys + \beta_8'sp + \varepsilon$	0.712	0.49	0.37

Table 4.3: Second sequence of computations

In the second sequence (Table 4.3), model nr 10 receives the highest value of  $R_p^2$ . The  $R_{p,10}^2$  of 0.756 is higher than  $R_{p,4}^2$ . This implies that the model improves its in-sample forecasting capability without the NYSE STD variable. A possible explanation for such

results may be that the NYSE STD series suffers from heteroskedasticity, and consequently normality of the data is lower than otherwise. The p-values of  $\gamma_1$  and  $\gamma_2$  also receive even more satisfactory values with respect to normality when the NYSE STD variable is excluded than when included.

A third sequence is made as model nr 10 is re-estimated without one of the explanatory variables in each regression (Table 4.4).

Nr	Model	$R_p^2$	$\gamma_1$	$\gamma_2$
13	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'i + \beta_5'ny + \beta_6'sp + \beta_7'un + \varepsilon$	0.758	0.75	0.54
14	$y_4 = \beta_1' + \beta_2'a + \beta_3'cr + \beta_4'i + \beta_5'ny + \beta_6'sp + \beta_7'un + \varepsilon$	0.725	0.83	0.51
15	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'i + \beta_5'ny + \beta_6'sp + \beta_7'un + \varepsilon$	0.682	0.17	0.18
16	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'ny + \beta_6'sp + \beta_7'un + \varepsilon$	0.636	0.93	0.53
17	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'i + \beta_6'sp + \beta_7'un + \varepsilon$	0.756	0.92	0.51
18	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'i + \beta_6'ny + \beta_7'un + \varepsilon$	0.648	0.73	0.12
19	$y_4 = \beta_1' + \beta_2'a + \beta_3'ca + \beta_4'cr + \beta_5'i + \beta_6'ny + \beta_7'sp + \varepsilon$	0.756	0.98	0.51

Table 4.4: Third sequence of computations

In the third sequence (Table 4.4), model nr 13 receives the highest value of measure-of-fit, as the Asset Price variable is excluded. The  $R_{p,13}^2$  of 0.758 is higher than the  $R_{p,10}^2$  of previously estimated model nr 10. Through the exclusion of Asset Price variable, the new model receives an even higher capability of forecasting in-sample observations. Model nr 17 and nr 19, respectively estimated without the NYSE variable and the Unemployment variable, also receive high values of measure-of-fit. A fourth sequence is made as model nr 13 is re-estimated without one of the explanatory variables in every regression (Table 4.5).

Nr	Model	$R_p^2$	$\gamma_1$	$\gamma_2$
20	$y_4 = \beta_1' + \beta_2'cr + \beta_3'i + \beta_4'ny + \beta_5'sp + \beta_6'un + \varepsilon$	0.748	0.65	0.51
21	$y_4 = \beta_1' + \beta_2'ca + \beta_3'i + \beta_4'ny + \beta_5'sp + \beta_6'un + \varepsilon$	0.605	0.08	0.05
22	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'ny + \beta_5'sp + \beta_6'un + \varepsilon$	0.649	0.96	0.60
23	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'i + \beta_5'sp + \beta_6'un + \varepsilon$	0.758	0.78	0.61
24	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'i + \beta_5'ny + \beta_6'un + \varepsilon$	0.663	0.40	0.42
25	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'i + \beta_5'ny + \beta_6'sp + \varepsilon$	0.769	0.76	0.54

Table 4.5: Fourth sequence of computations

In the fourth sequence (Table 4.5), model nr 25 receives the highest value of  $R_p^2$ . The remaining explanatory variables are the Current Account to GDP variable, the Domestic Credit variable, the Domestic Investments variable, the NYSE and the Interest Rate Spread variable. The  $R_{p,25}^2$  of 0.769 is higher than the previously estimated  $R_{p,13}^2$  of 0.758, and further improvement of the models forecasting capability has been achieved.

Model nr 21 testifies of low p-values for  $\gamma_1$  and  $\gamma_2$ , such that normality is rejected at the significance level of  $\alpha = 0.1$ . A possible explanation for the lack of normality is that the Domestic Credit variable contains vital information for the validity and the forecasting capability of the model. The probability of recession is thus significantly dependent on the level of domestic consumer credit liability of U.S. households.

A fifth sequence is made as model nr 25 is re-estimated without one of the explanatory variables in every regression (Table 4.6).

Nr	Model	$R_p^2$	$\gamma_1$	$\gamma_2$
26	$y_4 = \beta_1' + \beta_2'cr + \beta_3'i + \beta_4'ny + \beta_5'sp + \varepsilon$	0.740	0.67	0.50
27	$y_4 = \beta_1' + \beta_2'ca + \beta_3'i + \beta_4'ny + \beta_5'sp + \varepsilon$	0.615	0.13	0.08
28	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'ny + \beta_5'sp + \varepsilon$	0.670	0.91	0.95
29	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'i + \beta_5'sp + \varepsilon$	0.758	0.81	0.63
30	$y_4 = \beta_1' + \beta_2'ca + \beta_3'cr + \beta_4'i + \beta_5'ny + \varepsilon$	0.620	0.44	0.47

Table 4.6: Fifth sequence of computations

Table 4.6 reveals that no further elimination of explanatory variables will improve the measure-of-fit for the model, the best regression being nr 29 with a  $R_{p,29}^2$  equal to a value of 0.758 which is inferior to  $R_{p,25}^2$  of 0.769. Model nr 27 corroborates the previous finding that the Domestic Credit variable holds information vital to the model's validity and forecasting capability.

#### 4.1 The Final Model

The model with the best measure of fit includes the explanatory variables the Current Account to GDP variable, the Domestic Credit variable, the Domestic Investments variable, the NYSE and the Interest Rate Spread variable. It achieves a measure-of-fit of 0.769 (Table 4.7) and the normality of the data cannot be rejected at any conventional level of significance based on the p-values of  $\gamma_1$  and  $\gamma_2$ .

Variable	Coefficient	Std. Error	P-value
$\beta_1'$	-54.35	21.91	0.01
<i>ca</i>	0.37	0.68	0.58
<i>cr</i>	9.47	2.44	0.00
<i>i</i>	-11.35	3.61	0.00
<i>ny</i>	0.60	1.21	0.62
<i>sp</i>	-0.35	0.14	0.01

$\gamma_1$	0.76	$\gamma_2$	0.54
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Table 4.7: The final model

The p-values of the variables Current Account to GDP and NYSE imply that they are not statistically significant as the null hypothesis cannot be rejected at any conventional level of significance. When estimating the model without these variables the measure-of-fit decreases to 0.735; the small deterioration in measure-of-fit supports the low significance of the variables. In a forecasting scenario it may be easier to do without these variables as fewer

variables suggest fewer factors to take into account, but I will not alter the model at the expense of worsening the forecasting capability.

