THE MINISTRY OF FINANCE'S ADVISORY COUNCIL ON INVESTMENT STRATEGY

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The regional and currency distribution of the Government Pension Fund – Global

Introduction

The principles behind the regional and currency distribution of the benchmark of the Government Pension Fund – Global were laid out in the Revised National Budget 1997 and the National Budget 1998, with later important elaborations in the National Budget 2003 and Revised National Budget 2006.

In the beginning, the Fund's currency and market exposure corresponded to Norway's import weights. In the National Budget 1998, it was argued that other considerations reduced the importance of import weights, such as the tendency of real exchange rates to adjust according to purchasing power parity in the long run. It was also emphasised that the real exchange rate risk would be reduced as import of one good can be substituted by import of another good with a more favourable price development.

The Fund's current regional distribution is primarily the result of a trade-off between import weights on one hand and market cap and GDP weights on the other. Compared to import weights, market cap weights are expected to improve the diversification of market risk. Moreover, if the Fund's investments were too dominant in relatively small markets, the overarching goal of being a financial investor with small ownership shares in individual companies would be jeopardised. As the Fund's size has grown, it has also been argued that operational issues – such as liquidity and market size – increase the importance of market capitalization weights for the Fund's regional weights.

Given the importance of the regional and currency distribution in determining the composition of the Fund's benchmark, the Investment Strategy Council has spent some time on the issue.

While there exist some academic literature as well as international practice to draw on when considering such an issue for a resource fund, there is considerably less material available than for other investment strategy issues. The Council therefore found it useful to commission the report *Strategic Currency Allocation for Resource Funds* by Francis Breedon and Robert Kosowski, the main findings of which were presented at the Norwegian Ministry of Finance's Investment Strategy Summit on 3 June 2009.

The Breedon-Kosowski report

The report contains a very useful review of the international research literature on optimal currency allocation and related macroeconomic literature. It highlights several reasons why

market-capitalization weighting may not be optimal, such as departures from purchasing power parity and liability issues.

The theoretical framework of the report is based on an asset liability management approach, taking as a starting point the Fund's role in financing Norway's future imports. The static model has a simple logical structure, making it optimal to choose currency portfolio weights close to the expected net import shares in the presence of real exchange rate risk. Using trends in past net imports data to project future net import shares, the report suggests that the net import portfolio would give significantly higher allocation to near neighbours (such as Sweden and Denmark), emerging markets (China and Eastern Europe) and a reduced allocation to financially developed economies (USA, UK and Japan) that have high market capitalization relative to trade.

Evaluation of the report

The presentation of the Breedon-Kosowski report, first in the Investment Strategy Council and later in the Summit on 3 June, raised a number of different questions and issues. Hence, while the model is too simple to be applied literally, it raises several important questions and provides many insights. Among them are:

1. What is the proper measure of import weights? Is it gross or net import weights? What forecast errors are associated with estimating future weights?

2. Are there import substitution effects in the presence of real exchange rate shocks? If a country's currency is subject to significant real appreciation, for instance, to what extent will Norway switch imports away from that country? Such substitution possibilities would reduce the real exchange rate risk for the Fund.

3. Any significant tilt away from market capitalization weights should take into account the size of countries and their capital markets. A very large increase in the allocation to Sweden, for instance, is not realistic. An alternative approach could be to optimize across regions instead of countries.

4. What is the intrinsic currency exposure of stocks? This is a question which remains largely unresolved. A company often has exposure to many different currencies, not only the currency in which it is listed on the stock exchange.

5. One might consider separating the asset allocation issue and the currency exposure issue. One way to do this would be to adopt a currency overlay strategy. The costs and feasibility of such a strategy should be evaluated.

The analysis shows that there is considerable scope for further research.

The Council regards it as important to consider the real exchange rate risk as compared to the other risks of the Fund. The Council is not convinced, however, that hedging real exchange rate risk is an urgent issue. The reason is that the "liabilities" of the Fund – in terms of future imports – lie many years into the future. In the short to medium term, non-oil net imports will be financed by net oil exports, while the capital income of the Fund will be accumulated and not spent on net imports. Also, if purchasing power parity holds in the long run –

which is the most likely outcome – the need for hedging real exchange rate risks would no longer be important.

A framework for regularly reviewing the distribution
Finally, the Council would like to highlight the desirability of having in place a transparent framework and process for regularly reviewing the regional and currency distribution.

The strategic benchmark of the Government Pension Fund – Global is typically slow-moving and undergoes relatively few and infrequent changes over time. This would seem appropriate for this Fund, but it is nonetheless desirable to have in place a framework and a process for reviewing the benchmark as important parameters change.

As an illustration, if one were to continue the current fixed weights for the regional and currency distribution that are based on a combination of (net) import and market capitalization weights, it would seem appropriate to regularly review – for example every third year – the distribution to take into account any significant changes in the net import and market capitalization weights. In recent years China and other emerging markets have become more significant net exporters to Norway, and the USA's share of international capital markets has shrunk somewhat. Assuming the benchmark is to reflect such patterns, it would be useful to have in place a transparent framework for evaluating the regional distribution of the Fund.

Oslo, 27 August, 2009

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Strategic Currency Allocation for Resource Funds

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PRELIMINARY**

ABSTRACT

This report analyzes theoretically and empirically the case for making the currency allocation of a resource fund such as the the Norwegian Government Pension Fund's (GPF) partly dependent on the home country's projected net import weights. We review the relevant literature on optimal currency allocation (including static and dynamic international portfolio choice models with and without liabilities) as well as the recent international macroeconomic literature on a country's inter-termporal external budget contraint and external adjustments. Our review of the literature illustrates that market-capitalization weighting is not optimal in richer theoretical models and that it is not supported by recent empirical evidence. This leads us to the analysis of optimal currency allocations in an asset-liability framework and the liability matching role of currency allocations. We describe the conditions under which the optimal currency allocation is a function of the net imports. We derive proxies for liabilities based on net import weights and analyse the risk and return of financial asset portfolios that are dependent on historical net imports weights. Our empirical results show that the historical performance of the trade-weighted portfolio has been superior to the market weighted benchmark portfolio.

Keywords: Optimal Currency Allocations, Real Exchange Rate Risk, Asset-Liability Management, Balance of Payments

First version: March 1^{st}, 2009, *This version*: June 12^{th}, 2009

*Francis Breedon and Robert Kosowski are at Imperial College Business School, Imperial College London.**This version is preliminary and does not yet incorporate useful comments received from the strategy council and participants at the ministry of finance's investment strategy summit.The usual disclaimer applies.

"In terms of the Petroleum Fund, it is natural to apply a long investment horizon and to recognize the importance of preserving the Fund's international purchasing power." (Revised National Budget 1997)

This report analyzes theoretically and empirically the case for making the currency allocation of a Resource Fund (RF) such as the Norwegian Government Pension Fund (GPF) dependent on the home country's projected net import weights. We review the relevant literature on optimal currency allocation including static and dynamic international portfolio choice models with and without liabilities as well as the recent international macroeconomic literature on a country's inter-temporal external budget constraint and external adjustments. Many theoretical portfolio choice models of optimal currency allocations are built on highly restrictive assumptions, but it is nevertheless instructive to examine them, since some of these models provide the theoretical foundation for the widespread practice of market-capitalization weighted international asset portfolios. Our review of the literature illustrates that market-capitalization is not optimal when the assumptions of standard portfolio choice models are violated or in richer theoretical models. Moreover, the recent empirical evidence questions whether market-capitalization weighting provides consistently superior risk-adjusted returns. This leads us to the analysis of optimal currency allocations in an asset-liability framework and the liability matching role of currency allocations. We analyze the impact of real exchange rate risk on a country's external balance and describe the conditions under which the optimal currency allocation of a RF should be a function of net imports weights. The empirical analysis in the current report is preliminary and we describe some planned extensions of our empirical analysis at the end of this report.

Before rigorously deriving optimal currency allocations based on a country's external balance of payments, it is helpful to illustrate the basic problem in a simplified example. It has long been understood that the most appropriate economic response to a temporary resource windfall such as Norway's oil resources is to convert it into a permanent income stream by acquiring overseas assets. This effectively achieves consumption smoothing and mitigates the structural changes required on the production side of the economy (that is the Dutch disease).

Whilst in principle the normal operation of markets should result in this process occurring without government intervention, in practice resource funds such as the GPF have proved to be the most effective way of achieving this conversion. To illustrate the basic idea, the following table presents a simplified balance sheet of a natural resource rich country:

Table 1: Simplified Balance Sheet

Assets	*Liabilities*
Present Value of Natural Resources Underground	Present Value of Country's
$\Downarrow$	Future Liabilities (Excess of
Present Value of Financial Assets and Other	national non-oil spending over
Investments	national non-oil production)

The asset side of the balance sheet is transformed over time from the present value of oil under-

ground into the market value of international financial asset and other investments.