Three of the explanatory variables suffer from collinearity. An auxiliary linear regression where the Domestic Credit is regressed upon Domestic Investments and NYSE with an intercept reveals from the  $R^2$  of 0.96 that they are collinear. If the  $R^2$  from such auxiliary regression assumes a value above 0.80, it implies that a large portion of the variation in the dependent variable is explained by the variation in the explanatory variables (Hill et al, 2001).

The heteroskedasticity test reveals from the p-value of 0.61 that the final model does not suffer from heteroskedasticity. I let the squared Current Account to GDP represents the variable  $z_i$  in the auxiliary regression since it naturally has a very small intercept and the test statistic is thus Chi-squared of one degree of freedom. The p-value of 0.61 implies that the null hypothesis of homoskedasticity cannot be rejected at any conventional level of significance. Along with the previous assumption of normality which has not been rejected from previous tests of significance, no econometrical evidence of biasness at specified levels can be sustained and it can be informative to study the separate coefficients and their marginal effects.

#### **4.1.1 Marginal Effects**

The marginal effects have to be computed separately. As marginal effects are smaller when located at the tails of the probability density function  $f\{\dots\}$  the marginal effect will vary across the time series according to the value of  $\beta' x_i$ . In order to compute a constant marginal effect, I will let the mean of computed marginal effects according to the expression  $f(-\hat{\beta}' x_i) \hat{\beta}_i$  represent the marginal effect of each variable (Table 4.8, column M. E. Mean *a*). An alternative approach for computing marginal effects is to take the mean of all  $x_i$  and then compute the marginal effects according to the expression  $f(-\hat{\beta}' \bar{x}_i) \hat{\beta}_i$  (Table 4.8, column M. E. Mean *b*). The different approaches yield not too differentiated values.

Variable	M. E. Mean <i>a</i>	M. E. Mean <i>b</i>
Current Account to GDP	0.117	0.135
Domestic Credit	2.948	3.403
Domestic Investments	-3.533	-4.077
NYSE	0.187	0.216
Interest Rate Spread	-0.108	-0.125

Table 4.8: Marginal effects of the variables of the final model

The marginal effect of the Current Account to GDP variable on the probability of recession is positive. When the variable is increased by one percentage point, the  $P(y_i = 1)$  is increased by a value between 0.117 to 0.135 percentage points<sup>12</sup>. As a consequence, a decrease or a negative value of the Current Account to GDP will decrease the probability of a recession occurring. In the case of positive real GDP growth, a reduction of the Current Account deficit would increase the probability while an aggravated Current Account deficit would reduce the probability of recession. Meanwhile, the effect of the reversal has to be quite large in order to cause a significant effect. This finding is theory consistent as Current Account reversals are typically associated with a slowdown in domestic growth and investments (Debelle, Galati, 2005; Freund, 2000).

The marginal effect of the Domestic Credit variable on the probability of recession is positive. When Domestic Credit is increased by 1 percentage the  $P(y_i = 1)$  is increased by a value between 2.948 to 3.403 percentage points. The finding is verified by conventional theory since credit escalation constitutes a reliable indicator of subsequent banking crises (Caprio et al, 1994). As credit growth has a propensity to increase before and to peak one year after a Current Account reversal (Debelle, Galati, 2005), the Domestic Credit variable possibly reinforces the behaviour of the Current Account to GDP variable.

The marginal effect of the Domestic Investments variable on the probability of recession is negative. When the variable is increased by 1 percentage the  $P(y_i = 1)$  is decreased by a value between 3.533 to 4.077 percentage points. The finding is intuitive and consistent with theory as an increase in domestic investments automatically raises output by definition ( $Y = C + I + G + Ex - Imp$ ). A raise in output implies positive growth.

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<sup>12</sup> NB: The use of the term *percentages* is to be distinguished from the term *percentage point*.

The marginal effect of the NYSE variable on the probability of recession is positive. When the variable is increased by 1 percentage the  $P(y_i = 1)$  is increased by a value between 0.187 to 0.216 percentage points. This finding is somewhat dubious with respect to conventional theory as, in the words of Estrella and Mishkin (1998, p. 49), “*Finance theory suggests that stock prices may be interpreted as expected present values of future dividend streams.*”. High future dividend streams condition high future revenues, and these future revenues condition high future consumption which could be the result of real growth in domestic output. In such case, an increase in the NYSE variable should yield a decrease in the  $P(y_i = 1)$ , equivalent to a decrease of the probability of a recession occurring, given that real growth facilitates the occurrence of high future dividend streams.

An alternative approach would be that growth in the NYSE variable indicates an elevated presence of speculative bubbles that might result in a stock market crash. A stock market crash is empirically considered to be an element in a financial crisis and a possible adhering recession (Mishkin, 1996b). In such case, the finding is correct. These contradictory interpretations might be an explanation for the low significance of the variable. Nevertheless, the three variables Domestic Credit Log Level, Domestic Investments and NYSE are closely correlated, which implies that they should be evaluated together.

The marginal effect of the Interest Rate Spread variable on the probability of recession is negative which is equivalent of stating that when the variable is increased by one percentage point the  $P(y_i = 1)$  is decreased by a value between 10.8 to 12.5 percentage points. Conversely, a decrease of the spread translates into an increase in the probability of a recession occurring. The result is consistent with previous research as an increase in the short rate is likely to flatten the yield curve and the interest rate spread and to reduce real growth in the near term (Estrella, Mishkin, 1998). The final model is thus fairly consistent with conventional theory. The fitted probabilities of the model are depicted in figure 4.1.

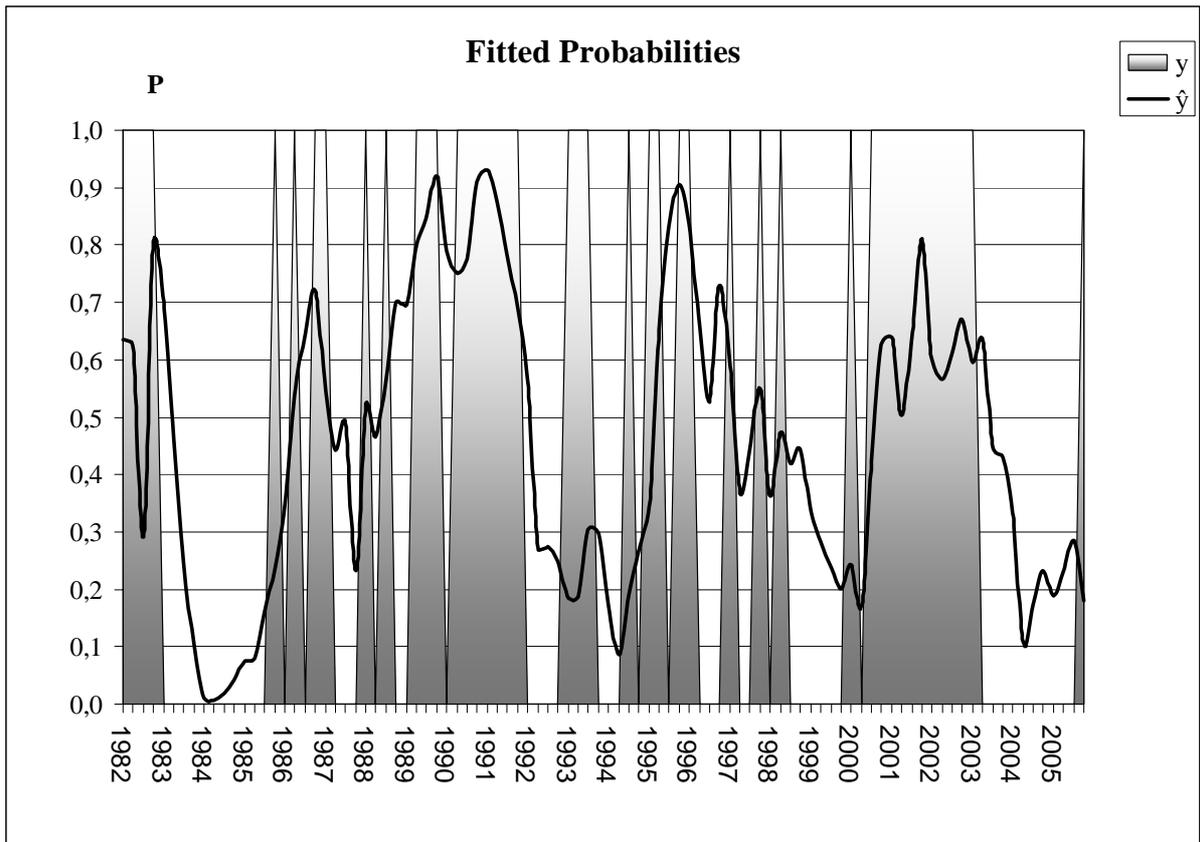


Figure 4.1: In-sample prediction by final model. Actual series of dependent variable  $y_4$  ( $y$ ), and fitted probabilities ( $\hat{y}$ ).

## 5 Analysis

The analysis will consist of various scenarios in which the future probability of recession is evaluated under various circumstances within the framework of the model. The premier part of the analysis will consist of a partial analysis of the various variables' impact on the probability of recession. The purpose is to establish by what minimum amount a specific variable must change, *ceteris paribus*, in order to provoke a recession. The changes will be determined given that the rest of the variables remain constant. The three collinear variables Domestic Investments Log Level, Domestic Credit and NYSE will also be treated jointly due to their high collinearity. The model cannot credibly simulate the probability in a scenario where the three variables do not coincide due to their correlation. Of course, exceptions can be made from the rule, such as a stock market crash for instance where the NYSE decreases separately along the lines of a couple of additional percentage points.

The second part will try to establish a parallel to the Current Account reversal in 1987. It was at the time the largest Current Account deficit observed in the history of the U.S., and many opinions were voiced on the future of the U.S. economy<sup>13</sup>. The purpose of the scenario is to establish the probability of recession if historic events were come to pass.

The third part will consist of a speculative scenario in which the explanatory variables follow a predetermined trend motivated by inflationary pressures. I will assume a causal chain of events – although the model does not reflect causality – in order to permit structure in the process of analysing and exogenously determined trends for the Current Account to GDP and the Interest Rate Spread. The model statistically relates the appearance of certain events to the probability of a recession, which in this context is defined as real GDP growth below its mean for the period 1982 to 2005. The assumption of causality should therefore be considered in this light. It is not positively established whether a change in the explanatory variables engenders a change in the dependent variable or vice versa, but it is established that they coincide. The assumption of causality remains inferior to the actual correlation of changes.

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<sup>13</sup> See Marris (1985) for an exposition on contemporary aspects and implications of the 1987 Current Account deficit.

## 5.1 Partial Analysis

The partial analysis of each variable will be elaborated according to the condition that the probability of recession must be superior to 50% after a period of 12 quarters due to the change in one variable, while the other variables remain constant. The quarterly rate of change in a variable will be constant for the period. The result will be computed through the use of an iterative process, and is consequently not solved for analytically. The probability of a recession in the last in-sample observation, 2005q4, is estimated to be approximately 0.18 which indicates that the model does not forecast an impending risk of recession.

In the case where the Current Account to GDP variable assumes an increase of 0.2 percentage points per quarter, the result will be a probability of recession superior to 0.5 in 2008q4. For the period 2005q4 (the last in-sample observation) to 2008q4, the Current Account to GDP increases from -1.78% to 0.63%<sup>14</sup>, and the total change in Current Account to GDP is 2.4 percentage points. Bear in mind that recession in the particular context implies a decrease in real GDP growth below *its mean*. An increment of 0.2 percentage points of the Current Account to GDP will thus engender a probability of a slight stagnation of the growth rate; not a probability of an imminent hard landing. A comparison of the previous Current Account reversal in 1987 reveals that the mean of the increment of the period 1986q4 to 1989q3 is approximately 0.03 percentage points, which is far from the required increment of 0.2 percentage points under these circumstances although the comparison is somewhat inequitable.<sup>0</sup>

For an increase in the Current Account to GDP variable to take place, an increase of the numerator (Current Account) or a decrease of the denominator (GDP), or both, is needed. It implies that if the variable increases through a decrease in GDP, the increase in probability of recession is self-evident and clearly endogenous. On the other hand, if the variable increases through a positive increase in the Current Account (the deficit turns into a surplus) while GDP continues along its mean, the amount of change in the Current Account has to be substantially large. A hypothetical increase has to be equivalent to a sum of 1.1 trillion dollars (base year 2000) for the period 2006q1 to 2008q4 for the probability of a recession to surmount 50%. This figure can be compared to the Current Account deficit of 2005. In 2005q4 the Current Account deficit was 226.8 billion dollars (seasonally unadjusted) and it added up to 804.9

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<sup>14</sup> The values and the change may seem low but keep in mind that the Current Account numerator is computed on a quarterly basis whereas the GDP denominator is computed on an annual basis.

billion dollars for the year 2005 (Bureau of Economic Analysis, 2006). The slower the turnaround of the Current Account deficit the larger the accumulated sum.

For the probability of recession to surpass 0.5 in the end of 2008q4, the three variables Domestic Credit Log Level, Domestic Investments and NYSE will have to assume a decrease of 5.95 percentage points per quarter, and they assume identical decreases due to their high correlation. For the NYSE series, there are periods of occasional observations of larger decreases, especially in 2000q4 to 2003q1, whereas the other series do not exhibit periods of such decreases more than for a rare observation or two. From a historical point of view the decrease is improbable. For the period 2005q4 to 2008q4, the decrease accumulates to 979 billion dollars in the Domestic Credit and 1.2 trillion dollars in the Domestic Investments. The changes are equivalent to a log decrease of 0.72. The change in the NYSE is equal to 3871 points.