Some papers on the optimal asset allocation for resource funds adopt a framework that ignores the liabilities side of the balance sheet and focuses on (unconditionally) hedging oil price risk through optimal diversification across non-oil financial assets such as equities and bonds. Gintschel and Scherer (2008), for example, examine the optimal asset allocation for a RF by solving a mean-variance optimization problem across oil assets and international equity and debt securities. The authors' approach fundamentally differs from our approach since it focuses on oil price risk rather than real exchange rate risk. We would argue that short positions in oil prices themselves is the most natural hedge for this risk (through a bilateral agreement with another Sovereign Wealth Fund perhaps given the limited liquidity of oil price derivatives) and thus our focus is purely on real exchange rate risk in the funds liabilities.

Although the expenditure from the GPF could take the form, pension payments, health care costs etc. ultimately such expenditure must result in an excess of domestic absorption over domestic non-oil production (i.e. net imports) and so the ultimate liability of the fund is a stream of future imports funded by returns from assets (these returns begin as revenue from resource extraction but eventually become income from financial assets). In essence, the GPF can be viewed as a centralized institutional investor that aims to convert the temporary income from oil extraction into a permanent one for Norwegian citizens and so despite being run and ultimately dispersed by the government can be viewed as independent from other elements of fiscal policy.[1]

The simplified balance sheet in Table 1 frames the objective of the RF as choosing assets such that the present value of the assets matches the liabilities. A rigorous analysis of the RF's optimal policy requires an analysis of Norway's balance of payments. In order to express the objective in terms of the returns on the assets and the returns on liabilities, we may assume that currently the fund's assets are sufficient to match the liabilities, that is the funding ratio is one. Therefore, the objective becomes selecting a portfolio of assets whose returns are positive on average and highly correlated with the returns on liabilities. Given today's level of assets and liabilities we can therefore think of the future value of assets and liabilities as being determined by the growth rate of assets and liabilities over time. Therefore the stock of assets and liabilities in the future is the result of flows during regular intervals. In economics, the balance of payments, measures the payments that flow between any individual country and all other countries. It is used to summarize all international economic transactions for that country during a specific time period, usually a year.

What is the interpretation of the asset and liabilities returns in the context of the balance of payments? The macroeconomic literature provides us with a framework for analysis. The net foreign asset (NFA) position of a country is the value of the assets that the country owns abroad, minus the value of the assets owned by foreigners. The *traditional* balance of payment identity ignores valuation effects and views changes in net foreign assets as being fully captured by the current account.[2] The

[1] The Norwegian Petroleum Fund has several other official purposes listed in Kjaer (2001).

[2] According to the balance of payments, the sum of the current account and the capital account equals the official reserve transactions balance (the net change in government reserves). The current account consists of the trade balance,

recent macroeconomic literature (Clarida (2006) for a survey) studies the implications of a *new* balance of payment identity, which considers the role of asset price changes and valuation effects. This research stresses that NFAs equal the current account *plus* valuation effects due to changes in asset prices of assets held abroad.

Current external imbalances can be compensated either by future trade surpluses (the trade channel) or by future favorable returns on the net foreign asset position (the valuation channel) of the home country. By examining the role of currency exposures in the trade and valuation channel, we will illustrate the rationale for why currency allocations should be dependent on trade weights.

The accumulation identity for net foreign assets (see Gourinchas and Rey (2007), for example) between periods t and $t-1$ captures the impact of the trade and the valuation channel on a country's net foreign asset holdings:

$$NFA_{t+1} = R_{t+1} \times NFA_t + NX_{t+1}, \tag{1}$$

where NX_{t+1} represents net exports, defined as the difference between exports X_{t+1} and imports M_{t+1} of goods and services; NFA_t measures net foreign assets, defined as the difference between gross external assets A_t and gross external liabilities L_t, measured in the domestic currency. R_{t+1} denotes the (gross) return on the net foreign asset portfolio, a combination of the (gross) return on assets R^n_{t+1} and the (gross) return on liabilities R^l_{t+1}.Equation 1 implies that the net foreign position improves with positive net exports and with the return on the net foreign asset portfolio.[3]

The importance of valuation effects has increased over the last years. According to Gourinchas and Rey (2007), the gross stocks of cross-border assets and liabilities have increased dramatically from roughly 50 percent of world GDP in the early 1990's to more than 120 percent a decade later. Therefore, capital gains and losses on those assets have significant effects on the balance of payments.

Equation 1 highlights the importance of reserve management and illustrates the conversion of natural resources into permanent foreign income and the role of the RF's currency allocation. In the early years's of the RF's existence NX_t is positive as resource exports X_t are likely to exceed imports M_t. As natural resources are exhausted over time NX_t can be expected to fall and become negative. To ensure that the current external balance is positive at any given point it is crucial that NFA_t (consisting to a large extent of RF's assets) fulfill certain conditions. First, for a given level of risk, the mean return on the NFA R_{t+1} should be as high as possible. In particular the mean return should exceed the increase in net imports. Second, the risk measures should reflect the RF's objectives such as minimizing the unconditional volatility (or standard deviation) of R_{t+1} as well as a maximizing the correlation between R_{t+1} and decreases in NX_t. The reason for the correlation objective is that the external balance can be expected to be adversely affected in a scenario where the value of net foreign assets drops while net exports suddenly fall at the same time. Of course,

other net receipts (from investment income, service transactions, and unilateral transfers (gifts, pensions, and foreign aid). The capital account is made up of net receipts from capital transactions (purchases of stocks and bonds, bank loans) as well as a statistical discrepancy item.

[3]Note that the accumulation identity ignores other elements that affect the balance of payments such as unilateral transfers, capital account transactions and errors and omissions.

a country's resource fund is not the only entity that can accumulate net foreign assets. However, given the size of the Norwegian GPF it is realistic to assume that over time the GPF accounts for the majority of net foreign assets.[4]

Equation 1 also illustrates the importance of the RF's currency allocation. R_{t+1} is the return on net foreign assets in domestic currency (that is in NOK in the case of Norway). We would like to study the impact currency allocations and currency risk on both NFA_t as well as NX_t. In particular, we would like to understand under which conditions the currency allocation in the RF may lead to a positive valuation effect on NFA_t while the country experiences a negative effect from its current account. To the extent that net imports can be seen as a liability, we will see that the currency allocation may fulfill a liability matching function when assets are optimized in the presence of liabilities.

As Equation 1 above shows the asset allocation decision should be conditioned on the future expected path of the balance of payments due to an expected non-oil trade deficit. In practice, this deficit – the difference between overall non-oil exports and imports - will consist of a large number of bilateral net import positions each with its own currency exposure.

If for simplicity we assume that all the bilateral positions are positive (i.e. Norway is a net non-oil importer from all its trading partners), then it is clear that the currency composition of the non-oil deficit is simply the weighted average of bilateral exchange rates based on bilateral net import positions (not gross imports as is sometimes assumed since export revenues will continue to fund a significant portion of imports). Allowing for a mixture of positive and negative net import positions complicates the analysis somewhat (by implying a mixture of positive and negative currency weights) but the principle remains the same. Thus the fund is faced with an asset-liability matching problem where liabilities are mostly driven by the uncertain currency value of future net imports.

i. The above discussion illustrates that the currency mix of the assets and liabilities may have an important effect on the success of the asset allocation approach. We therefore decompose the asset allocation problem into two components:

ii. We analyze and estimate the current and future expected net imports in terms of currency denomination and foreign currency nominal value.

iii. We examine which currency and asset allocation strategy is most likely to succeed in matching the expected currency mix of net imports.

Thus, we address the following question: *What is the optimal currency allocation of Norwegian Government Pension Fund's assets if the overall objective is for the volatility of assets to match that of liabilities?*

The framework outlined above will serve us to review the literature on optimal currency alloca-

[4] Alberola and Serena (2008) examine the subcomponents of sovereign external assets further by distinguishing between public and private capital flows in the following balance of payments identity: Current Account Balance + Capital Inflows - Private Capital Outflows = Change in Sovereign Wealth Fund Assets + Change in Reserves = Change in Sovereign External Assets.

tions. A subset of the literature on optimal portfolio choice largely focusses on static and dynamic optimal portfolio choice *in the absence* of liabilities. This literature examines optimal portfolio weights and currency allocations given a set of returns on assets R^n_{t+1}.The asset liability management (ALM) literature examines both assets and financial liabilities and models the return on assets R^n_{t+1} and the return on liabilities R^l_{t+1} discussed in the context of Equation 1. However, this literature does not model net exports NX_t as part of the liabilities. Our framework above clearly shows that the objective function of the RF should include NX_t. To our knowledge, we are the first to examine the role of optimal currency allocations in the context of the asset liability matching problem represented by a country's net foreign assets NFA_t and net exports NX_t over time.