If the Interest Rate Spread variable takes on a decrease of 0.22 percentage points per quarter accumulating to a total negative change of 2.62 percentage points, the probability of recession surpasses 0.5 in 2008q4. Large decreases of the Interest Rate Spread has been observed in the pass: a total decrease of 1.86 percentage points in 1985q2 to 1986q2; a total decrease of 2.52 percentage points in 1988q3 to 1989q3; a total decrease of 2.51 percentage points in 1994q3 to 1995q4; a total decrease of 1.72 percentage points in 1999q4 to 2000q4 and a total decrease of 2.92 percentage points in 2004q3 to 2005q4. Based on historical observations, the scenario is not unlikely to occur in the future although perhaps not under these particular assumptions. The last period of descending Interest Rate Spread, 2004q3 to 2005q4, indicates that the probability of recession has risen rapidly and that lower future growth has become more likely.

Mutual for the different analyses are that quarterly calculations add up to a different amount under alternative assumptions. It is not until after the decisive change in trajectory has taken place of a variable and continued for some time that the imminent probability of recession occurs. It implies that the variables may vary considerably without provoking noteworthy impact on the probability of recession.

## 5.2 Parallel to the Current Account Reversal in 1987

The U.S. experienced a Current Account reversal in 1987 combined with a stock market correction October 19 known as the *Black Monday*. During this period real GDP growth never went into a recession, defined as negative growth for two consecutive quarters, nor did it stay below its mean for more than a couple of scattered quarters after the reversal even though the worries for a severe impact of a large Current Account deficit were as large then as they are today.

The values for each variable in the period 2006q1 to 2008q4 have been derived from data of the period 1986q4 to 1989q3. The forecasted values assume the same relative changes as the values exhibited in the period 1986q4 to 1989q3 and the forecasted values can be observed in figure 5.2.1 to 5.2.6. For the period 2006q1 to 2008q4 the increase in Current Account to GDP is equivalent to 0.4 percentage points, the increase in Domestic Investments is 0.063 log units which is also equivalent to 6.3 %, Domestic Credit increases by 0.089 log units and NYSE increases by 0.316 log units. The stock market correction is reflected by a decrease of 0.224 log units of the NYSE in 2007q1.

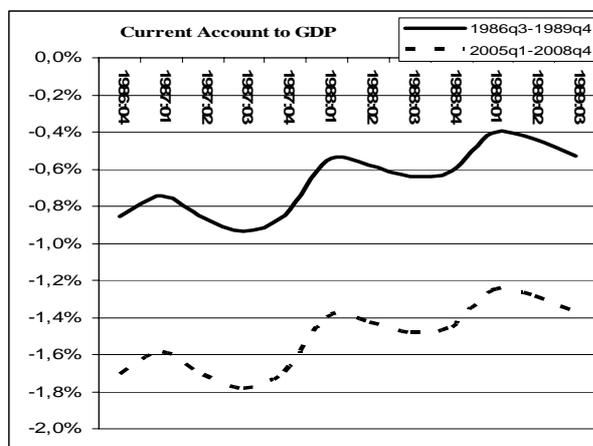


Figure 5.2.1: Current Account to GDP – 1987 Current Account reversal

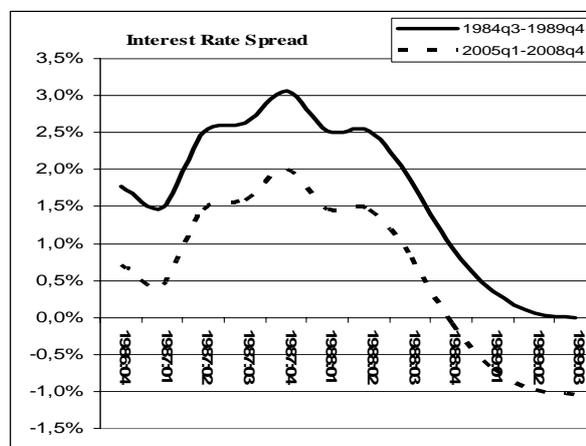


Figure 5.2.2: Interest Rate Spread – 1987 Current Account reversal

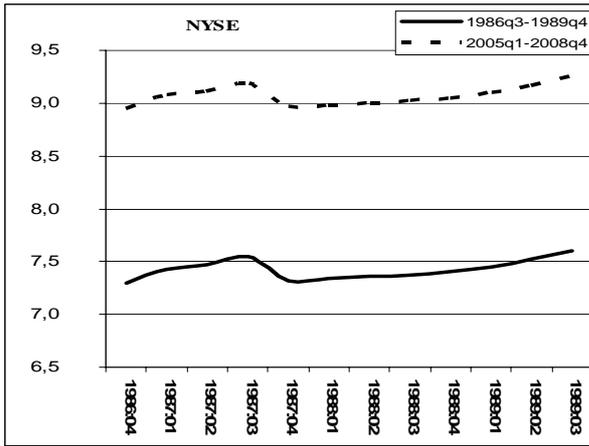


Figure 5.2.3: NYSE – 1987 Current Account reversal

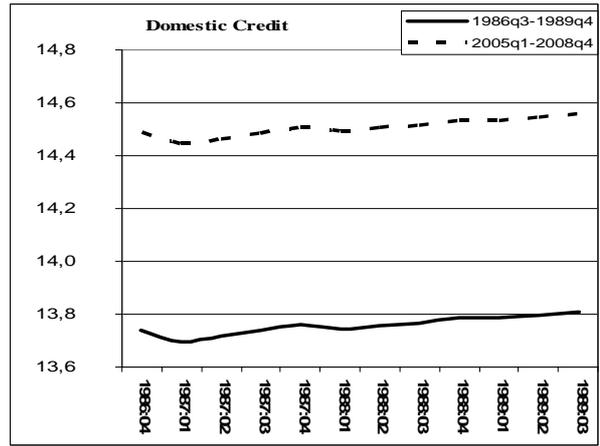


Figure 5.2.4: Domestic Credit – 1987 Current Account reversal

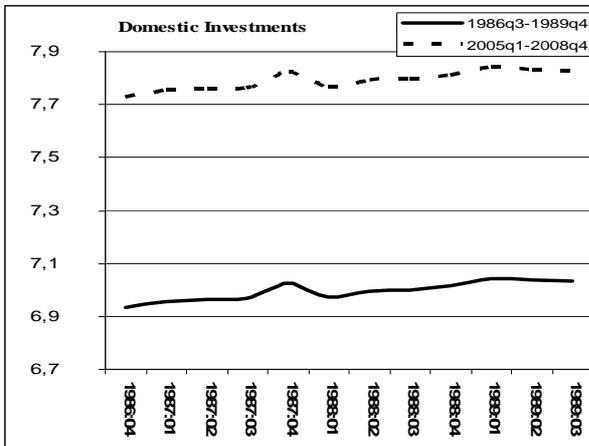


Figure 5.2.5: Domestic Investments – 1987 Current Account reversal

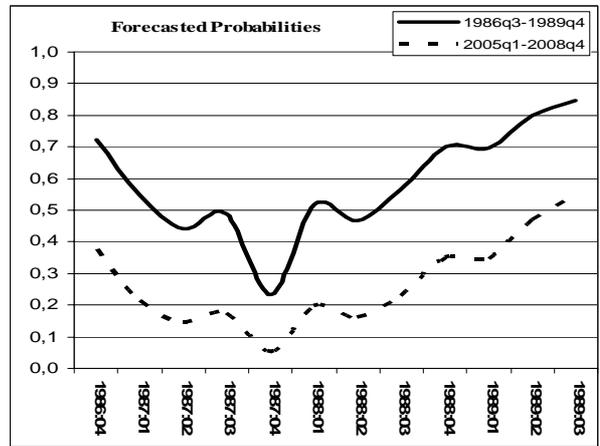


Figure 5.2.6: Fitted Probabilities – 1987 Current Account reversal

The probability of a recession in the last in-sample observation, 2005q4, is estimated to be approximately 0.18. The stock market correction does not seem to have a severe impact on the probability of recession. The NYSE series has a negative marginal effect on the probability of recession in the case of a reduction. Hence, the decrease in NYSE of 0.224 log units in 2007q1 does not correlate to an increase in probability of recession given the development of the other variables. From 2007q4 to 2008q4 the probability of recession surges from 0.23 to 0.55, and thus a predicted recession does not occur until the last quarter of 2008.

A comparison of probabilities of recession reveals that the mean of the calculated differences of probabilities from the two periods is approximately 31% lower in 2006q1 to 2008q4 than in 1986q4 to 1989q3. The lower mean may suggest, from an econometrical point of view, that the rather large Current Account deficit operates in favour of the U.S. economy

to a greater extent than in the past in spite of the Interest Rate Spread which assumes an unusually small (negative) value. In more general terms, the lower mean may suggest that the U.S. economy rests on a more solid ground than in the past. As financial- and goods-markets become globally integrated the result will probably be higher growth. The amount of U.S. trade, defined as [Imports + Exports, nominal values] (Bureau of Economic Analysis, 2006) has been growing with a mean of 1.84% per quarter for the period 1982 to 2005. However, the mean of 1.79% from the period 1982 to 1993 is lower than the mean of 1.86% from the period 1994-2005, which could reflect the entrance of new emerging markets in larger parts of Asia on the global arena of trade.

### **5.3 Inflationary Pressures**

The inflationary aspect is motivated by the general importance of monetary policy for economic growth and the fact that inflation is a factor which is mainly determined by domestic macroeconomic indicators; domestic in the sense that it arises from positive domestic demand conditions and higher domestic wages. In the case where heavy exports exert upward pressure on domestic inflation through an increase in demand - a foreign factor – such pressure is relatively feeble in comparison to inflation due to an equivalent increase in domestic consumption. Consumption is approximately seven times as large as exports in the measure of GDP from the year 1982 to 2005 (Bureau of Economic Analysis, 2006).

The main complication when choosing the development of domestic inflation as a key factor in a future speculative scenario is that inflation is complex and subdued to the influence of a multitude of factors. Future expectations, the technological evolution, the stickiness of nominal prices and the wage setting process, to mention some factors, all play a part in how inflation arises (Romer, 2006). It will not be possible to assess the effects of all factors and the key argument when basing a future scenario on inflationary pressure remains that it is chiefly a domestic phenomenon.

Imported inflation exerts a downward pressure on nominal output growth and domestic inflation. Through the definition of GDP ( $Y = C + I + G + Ex - Imp$ ) it is easily observed that an increase in foreign price levels will cause the immediate value of imports to rise and GDP to decline in the short term. In reference to previous mentioned scenarios, an increase in the price of oil may instigate an aggregate supply shock which might turn into domestic inflation. The oil dependent firms chose to pass the increase in cost to their customers and ultimately the consumers by raising prices (Romer, 2006).

The scenario in the previous subchapter 5.2 shed light on a possible development of the probability of recession in the case of a Current Account reversal and a heavily deteriorating interest rate spread; two factors working for an increase of the probability of recession. In this scenario, the assumptions will be slightly different. Global investors maintain their expectations on sufficient returns from the U.S. economy, thus continuing to extend the access to foreign capital at a previous rate. They might do this for a variety of reasons, but I will assume that the motive is conceived along the lines of subchapter 2.1. Higher real growth of the U.S. economy vis-à-vis its competitors, perceived higher risk in the rest of the world and similar incentives will have investors turning their eyes towards the U.S. Consequently, capital inflows to the U.S. will continue to be relatively elevated and I will assume that the negative Current Account to GDP will continue to deepen at the same rate as it has done for the period 2003q1 to 2005q4.

On the domestic scene, the Board of Governors of the Federal Reserve System (from now on referred to as the Fed) continue the raise of the DWPCR according to the mean of the rate of 2003q1 to 2005q4 (0.25 percentage points per quarter) for another 4 quarters before arriving at a plateau for which the DWPCR remains constant. The behaviour is meant to reflect previous raises in the periods 1994q4 to 1996q4 and 1987q2 to 1989q2 which have both arrived at a plateau and remained constant for some time. The steep and massive raise may be a strong assumption to make for the evolution of the DWPCR. The raise for the period 2004q2 to 2008q4 is equivalent to 3.96 percentage point which is an unprecedented raise in the history of the Fed. The justification for such a raise might be to counter the inflationary effect of the inflow of capital indicated by an also unprecedented Current Account deficit, or to counter inflationary effects from soaring oil prices. I will assume unaltered expectations in the medium term and the last observation of the rate of the 10 year maturity U.S. Treasury security will function as a guideline value for 2005q1 to 2008q4 when computing the Interest Rate Spread. The value of the 3 month maturity U.S. Treasury security will be given by the DWPCR since they correlate closely.

The three variables Domestic investments, Domestic Credit and NYSE will react as a result of the raise in DWPCR. To facilitate the forecasting of the variables, I have computed three linear regressions where I regress each of the variables upon the Primary Discount Rate and the Current Account to GDP (Table 5.3.1). The p-values for all coefficients are zero.

Regression	R <sup>2</sup>
$Credit_i = 14,16 - 0,07 * DWPCR_i - 0,35 * Current\ Account\ to\ GDP_i$	0.82
$Inv_i = 7,37 - 0,06 * DWPCR_i - 0,34 * Current\ Account\ to\ GDP_i$	0.81
$NYSE_i = 8,65 - 0,16 * DWPCR_i - 0,44 * Current\ Account\ to\ GDP_i$	0.73

Table 5.3.1

The regressions in Table 5.3.1 are biased due to endogeneity, but the purpose is not to analyze the results; they are entirely meant to provide assistance in the forecasting of the variables. The endogeneity of the regression may be subject to discussion, but I would like to assume exogenous explanatory variables for the sake of argument. To the extent that the dependent variables affect the explanatory variables, it is rather the expected future values of the dependent variables that are conditioning the evolution of the present values of the explanatory variables. The DWPCR for instance is managed in accordance with future expectations on inflation, unemployment or real and nominal output (Romer, 2006). The Current Account to GDP is by definition endogenous with respect to Domestic Investments, but the endogeneity is less apparent with respect to Domestic Credit and NYSE.

The forecasted values are generated by calculating the forecasted values of each variable from the assumed evolution made earlier of the DWPCR and the Current Account to GDP from the period 2005q1 to 2008q4. The relative changes of the period are then applied to the real series with the purpose of producing a reasonable forecast of Domestic Credit, Domestic Investments and NYSE. The results are depicted in figure 5.3.1 to 5.3.6.