The portfolio choice and asset management (AM) literature's conclusions regarding optimal portfolio weights are model specific and are derived for representative investors based on a specific set of assumptions about variables such as (i) investor's risk preferences, (ii) exchange rate movements, (iii) asset returns and (iv) market integration. Although, there is empirical evidence that several of the underlying assumptions are not fulfilled in practice - PPP, for example - it is instructive to review the conclusions from these models since they provide a useful framework to structure the analysis and isolate different hedging demand drivers. Moreover, it will become apparent that market capitalization weighting schemes and unhedged foreign asset holdings are only (theoretically) optimal under very restrictive assumptions. Another conclusion from the review of the literature is that given the complexity of international real return, inflation and exchange rate patterns, theoretical asset management models provide relatively little guidance regarding optimal hedging policies for specific schemes. Therefore, optimal currency allocations are portfolio and investor specific and the empirical literature that examines the risk-return properties of different currency hedging policies provides guidance. Recent evidence on currency hedging suggests that market capitalization weighting may not be optimal and adds to research that shows that market-capitalization weighted equity and fixed income indices underperform benchmarks based on alternative schemes (Arnott, Hsu, Li and Shepherd (2008), Arnott, Hsu and More (2005)). However, to the extent that historical risk premia and correlations may not be good measures of *ex ante* expected returns and risks, a forward-looking economic analysis conditional on current macro-economic conditions may be warranted. We attempt such a qualitative analysis when we interpret our empirical results.

The asset liability management (ALM) literature addresses the short-coming of traditional portfolio choice models that ignore liabilities. Given that RFs by their very nature exist to provide resources to match future liabilities, it is crucial to examine how conclusions regarding optimal portfolio choice and currency hedging change as assets and liabilities are explicitly modelled. The conclusions from this literature are similar to the AM literature in that optimal portfolio weights and hedging policies crucially depend on (i) investor's (inter-temporal) risk preferences with respect to assets and liabilities, (ii) the correlation between returns on assets and liabilities, (iii) the impact of exchange rate risk on assets and liabilities and (iv) the time-variation in assets and liabilities. Optimal portfolio allocations eventually depend on a scheme's specific asset and liabilities and therefore our empirical analysis will take into account the specific assets and liabilities of the Norwegian GPF. In particular, we will discuss the conditions under which Norway's net import mix can be expected

to affect the optimal asset and currency allocation. We then derive the optimal currency allocations and examine the risk-return properties of using currency allocations that match liabilities instead of using market-capitalization based currency allocations.

The report is structured as follows. Section I reviews theoretical and empirical work on optimal currency allocations without liabilities. Section II reviews the theoretical work on surplus maximization and exchange rate theory and describes our theoretical framework. Section III describes our empirical implementation of out net import framework and its performance. Section IV concludes.

I. Optimal Currency Allocation in the Asset Management Context (in the Absence of Liabilities)

Given our discussion of the practical importance of net foreign assets and net exports for the RF's optimal portfolio choice, one may question the practical recommendations based on theoretical portfolio choice models that ignore liabilities. However, it is instructive to review these models since (a) they provide the theoretical foundation of different forms market capitalization weighting schemes that are implicitly followed by some large institutional investors and (b) they are important determinants of the RFs current approach to asset allocation[5]. The Norwegian Ministry of Finance formulates both the overall investment guidelines and the benchmark portfolio against which the performance of the Norwegian GPF is measured, while Norway's central bank is the operational manger of the fund. The benchmark portfolios are market-capitalization or value weighted benchmarks for both fixed income and equities securities. China has three sovereign wealth funds including China Investment Corporation (CIC), National Social Security Fund (NSSF) and China-Africa Development Fund (CAD) which were projected to manage a pool of $729 billion by 2010[6]. The equity investment mandates are benchmarked against value-weighted MSCI benchmarks and the fixed-income mandates are benchmarked against JP Morgan and other fixed income benchmarks. The Kuwait Investment Authority also uses market-capitalization weighted equity indices as benchmarks for its equity portfolios.

A subset of the optimal portfolio choice literature examines optimal portfolio weights and expected returns in the context of a domestic and foreign asset portfolio while, for simplicity, abstracting away from liabilities. In terms of Equation 1 this literature derives optimal asset weights and currency allocations given a set of returns R^n_{t+1}. These models typically start from a micro-theory of individual portfolio choice and via aggregation and market clearing, the models provide optimal portfolio weights as well as equilibrium pricing relationships and risk-return trade-offs.

Below we examine what insights the theoretical and empirical finance literature provides regarding optimal currency allocations for an international diversified fund. Two key questions that arise are whether (1) an international investors should hedge currency risk and (2) whether investment

[5]Ugano (2000) reviews the operational modalities and experience of different oil funds. Chhaochharia and Laeven (2008) examine investment strategies and performance of Soveign Wealth Funds.

[6]BusinessWeek (15 April 2008) "China's Sovereign Wealth Funds to Outsource $320 Billion," by Liz Mak

weights should be determined by market cap weighting. The theoretical framework that addresses (2) is given by the CAPM while the International CAPM addresses (1).

A. Theoretical Models

The case for market-capitalization weighting is based on the normative conclusions from the well known CAPM (Capital Asset Pricing Model) which says that every investor should hold the same portfolio of risky assets, and the optimal combination of risky assets can be separated from the investor's preferences toward risk and return (Sharpe (1964), Lintner (1965)). This portfolio of risky assets must therefore be the *domestic* market portfolio made up of all assets traded in proportion to their market capitalization.

In the absence of barriers to international investment and in the presence of exact PPP (Purchasing Power Parity) and identical consumption baskets, the standard one-factor capital asset pricing model obtains internationally (Grauer, Litzenberger and Stehle (1976)).[7] In the extended domestic CAPM the market portfolio consists of the market capitalization weighted portfolio of all risky assets in the world. A domestic investor is concerned with the domestic purchasing power of her portfolio, so real exchange rate movements make foreign currency risky from her perspective.

There is extensive empirical evidence that PPP does not hold (Lothian (1990), Froot and Rogoff (1995), Taylor 2002, Taylor and Taylor (2004), Lopeze, Murray and Papell (2005)) and that consumption preferences can differ among countries[8]. Therefore, real prices of consumption goods may differ between countries leading to real exchange rate risk that investors will want to hedge against.

The International CAPM (ICAPM) describes the optimal portfolio choice and expected returns under these conditions (Solnik (1974), Sercu (1980), Stulz (1981), Adler and Dumas (1983)). In Solnik's International Asset Pricing Model (IAPM) investors are rational mean-variance optimizers that hold optimal portfolios that provide hedges against domestic inflation and currency risk. The general version of the model predicts that investors should hold a combination of a so-called universal logarithmic portfolio and a personalized hedge portfolio (which constitutes the best protection against domestic inflation). Under the additional assumption of zero domestic inflation rates, the model results in an optimal portfolio that is a combination of the domestic risk-free asset and a portfolio of all assets, including stocks and forwards that provide a currency hedge.[9]

It is important to stress that the practical relevance of the normative implications of the ICAPM model is limited by constraints that RF face with respect to currency forward contracts. Most RFs such as the GPF face restrictions regarding currency hedging (at least hedging back into the home currency). The practical implication of these currency derivative constraints is that the assumptions

[7] If PPP holds then nominal exchange rate changes are offset by changes in relative prices so that investors in different countries perceive the same real returns from assets in different countries.

[8] Lopez, Murray and Papell (2005) find that long run PPP held for just over half of the real exchange rates in Taylor's (2002) sample.

[9] Under Covered Interest Rate Parity holdings of forwards are equivalent to foreign currency denominated bond positions.

of the ICAPM framework may be violated in practice, thus questioning the conclusions of the model. Moreover, even if several of the assumptions of the model were to hold, there are implementation issues related to currency derivatives if an investor wanted to closely implement the optimal portfolios implied by the model. Nevertheless, we review the normative implications of the model for currency hedging below.

In the ICAPM model framework, we can define the *hedge ratio* as the proportion of the portfolio that is currency hedged. The optimal hedge ratio is a function of variables such as differences among countries in relative wealth, foreign investment position, and risk aversion. Since these variables cannot be inferred from market data, the international CAPM does not provide recommendations about the optimal currency hedge ratios.

Black (1989, 1990) add's additional assumptions to the ICAPM and derives a 'universal' hedge ratio that is optimal to all investors. Black's (1990) universal hedging formula is given by

$$\frac{\mu_m - \sigma_m^2}{\mu_m - \frac{1}{2}\sigma_e^2}$$

where μ_m = the average across investors of the expected excess return (return above each investor's riskless rate) on the world market portfolio (which contains stocks from all major countries in proportion to each country's market value); σ_m = the average across investors of the volatility of the world market portfolio (where variances, rather than standard deviation, are averaged) and σ_e = the average exchange rate volatility (averaged variances) across all pairs of countries.

The formula suggests that everyone hedge the world market portfolio with forward currency contracts in the same way, because everyone holds the same risky portfolio. Unfortunately, this universal hedging formula only gives the aggregate dollar amount to hedge as a proportion of the total dollar value of the world equity market portfolio. Nevertheless, universal hedge ratios may be useful in simplifying the design of currency hedges for portfolios that are owned and managed in different countries. Further, they would be useful in the construction of a single performance benchmark for evaluating and comparing international funds, if the underlying assumptions hold.

Adler and Prasad (1992) generalize Black's (1990) result, relaxing some of the earlier assumptions.[10] Summarizing and extending much of the earlier literature, Lioui and Poncet (2003) develop a model where deviations from international purchasing power parity can occur. The authors find that investors hedge against movements in international real interest rate differentials with respect to local real rates. These movements obey to purchasing power parity deviations, which in turn depend on real exchange rate fluctuations. Thus, in this model currency hedging is optimal.