Under these circumstances it is possible to compare computed probabilities of the 1987 Current Account reversal from the model at hand along with linearly generated forecasts of Domestic Investments, Domestic Credit and NYSE (Model 5.3), with the probabilities generated by the model from subchapter 5.2 (Model 5.2). In Model 5.3 forecasted values are derived from historic data for the Current Account to GDP as well as the Interest Rate Spread, while Domestic Investment, Domestic Credit and NYSE are generated by the equations in Table 5.3.1. In Model 5.2 all forecasted values are derived from historic data (figure 5.3.7). They appear to predict the historic event similarly, apart from the end observations, and an auxiliary regression reveals by the R<sup>2</sup> of 0.77 that they are closely correlated, in spite of the meagre sample. The discrepancy of the probabilities from the two models has a mean of 0.0334 and a standard deviation of 0.0713.

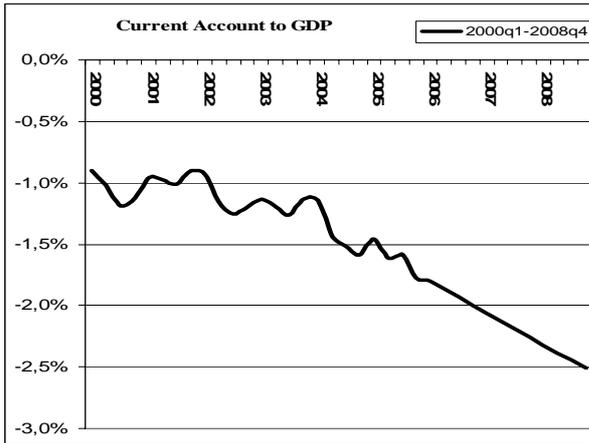


Figure 5.3.1: Current Account to GDP – Inflationary pressures

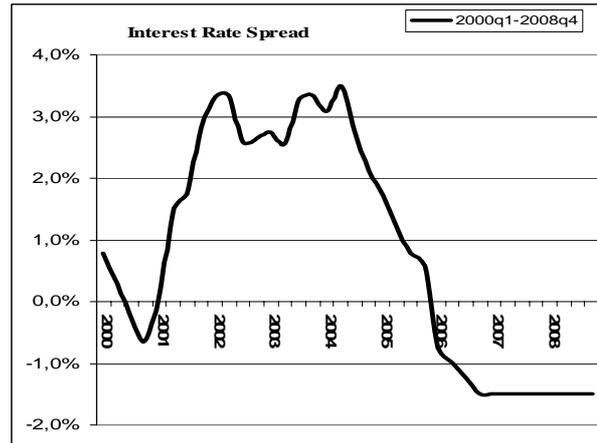


Figure 5.3.2: Interest Rate Spread – Inflationary pressures

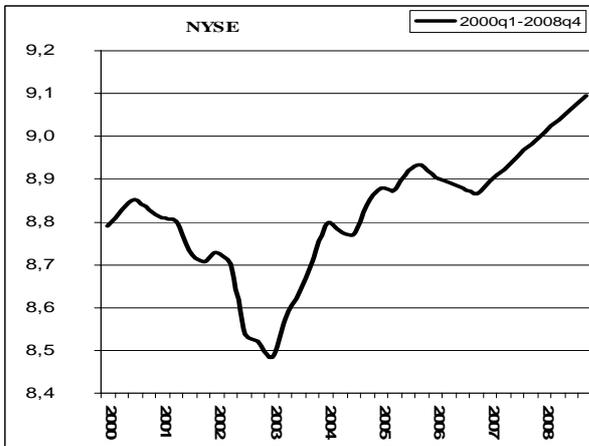


Figure 5.3.3: NYSE – Inflationary pressures

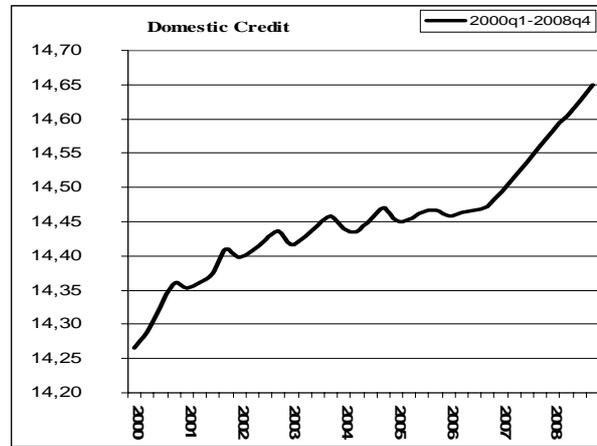


Figure 5.3.4: Domestic Credit – Inflationary pressures

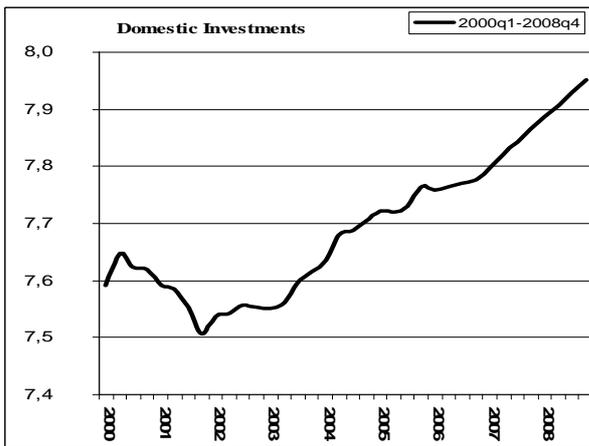


Figure 5.3.5: Domestic Investments – Inflationary pressures

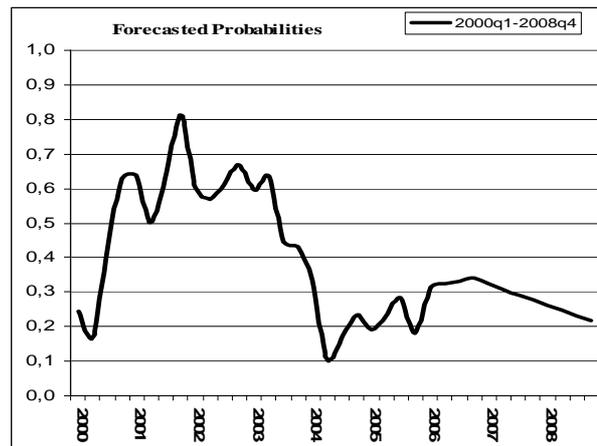


Figure 5.3.6: Forecasted Probabilities – Inflationary pressures

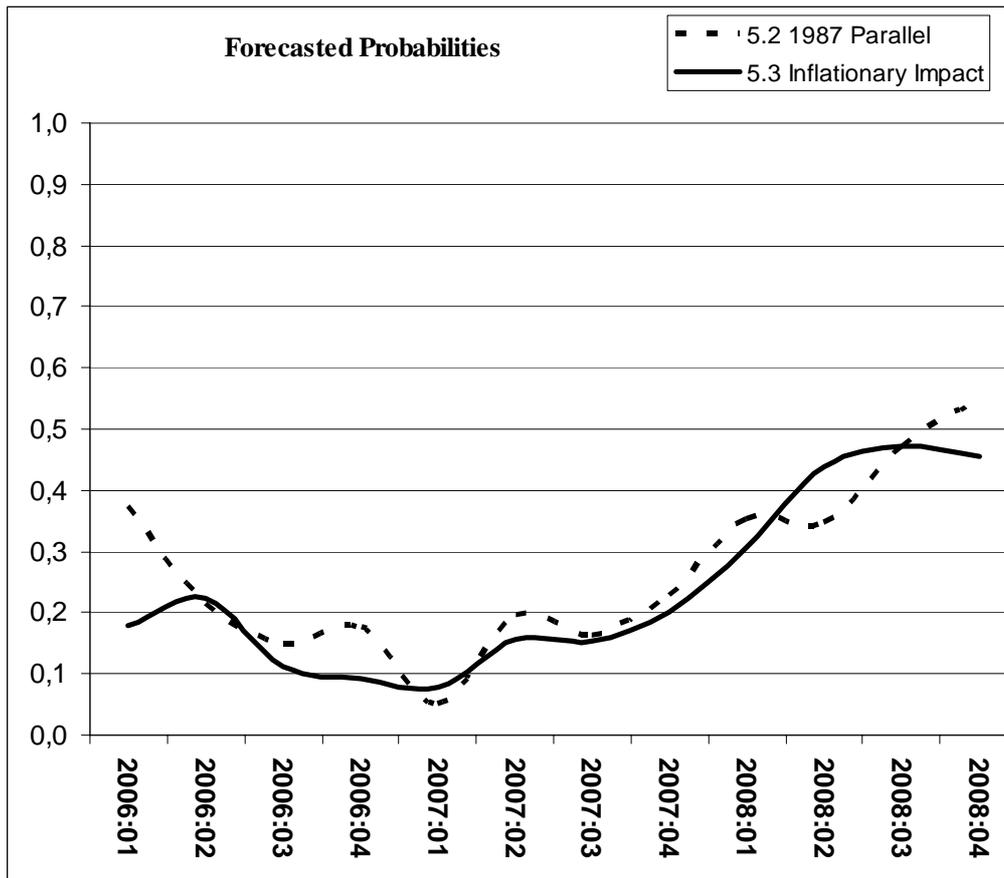


Figure 5.3.7: Comparison of forecasted probabilities (model 5.3) and computed probabilities (model 5.2) on the 1987 Current Account reversal.

Forecasted probabilities of recession reveal that no moderate increase in inflation and subsequent raises of the DWPCR will pose an imminent threat to the U.S. economy as long as the U.S. retain its global credibility as a ‘good investment’. The probability will peak in 2006q4 with a value of 0.34, and fade from thereon as the Current Account to GDP continues to deepen. In fact, the robustness of the economy is quite impressive under these assumptions. The Fed would have to effectuate a quarterly increase of 0.27 percentage points of the DWPCR for the following 12 quarters for the probability to surpass the 0.5 threshold. The result would be an astounding Interest Rate Spread of -3.74 percentages, unprecedented in the history of the U.S., and therefore I will have to conclude that the real conundrum is the future development of the Current Account to GDP.

## 6 Conclusion

Recent events, such as the deteriorating Interest Rate Spread, indicate that the U.S. economy has embarked on some sort of adaptation to lowered expectations on future real growth, although the prospect of a recession as defined by conventional standards, or 'hard landing', seems less likely in the light of the various scenarios. The probability of a financial crisis however cannot be explored within these frameworks. The U.S. economy simply appears to be sturdier nowadays than 20 years ago, even if the solid inflow of capital on which the U.S. is resting is conditioned upon the expectations as being a sound investment to foreign investors. A possible explanation for the seemingly robust U.S. economy might be given by the new emerging markets in Asia, which emerged after the dissolution of the Soviet Union. As they become increasingly open to foreign- and U.S. capital especially, their fresh surge in growth generates capital transfers in form of returns on U.S. held regional assets which in turn favour U.S. real growth. Such a state of affairs could be the case where comparative advantages of capital and labour are exploited in their full effect, according to the well-known principles initially presented by Adam Smith (1776).