A.1. Market Imperfections and Segmentation

The recommendation of a universal hedge ratio is chiefly dependent on the assumptions that investors hold the world market portfolio since the diversification benefits of foreign asset holdings depend on

[10] Adler and Prasad (1992) generalized Blacks (1990) findings by identifying five universal currency hedge ratios based on hedge positions in foreign bonds, stated as a fraction of national or global equity portfolios.

the relative holdings of foreign and domestic assets. There is ample evidence that investors exhibit a home bias which affects currency hedging. Moreover some investors also pursue dynamic country weight allocations in their foreign asset holdings which also affects the optimal hedge ratio.

The normative implications of the ICAPM are not only that investors should hold a currency hedged global market portfolio but also that expected returns are determined by the beta exposures to the market portfolio and different currency risk premia. Jorion (1989) and Solnik and McLeavy (2002) interpret the normative recommendations from these models as suggesting that optimal currency hedging is an investor specific decision that depends on each investor's portfolio and risk preferences. Given the lack of theoretical recommendations regarding optimal currency hedge ratios, funds pursue different strategies: 1) full hedging, 2) no hedging, 3) use of a 50 percent-hedged benchmark.

The international CAPM relation applies to all securities only in an integrated world capital market. If currency hedging is not available, the simple pricing relation breaks down. The ICAPM proposes a simplified structure for global asset management - in other words, a benchmark or passive investment strategy. It basically recommends 'buying the market' optimally hedged against currency risk. The international CAPM concludes that everyone should hold the same risky portfolio with the same amount of currency hedging.

Solnik's (1974) analysis underlies the conventional wisdom that foreign equity exposure should be hedged. One of the factors that may overturn Solnik's conclusions is a correlation between local currency equity returns and the exchange rate. One example would be a depreciation of a foreign currency against the dollar which offsets and increase in the foreign currency value of foreign equities, thus leaving the dollar value unchanged. There is evidence that some emerging equity markets behave this way, in particular in periods of currency crises (Froot(1993)).

Mean-variance investors can be expected to hold foreign currency for two main reasons: risk management demands (resulting from covariances of foreign currency with the state variables that determine investors marginal utility) and speculative demands (resulting from positive expected excess returns or alpha on foreign currency over domestic safe assets). When currencies and equities are uncorrelated, risk management demands for foreign currencies are zero, implying that in the absence of speculative demands, full hedging is optimal (Solnik (1974)).

One type of risk management demand arises if there is no domestic asset that is riskless in real terms, for example because there are only nominal bills and there is inflation rate uncertainty. In this case, the minimum variance portfolio may contain foreign currency (Adler and Dumas (1983)). This effect can be substantial in emerging markets countries with high inflation rate uncertainty. Campbell, Viceira and White (2003) show that it can be important for investors with long time horizons, because nominal bills expose investors to fluctuations in real interest rates, while nominal bonds subject them to inflation uncertainty which is relatively more important at longer horizons.

Behavioral Finance and Optimal Currency Allocations The above literature is based on rational representative agent models. Behavioral factors such as cognitive bias may also play an important practical role in optimal currency allocation. Statman (2005) points out that the cognitive

bias of hindsight is followed by the emotion of regret. He reports that some portfolio managers hedge 50% of the currency exposure of their portfolio to avoid the pain of regret, since a 50% hedge is sure to make them 50 percent right. He quotes a Mercer survey of staff at a large pension funds worldwide in 2000 which revealed that 34% of respondents with partially hedged benchmarks believed that currency exposure should be set at 50% to minimize regret.

B. Review of Empirical Work

How should an investor interpret the practical implications of research on optimal currency allocations? One approach is to test the implications of the International CAPM. A model that shows how assets are priced in a world in which asset markets are fully integrated, can be used to test whether asset markets are segmented internationally or not (Stulz (1980)). A failure to reject the predictions of the ICAPM may be taken as evidence in support of the ICAPM and the holding of a currency hedged global market portfolio.

Another approach is to focus on empirical research on optimal currency allocations based on historical data and a given asset portfolio. Here we first review the literature on tests of the ICAPM before turning to the empirical literature on optimal currency allocations. Next we turn to empirical work on dynamic asset pricing models and its implications for optimal currency ratios. Then we examine the recent portfolio balance literature.

The empirical work can be subdivided into (1) studies that test International Capital Asset pricing model by testing its implications and (2) work that calculates optimal currency allocations for given portfolios of domestic and foreign bonds and equities.

B.1. Tests of the ICAPM and Market Segmentation

If the assumptions or implications of the International CAPM are empirically rejected then this would not support the empirical validity of the ICAPM model and its normative recommendations regarding optimal currency allocations.

Of course, tests of the International CAPM suffer from the same caveats as tests of the domestic CAPM, namely the Roll critique and the fact that the global market portfolio is not observable. Moreover, there is extensive evidence that investors exhibit a home bias (French and Poterba (1991), Tesar and Werner (1995)) which violates one of the assumptions of the International CAPM. Nevertheless, tests of the International CAPM have been conducted by testing the relationship between risk exposures and expected returns. The literature on International CAPM tests can be divided into two groups groups.

First, some papers examine whether currency risk is priced unconditionally and conditionally. Giovannini and Jorion (1989) apply the traditional CAPM to international markets and find that the price of world market risk is not significantly different from zero. Korajczyck and Viallet (1990) find that a multifactor model outperforms single factor models and that foreign exchange risk is

a priced factor. Dumas and Solnik (1995) examined time variation in expected returns and risk and reported that significant currency risk premiums exist. De Santis and Gerard (1998) conclude that there is strong support for the conditional International CAPM with time-varying market and currency risk which supports the use of tactical asset allocation.[11] Tai (2008) presents evidence of asymmetric currency exposure and currency risk pricing, suggesting that both asymmetry and conditional heteroskedasticity play important roles in testing currency exposure and its price.

Second, some studies test the ICAPM indirectly by examining market segmentation, that is, whether domestic market risk is priced beyond global market risk. The International CAPM implies that global risk factors should matter and country specific factors should not. Bekaert and Harvey (1995) examined country returns exposure to the world market portfolio (beta) and the variance of a country's returns. They found that emerging markets have become more integrated over time but that some segmented markets remain. De Santis and Gerard (1997) test a conditional version of the CAPM in an international setting and find that country specific risk was not priced while the world price of covariance risk was equal across countries and time-varying.

B.2. Optimal Currency Hedging

The empirical evidence regarding the optimality of currency of hedging shows mixed results. Eun and Resnick (1988) argue that exchange rate risk is, to a great extent, non-diversifiable, and find that stock portfolios perform better when fully hedged.

Perold and Schulman (1988) compare fully hedged and unhedged (bond and equity) portfolios and present evidence that currency hedging reduces portfolio volatility (standard deviation), but the authors do not document the statistical significance of their results and the impact of currency hedging on the return and Sharpe Ratio of the associated portfolios. Bekaert and Hodrick (1992) show that the addition of currencies improves the performance of stock portfolios.

Glen and Jorion (1993) calculate optimal portfolio weights and currency allocations for a U.S. investor who chooses fixed currency weight to minimize the unconditional variance of a portfolio containing equities, bonds and one-month forward contracts. The authors examine the baseline case of unconstrained mean variance optimization but also carry out robustness checks with respect to currency short-sale restrictions, conditional hedging strategies based on interest differentials and out-of-sample tests. The authors report that, in their sample period from 1974 to 1990, a conditional hedging strategy substantially raises portfolio performance, even when using out-of sample tests and short-sale restrictions. Given the reported importance of conditional hedging strategies, these results question the relevance of unitary and universal hedge ratios, in particular and of the unconditional asset-pricing frameworks in general.

Recent research on optimal currency hedging from the perspective of several countries over the

[11] Other papers that empirically examine the inclusion of exchange risk(s) in a multi-factor model include Jorion (1990, 1991), Bodnar and Gentry (1993), Cooper and Kaplanis (1994), Choi and Prasad (1995) and He and Ng (1998) among others. Vassalou (2000) provides some tests of unconditional restrictions implied by this inclusion and finds support also for the pricing of foreign exchange risk in stock returns.

period 1975 to 2005 finds qualified support for the argument that adding forward contracts to international portfolios significantly improves the risk-return profile of global investments (Campbell, Serfaty-de Medeiros and Viceira (2008)). The authors find support for conditional hedging strategies (based on interest rate differentials) but report that the risk-reduction properties of different currencies vary and depend on the country's reserve currency status and correlation with the global business cycle. Interestingly, most currency returns are almost uncorrelated with bond returns and thus risk-minimizing bond investors should avoid holding currencies.[12]

One of the caveats of the study by Campbell et al (2008) is that the authors focus their analysis on currency allocation's risk reduction properties as captured by the standard deviations of the resulting portfolios. They only report portfolio Sharpe Ratios in the online appendix. The evidence from the Sharpe ratios is much less supportive of the 'baseline' unconditionally hedged portfolio. For most countries the 'baseline' unconditionally hedged portfolio does not dominate the fully or unhedged portfolio. Moreover the conditionally hedged portfolio and a portfolio that includes a 'synthetic' currency allocation (a carry trade portfolio based on Lustig and Verdelhan (2007)) dominates the alternatives. The results show that the allocation to the carry trade portfolio reduces portfolio risk almost as much as a constrained conditional currency hedging strategy, but that it increases the mean portfolio return significantly more than alternative strategies, thus resulting in the strategy with the highest Sharpe ratio during the sample period. Similarly, conclusions regarding optimal bond portfolio currency hedging change when looking at the Sharpe Ratio. The Sharpe ratio of a bond portfolio can be significantly increased by an overhedged position or holdings of a synthetic currency. Overall, there is evidence that currency hedging leads to significant risk-return improvements. A final caveat of the study is that it is based on a historical period which has seen changes in the reserve status of different currencies. The authors find that over the 1985 period the US dollar and the euro and Swiss franc have moved against world equity markets. Thus these currencies should be attractive to risk-minimizing equity investors. The authors report for example that the euro and U.S. dollar are reserve currencies. During the 2007-2008 crisis the euro has fallen significantly against the US dollar. Therefore a forward-looking investor will want take into account expected changes in a currency's 'safe haven' status in the future when forming expectations about the risk reducing properties of different currency allocations.

B.3. Dynamic/Multi-Period Portfolio Choice and Optimal Currency Allocations:

The empirical research reviewed above is mostly based on a one-period mean variance setting. In a multi-period framework, optimal currency holdings are influenced by additional effects.

Campbell, Viceira and White (2002) show that in a multi-period model long-term investors may not want to hedge all currency risk since foreign currency holdings may provide an intertermporal hedge against domestic long-term real interest rate risk. The authors' argument is based on Uncovered Interest Rate Parity according to which expected returns are equated across currencies. Thus a domestic investor who holds foreign currency is compensated for the deterioration in domestic

[12]The authors note that this is consistent with common practice of institutional investors.

investment opportunities (that is a fall in domestic real interest rates) by an immediate increase in wealth derived from foreign currency holdings. The authors acknowledge several caveats. First, they point out that the hypothesis of uncovered interest rate parity (UIP) is rejected by several studies (Fama (1984), Hodrick (1987), Froot and Thaler (1990) and Engel (1996)), but point to more recent evidence that they argue is more supportive of the hypothesis, especially at longer horizons which are relevant for long-term investors (Baillie and Bollerslev (2000), Chinn and Meredith (2001), Bekaert and Hodrick (2001), Bekaert, Wei and Xing (2002)). Given that Campbell, Serfaty-de Medeiros and Viceira (2008) report strong evidence of significant risk-adjusted returns on the carry trade during the period 1975-2005, one may question conclusions based on the failure of the UIRP. Second, the authors acknowledge that movements in the exchange rate may be unrelated to the domestic real interst rate. Examples are changes in the long-run equilibrium real exchange rate, movements in the foreign real interest rate or short-term deviations from uncovered interst parity. Similarly there is evidence for a slow reversion of real exchange rates to a stable long-run mean as implied by the theory of PPP (Lothian (1990), Froot and Rogoff 1995), Taylor 1995, Frankel and Rose 1996, Lotian and Tailer 1996 and Taylor 2002). Third, Campbell, Viceira and White (2002) only examined country pairs and only two assets, i.e. domestic bills and foreign bills. They have ruled out other inter-temporal hedging assets such as long-term nominal bonds and inflation indexed bonds or equities.

A separate strand of the empirical literature on currency hedging is represented by work on the portfolio balance theory of international investment. When faced by increased foreign exchange risk due to an appreciation of the foreign assets of their portfolios relative to the domestic ones, investors rebalance out of foreign assets.[13] This risk rebalancing investment strategy implies net sales of the foreign currency and hence an appreciation of the domestic exchange rate. Hau and Rey (2006) label this portfolio rebalancing 'uncovered equity parity condition' since exchange rates adjust and partly off-set the valuation effects of differential equity market performance. They provide evidence that dollar exchange rate changes of OECD countries are indeed negatively related to the relative performance of the respective equity markets. In contrast to the work by Glen and Jorion and Campbell, Serfaty-de Medeiros and Viceira (2008), Hau and Rey (2008) assume that investors cannot hedge currency risk using FX derivatives contracts and examine the hypothesis of whether (equity) portfolio rebalancing by international investors is related to equity and foreign exchange exposure.[14] The authors test the portfolio balance theory of investment using a comprehensive data set on the stock allocations of approximately 6,500 international equity funds domiciled in four different currency areas. The find strong support for portfolio rebalancing behavior aimed at reducing both exchange rate and equity risk exposure.

Related to this research Adrian and Shin (2008) report that changes in aggregate balance sheets of financial intermediaries forecast exchange rate returns, both in and out of sample, and for a large

[13] These predictions concern the portfolio risk dynamics of individual funds and are specific to the conjectured international market segmentation.

[14] The authors adopt imperfect international exchange rate risk trading as our working hypothesis and highlight that the predicted rebalancing behavior should not occur if exchange rate risk were fully traded.

set of countries. The authors estimate prices of risk using a cross-sectional, arbitrage-free asset pricing approach and show that balance sheets forecast exchange rates because of the latter's association with fluctuations in risk premia.

Overall, it appears that the are benefits to currency hedging. The evidence is stronger for currency hedging conditional on interest rate differentials and for stock portfolios than bond portfolios. Moreover, optimal currency hedges are dependent on portfolio specific assets and liabilities. The evidence on the optimality of conditional currency hedging highlights the importance for forward-looking analysis since unconditional historical average returns and correlations may provide a poor guide to ex ante expected returns and correlations.

So far we have reviewed the literature on currency hedging in the asset management context. Now we will turn to insights from the asset-liability management literature.

II. Optimal Currency Allocation in the Asset-Liability Management Context

The asset-liability management problem faced by the GPF is a complex dynamic optimization problem. For simplicity, however, we will abstract from the dynamic nature of the problem and assume that either the relative import weights are going to remain constant over time or continue their recently observed trend. This will allow us to make assumptions about future liabilities. The asset liability management (ALM) literature explicitly takes into account the role of liabilities and the resulting additional hedging demands.

A. Static

Sharpe and Tint (1990) and Nijman and Swinkels (2007) use surplus optimization as a method to reflect the presence of liabilities and its effect on optimal portfolio choice. *Surplus* at time t is a function of $\widetilde{k}$ (importance of liabilities)

$$S_t(k) = A_t - \widetilde{k} \times L_t$$

where A_t assets and L_t the value of liabilities at time t.

For a general $\widetilde{k}$, the return on the fund surplus can be defined as

$$\begin{aligned} R_t^s\left(\widetilde{k}\right) &= \frac{S_t\left(\widetilde{k}\right) - S_{t-1}\left(\widetilde{k}\right)}{A_{t-1}} \\ &= \frac{A_t - A_{t-1}}{A_{t-1}} - \widetilde{k} \times \frac{L_{t-1}}{A_{t-1}} \times \frac{L_t - L_{t-1}}{L_{t-1}} \\ &= \frac{A_t - A_{t-1}}{A_{t-1}} - \underbrace{\widetilde{k} \times \frac{1}{FR_{t-1}}}_{\text{importance of liabilities}} \times \frac{L_t - L_{t-1}}{L_{t-1}} \\ R_t^s(k) &= R_t^A - k \times R_t^L \end{aligned} \tag{2}$$

where $FR_{t-1}\frac{A_{t-1}}{L_{-1}}$ is the funding ratio at time $t-1$ and $R_t^s(k)$, R_t^A and R_t^L are the return on the surplus, the assets, and the liabilities, respectively. The surplus at time t is a function of k, a parameter that measures the importance that the fund management attaches to the value of the liabilities.

Thus, we define the return on the fund surplus as

$$R_t^s(k) = R_t^A - k \times R_t^L \tag{3}$$

where k $(=\frac{\widetilde{k}}{FR_{t-1}})$ so that actual importance of liabilities is reduced when the assets exceed the pension liabilities is defined as $FR_{t-1} = \frac{A_{t-1}}{L_{-1}}$, i.e. the funding ratio at time $t-1$; and R_t^S, R_t^A, and R_t^L the return on the surplus, the assets and the liabilities respectively.

We can rewrite the accumulation identify in Equation 1 as a surplus by noting that net foreign assets NFA_{t+1} increase with net foreign assets and decrease with net imports (NM_t):

$$\begin{aligned} NFA_{t+1} &= R_{t+1} \times NFA_t - NM_t \\ &= A_{t+1} - L_{t+1} \end{aligned}$$

where we have assumed that $\widetilde{k} = 1$ for simplicity. Note that NFA_t can itself also be interpreted as a surplus. It is the surplus of a countries financial assets over its financial liabilities. For simplicity we do not break up NFA_t into its components. Therefore, the objective of the RF can be described as maximizing the surplus return in Equation 3. Note that for a fund with $k = 1$ equation 3 simplifies to

$$R_t^s(k) = R_t^A - R_t^L. \tag{4}$$

The choice of $k = 1$ can be justified by assuming that (a) the fund's liabilities are currently fully funded and that the's managers attached equal importance to assets and liabilities in the surplus calculation. This assumption is realistic in the case of the GPF, since in contrast to a pension fund with known future liabilities, the level of Norway's liabilities and spending (i.e. net imports) are likely to be partly a function of the size of the GPF in the future.