The threat of heavy domestic inflationary pressures will not provoke a significant increase in the probability of recession based on the predictions of the model. Needless to say, these heavy inflationary pressures are assumed to be countered by the Fed. If such events were to pass, as long as the Current Account deficit continues to widen the probability of recession will not take off. These judgements are of course clouded by the out-of-sample characteristic of the model, but they still provide a notion of what to expect in the future.

For a Current Account reversal to pose an impending threat to the U.S. economy it has to be not only large but also swift. A moderate reversal of the Current Account deficit, along the lines of the reversal in 1987, will increase the probability of real growth below its mean but only after some time; the probability that the specific quarter will be a recession as defined in model 5.2 does not appear until 2008q4. Evidently, these aspects include the hardly predictable real exchange rate. Conventional theory suggests that a real depreciation facilitates the upholding of trade balance in the case of a Current Account deficit by making domestic goods more competitive, but to illuminate the complexity of the matter I use the words of Olivier Blanchard (2003, p. 409): "*But just the opposite happened to the U.S. real exchange rate in the late 1990s: The United States experienced a real appreciation, not a real depreciation.*". Various reasons thereof have been accounted for in chapter 2, but the incident per se reflects an increase in the foreign demand of U.S. assets. If the U.S. economy, robust as

it seems under previous assumptions, does not suffer an elevated risk of recession due to its domestic affairs, it may suffer an elevated risk of recession due to its relations with foreign capital. The foreign demand of U.S. assets might thus be, through the Current Account channel and the NIIP, correlated to the probability of recession. If demand of U.S. assets were to seize there would probably be implications for the United States.

## 7 Further Research

Certain questions remain unanswered. The timing and the pace of a reversal of the Current Account deficit has not been forecasted because it depends on difficultly assessed foreign factors such as the political agenda in greater parts of Asia. It also comprises an element in the forecasting of the demand of U.S. assets, which in turn depends on the value of the dollar vis-à-vis other currencies. The future value of the dollar and its effect on the Current Account and the NIIP is interesting and complex to estimate as global integration evolves over time. Much of U.S. foreign liabilities are denominated in U.S. dollars, whereas U.S. foreign assets are frequently denominated in foreign currencies. A depreciation of the dollar would leave the value of the liabilities unchanged but it would boost the US dollar value of foreign assets. Consequently a depreciation of the dollar would reduce the value of U.S. net foreign liabilities, and improve the NIIP (Debelle, Galati, 2005). Is it reasonable to assume that a similar improvement of the NIIP could encourage foreign investors to continue acquiring U.S. assets, and if so, to what extent?