In this static framework a standard objective would be for the fund to aim at maximizing the mean surplus for a given surplus volatility. This leads us to a mean-variance optimization problem.

B. Optimal portfolio weights

If we assume the fund has MV utility function in the return on surplus

$$U\left(R_t^S\right) = E\left\{R_t^S\right\} - \underbrace{\gamma}_{\text{risk aversion}} \times Var\left\{R_t^S\right\}$$

it can be shown (see appendix and Nijman and Swinkels (2007) for details) that the optimal portfolio weight

$$\begin{aligned} w^* &= \underbrace{\frac{1}{\gamma} \times \Sigma^{-1}(\mu - \eta \times 1)}_{\text{asset only weights}} + k \times \Sigma^{-1}\Sigma_L \\ &\underset{k=1}{=} \underbrace{\frac{1}{\gamma} \times \Sigma^{-1}(\mu - \eta \times 1)}_{\text{asset only weights}} + \Sigma^{-1}\Sigma_L \end{aligned} \tag{5}$$

where Σ (covariance matrix of asset returns) and Σ_L (vector of covariances between assets and liabilities) and the

$$\eta = \frac{\mu'\Sigma^{-1}1 + \gamma \times k \times \Sigma_L'\Sigma^{-1}1 - \gamma}{1'\Sigma^{-1}1}.$$

The variance of the fund surplus can be written as

$$\begin{aligned} \sigma^2\left\{R_t^A - k \times R_t^L\right\} &= \sigma^2\left\{R_t^A\right\} + \sigma^2\left\{-k \times R_t^L\right\} + 2 \times cov\left\{R_t^A, -k \times R_t^L\right\} \\ &= w'\Sigma w + k^2 \times \sigma_L^2 - 2 \times k \times w'\Sigma_L \\ &\underset{k=1}{=} w'\Sigma w + \sigma_L^2 - 2 \times w'\Sigma_L \end{aligned}$$

where $R_t^A = w'R_t^{A,i}$ and $R_t^{A,i}$ the vector with returns on assets with $E\left\{R_t^{A,i}\right\} = \mu^{A,i}$, Σ is the covariance matrix of the returns of the assets and Σ_L the vector with covariances between the assets and liabilities. The return on the assets $r_t = \frac{P_t - P_{t-1}}{P_{t-1}} = \frac{P_t}{P_{t-1}} - 1; R_t = \log(1 + r_t) = \log\left(\frac{P_t}{P_{t-1}}\right) = p_t - p_{t-1}$.

Choice of Assets and Liabilities To gain further insight into the surplus, we can decompose Equation 4 into its components.

The domestic currency return on the assets R_t^A can be decomposed into the return on assets $i = 1, ..., N$ which consist of net equity and fixed income positions in different countries weighted by w_i

$$R_t^A = w'R_t^A = \sum_{i=1}^{N} w_i^A \times R_{t,i}^A$$

The returns on liabilities can be view as the change in net imports from countries $j = 1, ..., Q$

$$R_t^L = w'R_t^{L,j} = \sum_{j=1}^{Q} w_j^L \times R_{t,j}^L$$

Here, we assume for simplicity that w_i and w_j are constant over time, but as discussed in Section I, they could be time-varying.

C. Impact of currency fluctuations and weights on surplus return

We can examine the impact of currency allocations and currency fluctuations on the country's surplus by examining a simple two country case consisting of Norway and China, for example. This example assumes for simplicity that equity and fixed income investments are only possible in Norway and China and trade occurs only between Norway and China.

As explained above the change in net foreign assets can be viewed as a surplus return of net foreign assets over net imports

$$\begin{aligned} NFA_{t+1} &= R_{t+1} \times NFA_t - NM_{t+1} \\ &= R^A_{t+1} \times A_t - R^L_{t+1} \times L_t \end{aligned}$$

C.1. Surplus Decomposition into Assets and Liabilities

In the two-country example, the (nominal) return on assets is given by

$$\begin{aligned} & R^A_{t+1} \\ = \; & w' R^{A,i}_{t+1} \\ = \; & w_{NOK,t} \times R_{NOK,t+1} + \\ & + w_{RMB,t} \times R_{RMB,t+1} \times \frac{S_{t,RMB}}{S_{t+1,RMB}}. \end{aligned} \tag{6}$$

where $R_{NOK,t+1}$ and $R_{RMB,t+1}$ are the *nominal* domestic and foreign currency portfolio returns (consisting of fixed income and equity securities) on net Norwegian and Chinese financial assets and $S_{t,RMB}$ $(= \frac{NOK}{RMB})$ are direct currency quotes, that is domestic currency per foreign currency. The (nominal) return on liabilities can be defined as the percentage change in net imports between t and $t+1$

$$\begin{aligned} & R^L_{t+1} \\ = \; & w' R^L_{t+1,i} \\ = \; & \frac{\left(p^{t+1}_M q^{t+1}_M - p^{t+1}_X q^{t+1}_X\right) - \left(p^t_M q^t_M - p^t_X q^t_X\right)}{\left(p^t_M q^t_M - p^t_X q^t_X\right)} \end{aligned} \tag{7}$$

or

$$R^L_{t+1} = \frac{\left(S_{t,RMB} \times p^{t+1}_{M,RMB} q^{t+1}_M - p^{t+1}_X q^{t+1}_X\right)}{\left(S_{t,RMB} \times p^t_{M,RMB} q^t_M - p^t_X q^t_X\right)} - 1,$$

where q^{t+1}_M and q^{t+1}_Xdenote units of imports and exports and p^{t+1}_M and p^{t+1}_X denote import and export prices respectively.

In reality, investors care about real returns. We obtain the change in net imports in real terms by dividing by the Norwegian price level at time $t+1$ and t, respectively:

$$\Delta NM_t = \left(\frac{S_{t,RMB} \times p^{t+1}_{M,RMB} q^{t+1}_M}{P_{t+1}} - \frac{p^{t+1}_X q^{t+1}_X}{P_{t+1}} \right) - \left(\frac{S_{t,RMB} \times p^{t}_{M,RMB} q^{t}_M}{P_t} - \frac{p^{t}_X q^{t}_X}{P_t} \right), \quad (8)$$

where P_{t+1} and P_t is the Norwegian price index.

Equation 8 can be used to analyze the impact of trade weights on asset allocations.

For a given level of exports and for a given (unit) volume of imports, net imports increase if (a) the foreign currency denominated price of imports increases and (b) purchasing power parity (PPP) does not hold. If purchasing power parity *holds*, then there is no real exchange risk. According to PPP the nominal exchange rate is driven by changes in relative prices: $S_t = \frac{P_{domestic,t}}{P^{foreign}_t}$, e.g. $S_{t,RMB} = \left(\frac{NOK}{RMB}\right)_t = \frac{P^{NOK}}{P^{RMB}}$. Stated in terms of the real exchange rate RS, PPP can be restated as implying a time-invariate real exchange rate $RS = \frac{S \times P^{foreign}}{P^{domestic}}$. In practice frequent deviations from PPP are observed in the short run and medium term (see Isard (1997), Taylor and Taylor (2004) for a surveys) leading to real exchange rate risk.

If PPP does not hold then real exchange rate risk leads to fluctuations in real net imports. What is the implication for foreign asset holdings?

In the two-country example the *nominal* return on net foreign assets also depends on changes in exchange rates

$$\begin{aligned} R^A_{t+1} &= w_{NOK,t} \times R_{NOK,t+1} + & (9) \\ &\quad + w_{China,t} \times R^{China}_{NOK,t+1} \times \frac{S_{t,RMB}}{S_{t+1,RMB}}. \\ &= w_{NOK,t} \times R_{NOK,t+1} + & (10) \\ &\quad w_{China,t} \times \left(R^{China}_{RMB,t+1} + s + \left(s \times R^{China}_{RMB,t+1} \right) \right) & (11) \end{aligned}$$

where $R_{NOK,t+1}$ and $R^{China}_{NOK,t+1}$ are the nominal local currency returns on Norwegian and Chinese financial assets and $s = \frac{S_{t+1} - S_t}{S_t}$. If we assume that the term $\left(s \times R^{China}_{RMB,t+1} \right)$ is of second order and small for short time periods, we obtain the following first order approximation

$$\begin{aligned} R^A_{t+1} &= w_{NOK,t} \times R_{NOK,t+1} + & (12) \\ &\quad w_{China,t} \left(R^{China}_{RMB,t+1} + s + \left(s \times R^{China}_{RMB,t+1} \right) \right) & (13) \\ &\approx w_{NOK,t} \times R_{NOK,t+1} + & (14) \\ &\quad w_{China,t} (R^{China}_{RMB,t+1} + s) & (15) \end{aligned}$$

Investors care about real returns. We therefore have to taking into account Norwegian inflation π_{Norway}. If we denote real returns by r as nominal returns minus inflation, then we obtain

$$\begin{aligned} r^A_{t+1} &= R^A_{t+1} - \pi_{Norway} \\ &= w_{NOK,t} \times (R_{NOK,t+1} - \pi_{Norway}) + \\ &\quad w_{China,t} (R^{China}_{RMB,t+1} + s - \pi_{Norway}) \end{aligned}$$

Real exchange rate movements rs are defined as movements in the exchange rate that are not explained by inflation differentials between the two countries $rs = s + \pi_{China} - \pi_{Norway}$. We can rewrite this as

$$\Rightarrow s - \pi_{Norway} = rs - \pi_{China}. \tag{16}$$

Under PPP $rs = 0$ and fluctuations in $s - \pi_{Noway}$ are driven by π_{China} only so that we obtain

$$\begin{aligned} r^A_{t+1} &= w_{NOK,t} \times (R_{NOK,t+1} - \pi_{Norway}) + \\ & \quad w_{China,t}(R^{China}_{RMB,t+1} - \pi_{China} + rs) \end{aligned}$$

Denoting real returns as r , in real terms we get

$$\begin{aligned} r^A_{t+1} &= w_{NOK,t} \times r_{NOK,t+1} + \\ & \quad w_{China,t}(r_{RMB,t+1} + rs) \end{aligned} \tag{17}$$

C.2. Currency allocations and the net external balance

Equation 8, which shows the effect of real exchange risk on the change in real net imports, and Equation 17 which shows real NOK denominated returns of net financial assets shows that real exchange rate risk in liabilities can be potentially hedged by the appropriate currency allocation.

Equation 17 shows that violations of PPP ($rs \neq 0$) that lead to an increases in the NOK value of net imports, can be hedged by an allocation to Chinese financial assets with real return $r_{RMB,t+1}$assuming everything else is held constant.

In Equation 8 we had for simplicity assumed that China is the only trade partner for Norway. In a more realistic 4 country example with additional trading partners, Equation 8 illustrates the aggregate real exchange risk would depend on trade weights of different trade partners ($w_{China,t}$,...,etc). Therefore the net import currency weights - the liabilities side -should be match by the currency allocations on the asset side.

C.3. Comments and Extensions

Our objective of determining the RF's optimal currency allocations has been guided by equation 1 which highlights the link between net foreign assets and net imports. One of many caveats is that the optimal currency allocation in the asset portfolio may be driven by considerations other than real exchange rate risk hedging. There may, for example, be speculative reasons for conditioning the RF's currency allocation. There is evidence (Lustig and Verdelhan (2008) and Campbell et al (2008)) that the carry trade is profitable. High interest rate currencies provide higher returns than low interest rate currencies. In particular in global business cycle upturns the carry trade provides high risk-adjusted returns. Emerging markets currencies tend to have higher yields than developing

countries. Therefore allocations to countries such as China may be expected to generate some yield pick up in the future.

Second, in practice institutional investors can be assumed to face restrictions regarding allowable portfolio weights. We have not discussed short-sale restrictions in the above framework since it proves to be empirically unimportant below.

Third, the above surplus optimization framework has been static. Given that the RF by definition faces a multi-period dynamic optimization problem it may be argued that the analysis should take into account difference between static and dynamic optimization. However, at longer horizons parameter uncertainty and model uncertainty tend to offset benefits from incorporating time-variation and dynamic hedging. Below we briefly review the literature on dynamic surplus maximization.

C.4. Dynamic Asset Liability Management Without Parameter Uncertainty

For simplicity we have assumed above that the investment fund solves a static investment problem. In a more general multi-period asset-liability problem the agent maximizes inter-termporal expected utility defined over a surplus. This leads to potential hedging demands. In practice, however the difficulty of precisely forecasting surplus returns given a set of state variables in the presence of parameter uncertainty may mean that hedging demands are small and the optimal multi-period solution under uncertainty may be close to the static solution. To illustrate this result we briefly review the literature on multi-period surplus maximization.

Rudolf and Ziemba (2004) extend the framework of Sharpe and Tint (1990) to a dynamic setting with more general utility functions. Other examples include (Boulier et al. (1995) and Cairns (2000, Sundaresan and Zapatero (1997), Van Binsbergen and Brandt (2006))). The authors present an intertemporal portfolio selection model for investment companies that maximizes the intertemporal expected utility of the surplus of assets net of liabilities. Following Merton (1973) the authors assume that both the asset and the liability return follow Ito processes as functions of a state variable. The surplus S_t and the funding ratio FR_t are defined by

$$S_t = A_t - L_T,\ FR_t = \frac{A_t}{L_t}$$

According to Merton (1973), the state variable Y follows a geometric Brownian motion where μ_Y and σ_Y are constants representing the drift and volatility, and Z_{Y_t} is a standard Wiener proess. Rudolf and Ziemba (2004) note that Y may represent exchange rate fluctuations that affect the surplus of the investment company (e.g. a pension fund or life insurance company). The state variable as well as the assets and the liabilities are assumed to follow the stochastic processes:

$$\begin{aligned} dY_t &= Y_t\left[\mu_Y dt + \sigma_Y dZ_{Y_t}\right] \\ dA_t &= A_t\left[\mu_A\left(t, Y_t\right) dt + \sigma_A\left(t, Y_t\right) dZ_{A_t}\right] \\ dL_t &= L\left(t\right)\left[\mu_L\left(t, Y_t\right) dt + \sigma_L\left(t, Y_t\right) dZ_{L_t}\right] \end{aligned}$$

Following Sharpe and Tint (1990) and assuming $\widetilde{k} = 1$ in equation 3 above the authors define

the surplus return as

$$\begin{aligned} R_t^S &= \frac{dS_t}{A_t} = R_t^A - \frac{R_t^L}{FR_t} \\ &= \frac{A_t - A_{t-1}}{A_{t-1}} - \frac{L_{t-1}}{A_{t-1}} \frac{L_t - L_{t-1}}{L_{t-1}} \\ &= \left[\mu_A - \frac{\mu_L}{FR_t}\right] dt + \sigma_A dZ_t^A - \frac{\sigma_L}{FR_t} dZ_t^L \end{aligned}$$

They show that the optimal portfolio w consists of investors holding a combination of four funds: the market portfolio, the hedge portfolio for the state variable, the hedge portfolio for liabilities and the riskless asset. In contrast to Merton's result in the asset only case, the liability hedge is independent of preferences and only dependent on the funding ratio. Demand for the state variable hedge demand and the market portfolio are dependent on investors' utility preferences.

Detemple and Rindisbacher (2008) extend the framework of Rudolf and Ziemba (1994) by (a) allowing the factors in the model to follow more general diffusions and (b) by defining preferences over the intermediate cash flows, instead of the surplus.[15] Modelling preferences directly over excess cash flows may be important because intermediate pension benefits are contractually agreed payments.

Although the dynamic surplus maximization analysis is theoretically appealing since it takes into account multi-period liabilities that are ignored by standard dynamic asset management models, these dynamic ALM models suffer from similar caveats. First, the normative conclusions are based on the stochastic process that returns of different asset classes in the models are assumed to follow. Second, hedging demands are based on the ability to model predictability based on a set of state variables. Third, investment opportunities are time-varying. Fourth, conclusions are based on preferences of representative agents. Fifth, there is evidence that hedging demands are affected by parameter uncertainty. In the extreme parameter uncertainty may lead to a reduction in hedging demands and an optimal portfolio that resembles the static portfolio. Barberis (2000) examines how the evidence of predictability in asset returns affects optimal portfolio choice for investors with long horizons. He finds that incorporating parameter uncertainty reduces the amount an investor allocates to stocks for a given horizon. Barberis's findings are relevant to the dynamic asset liability problem since it is likely that parameter uncertainty is even more important for the asset-liability case where the relationship between multiple state variables and both assets and liabilities has to be taken into account. Therefore the finding that parameter uncertainty reduces the hedging demand is one motivation for our focus on the static optimization case.

[15] The autors examine a dynamic asset allocation problem of a fund manager with von Neumann-Morgenstern preferences with terminal utility function defined over the excess of liquid wealth over a minimum liability coverage tolerated and intermediate utility function defined over dividends, the excess of expenditures over liability cash flows.

III. Empirical Implementation

Although ALM is often implemented through a simple optimaization procedure using estimates (usually based on historical data) of asset and liability returns, variances and covariances to estimate portfolio weights that minimise the variance of returns on the surplus (asset minus liabilities) subject to a target return, such an approach is inapproriate in this case for a number of reasons First, the measurement of the GPF's liabilities (the present value of future net imports) is problematic and so a reliablie estimate of the surplus is not available to us (though we can employ variaous proxies as discussed below). Second, even if the surplus could be constructed reliably, it is well known that statisitical optimization often yields results that are not robust or easily comprehensible. We feel that such drawbacks would be particularly problematic in the case of the GPF where a tranparent and robust framework is important in order to engage Norwegian citizens in discussions of the fund's operation. Thus we take a more straightforward approach and focus simply on the property that both asset returns and net imports are subject to real exchange rate risk and thus a net import weighted portfolio is the approriate allocation in order to mitigate that risk that is present in the fund's liabilities. In future versions of this report we plan to compare a statisitcally optimized portfolio with the one we present here.