An alternative approach when studying the foreign held U.S. assets and the probability of recession is to scrutiny the incentives for upholding the value of the dollar. In the case of the U.S. – China nexus, this approach can become quite interesting. By revaluating the Renminbi, the Chinese authorities implicitly reduce the value of their U.S. holdings, when denominated in Renminbi, as they are to a great extent denominated in U.S. dollars. The appreciation of the Renminbi also reduces the competitiveness of Chinese goods in comparison to U.S. goods, and lesser exports are to be expected. Is such an event in the interest of the Chinese authorities?

The inflationary aspect of subchapter 5.3 and affiliated raises in the U.S. DWPCR becomes quite remarkable when combined with additional observations from previous research. If U.S. interest rates were to take off, the Chinese interest rates would have to rise by an equal amount in order to retain domestic liquidity as the renminbi is committed to a fixed parity. If the Chinese authorities would not follow up with a raise in discount rate, they would probably engender a loss of Chinese reserves. To complete the picture, I refer to Goldstein and Lardy (2004) who have stated that “*the increase in domestic currency credit extended in 2004 will almost certainly be the second highest ever. It will take additional years of moderating credit growth to get investment down to a sustainable level*”. A raise in interest rates would definitely cool off the Chinese economy through their large stock of domestic credit.

If a large part of these loans would turn into non-performing-loans (NPL)<sup>15</sup>, or ‘bad credit’, as roughly 40% of them did in the last Chinese credit boom in the early 1990s (Goldstein, 2004), then the Chinese authorities could have to deal with a financial crisis as defined by Bordo et al (2001, p. 55)<sup>16</sup>. The NPLs would also pose a serious problem for domestic banks, possibly provoking a bank crisis. If foreign investors were to sell off their Chinese assets en masse due to the newly emerged crisis, or to use a term of Calvo and Mendoza (1997), act according to a herding behaviour in the absence of satisfactory information quality, a plunge in asset prices would take place (after all, the foreign investors acting on a market where information is scarce infer information from the actions of other investors).

The implications for the U.S. would be transferred through two channels mainly. The first channel is the Renminbi. A similar bank crisis could very well turn into a Chinese currency crisis as foreign investors withdrew their assets and exchanged them for dollars. Problems in the banking sector typically precede a currency crisis and the currency crisis deepens the banking crisis, thus reinforcing each other (Kaminsky, Reinhart, 1999). If Chinese reserves were depleted, the fixed exchange rate would have to be dropped, and the Renminbi would probably depreciate as to reflect the poor state of the economy, in which case the position of Chinese banks would be weakened further if a large share of their liabilities were denominated in foreign currency (Mishkin, 1996a). The plunge of the Renminbi would strengthen the U.S. dollar even further. Depending on the Marshall-Lerner effect and the J-curve, the cost of imports would decrease up to six months to a year after the currency crash (Blanchard, 2003 p. 406) only to increase in the medium term, whereas U.S. exports would decrease. The effect on the U.S. real GDP would probably be negative.

The second channel consists of the U.S. held Chinese assets. The crisis in China could transmit to the U.S. via deteriorating Chinese assets held by U.S. banks. Banking problems tend to arise from the deterioration in asset quality possibly resulting from a collapse in real-estate prices or increased bankruptcies in the nonfinancial sector (Kaminsky, Reinhart 1999). A crisis is also more likely to spread between countries through the channels of income

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<sup>15</sup> A report on Chinese NPLs were emitted by Ernst & Young as a part of their annual global survey, stating that the value of the NPLs were as high as 900 billion U.S. dollars, approximately four times the amount admitted by official Chinese sources (McGregor, 2006), but it was later withdrawn.

<sup>16</sup> Bordo et al (2001, p. 55): “...episodes of financial-market volatility marked by significant problems of illiquidity and insolvency of financial-market participants and/or by official intervention to contain such consequences”

effects if there is a large degree of bilateral trade. These chains of events are particularly noticeable in open emerging market and even ones with relatively sound fundamentals are not capable of insulating themselves from events in the rest of the world (Fratzscher, 2003). Goldstein (1998) put forward the observation that the level of economic activity, in the wake of a crisis for example, spread across borders as global operators reassess their portfolios and strategies in accordance with altered pay-offs on investments, raising the degree of financial market co-movements. If a classical banking crisis would strike the U.S. economy, the implications could be grave as the liquidity and the stability of the international financial system would be in jeopardy.

This is a scenario where the chain of events has been taken very far and they might be unlikely to occur and definitely contested but nevertheless the probability remains if ever so slight that they may take place in which case they will have noticeable effects on the U.S. economy and the global economy. These events are of course difficultly assessed but still they comprise an element in the forecasting of the probability of an occurrence of a U.S. recession. Unfortunately, it is not within the elaborated framework of the conceived probit model to quantify the probability of such overseas events, and even less the magnitude of the effects on the U.S. economy.

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## **Appendix A**

### **Source reference of data**

#### **Gross Domestic Product (GDP)**

Bureau of Economic Analysis (2006)  
Table 1.1.5. Gross Domestic Product  
Last Revised March 30, 2006

#### **Price Deflator**

Bureau of Economic Analysis (2006)  
Table 1.1.9. Implicit Price Deflators for Gross Domestic Product  
Last Revised March 30, 2006

#### **Asset Price**

Federal Reserve (2006)  
Unique Identifier: Z1/Z1/FL152000005.Q  
Households and nonprofit organizations total assets asset (Seasonally Unadjusted Level)

#### **Current Account**

Bureau of Economic Analysis (2006)  
Table 1. U.S. International Transactions  
Earliest Year Revised on March 14, 2006

#### **Domestic Credit**

Federal Reserve (2006)  
Unique Identifier: Z1/Z1/FL153166000.Q  
Households and nonprofit organizations consumer credit liability (Seasonally Unadjusted Level)

#### **Domestic Investments**

Bureau of Economic Analysis (2006)  
Table 5.1. Saving and Investment  
Last Revised March 30, 2006

#### **NYSE**

NYSE Group (2006)  
Historical Data for NYSE Composite Index (Symbol NYA)

#### **Interest Rate Spread**

Federal Reserve (2006)  
Market yield on U.S. Treasury securities at 10-year constant maturity, quoted on investment basis; Unique Identifier: H15/H15/RIFLGFCY10\_N.M  
Market yield on U.S. Treasury securities at 3-month constant maturity, quoted on investment basis; Unique Identifier: H15/H15/RIFLGFCM03\_N.M

**Unemployment**

Department of Labor (2006)

Series Id: LNU04000000Q

Unemployment Rate; 16 years and over; Not seasonally adjusted

**Discount Rate**

Federal Reserve (2006)

Average Discount Rate on Loans to Member Banks Quoted on Investment Basis,  
Federal Reserve Bank of New York

Unique Identifier: H15/discontinued/H0.RIFSRD\_F02\_N.M

**Discount Window Primary Credit Rate (DWPCR)**

Federal Reserve (2006)

The rate charged for primary credit under amendment to the Board's Regulation A

Unique Identifier: H15/H15/RIFSRP\_F02\_N.M