Therefore, in this section we aim to assess the empirical implementation of a net import weighted portfolio. We should note once again that we have deliberately ignored the issue of oil price risk both in terms of the valuation of residual assets that remain under the North Sea and in terms of the oil component of future net imports (when Norway's oil runs out). In the first case we would argue that oil price risk would be best addressed through a direct hedge of the oil price (perhaps through a bilateral arrangement with another Sovereign Wealth Fund given the limited liquidity of oil derivatives markets). In the second case we would argue that oil prices are set in international markets and so are not influenced by the real exchange rate risk which we are aiming to hedge, thus once again this risk would be best addressed through a direct oil price contract.

A. Net Import Data

Statistics Norway have kindly supplied us with data on bilateral trade in goods excluding oil and petroleum products for the period 1960 to 2008 from which we can construct net import shares. Before analyzing this data in detail it is worth pointing some deficiencies in this data set.

1) Trade in services: The major omission in our data is that reliable figures on bilateral trade in services is not available Services make up nearly 40% of non-oil exports and 30% of imports, so the omission is potentially significant (though up to around 10% of trade in services is directly related to oil). However, the little information we have on services is relatively encouraging as it highlights the importance of the EU and Nordic countries (Sweden, Finland, Iceland and Denmark) in the same way as the data on trade in goods. Table 2 shows estimates of trade in non-financial services (around 80% of the total) for 2006

Table 2: Estimates of Trade in non-financial services (2006)

	Import Share	Export Share	Net Imports
Nordic Countries	20%	15%	+5%
EU (exc. Nordic)	44%	39%	+5%
Rest of Europe	8%	11%	-3%
Asia	8%	12%	-4%
North America	11%	11%	0%
RoW	9%	12%	-3%

Source: Statistics Norway

2) Non-oil trade - Whilst excluding oil and petroleum products gives a close proxy to total non-oil trade it is hard to exclude trade in oil related activity such as imports of oil-related investment goods so it is not possible to construct a precise measure of non-oil goods trade. Although it is not possible to estimate how important this type of trade is in practice, it is unlikely to be a major contributor.

3) Other elements of the current account As well as trade in good and services, Norway is potentially exposed to real exchange rate risk on other elements of the current account such as remittances and aid which amount to around 2% of imports and 7% of exports (though note that in the case of aid, the aid budget is fixed in Krone terms thereby effectively passing the exchange rate risk to aid recipients)

4) Commodities versus Countries - as discussed above, the key risk in liabilities that the net import weighted portfolio is aimed at hedging is real exchange rate risk. However, for some goods - namely commodities, this risk is negligible and so net imports of commodities should perhaps not be hedged in that way. In principle commodity trade could be hedged by long positions in the commodities themselves. Unfortunately, very few of the categories that we have identified as commodities have an easily identifiable market price, so we simply exclude them to see if they significantly influence the results. Table 3 shows the categories we have chosen to exclude - these consititute about 15% of Norwegian non-oil imports..

Table 3: Commodity categories

RAW HIDES & SKINS
OIL SEEDS & OIL FRUITS
CRUDE RUBBER
CORK & WOOD
PULP & WASTE PAPER
TEXTILE FIBRES & WASTES
CRUDE FERTILIZERS ETC.
METAL ORES & SCRAP
CRUDE ANIMAL & VEGETABLE MATERIALS
IRON & STEEL
NON-FERROUS METALS
PETROLEUM & PRODUCTS
GAS

A.1. Time series Properties of net imports

Charts 1 and 2 show estimates of net import shares - both including and excluding commodities - since 1960 (5 year moving averages in order to iron out short term erratic movements). Encouragingly, these shares a generally quite stable given that they represent the balance of two large numbers. The importance of net imports from the Eurozone and - to a lesser extent - Sweden is clear in both total trade and trade excluding commodities. Net imports from the US and UK are more variable in importance whilst China, that was barely represented prior to 1990, has risen dramatically in importance over the last twenty years to over 10% of net imports.

As a simple comparison we note the net imports in 2004-2008 have a similarity index with net imports in 1960-1964 (intersection of net import shares divided by union of net import shares) of 57% as compared with 32% similarity between net imports in 2004-2008 and the current currency allocation of the GPF (discussed below)

Chart 1: Net non-oil import Shares (Selected Countries)

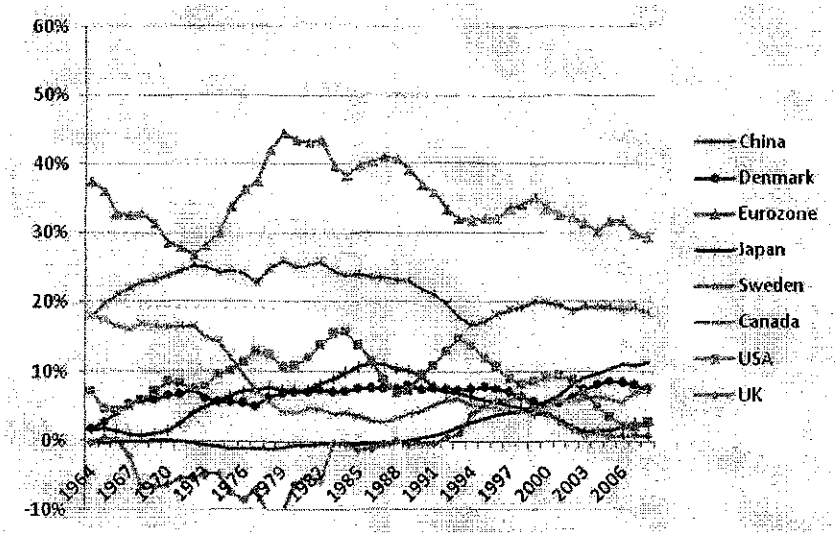
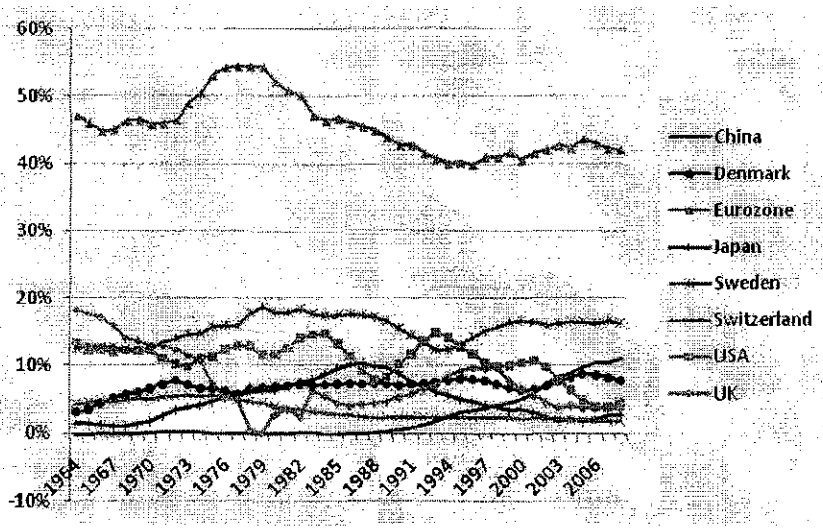


Chart 2: Net Import Shares excluding commodities (Selected Countries)

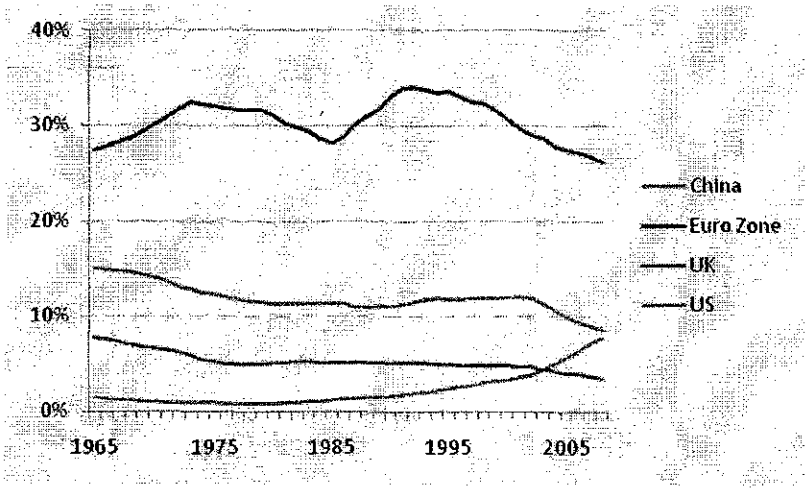


A.2. Projecting future net imports

Since the effectiveness of the net import weighted portfolio depends in part on the stability and predictability of net imports, we have undertaken some analysis of the determinants of these net import shares.

1) Share of World Trade. A likely influence on Norway's Import profile are global trends in world trade. As Chart 3 shows, there seems to be some important parallels between global trends (country exports of goods as a share of world exports), and Norway's net import shares The most clear of these is the rise of China's importance world trade, but the decline in US share and, to a lesser extent the Euro-Zone mirrors the change in Norway's trade patterns. A simple fixed effect estimate (using a sample form 1989 to 2009 and including Brazil, Canada, China, Czech, Denmark, Eurozone, Hong Kong, Japan, South Korea, Poland, Russia, Sweden, Switzerland, Taiwan, UK and US) of the global trade and import share relationship yields a coefficient of 1.1 (a 1 percentage point rise in world export share increases Norwegian net imports by 1.1 percentage points) which is significant at the 1% level

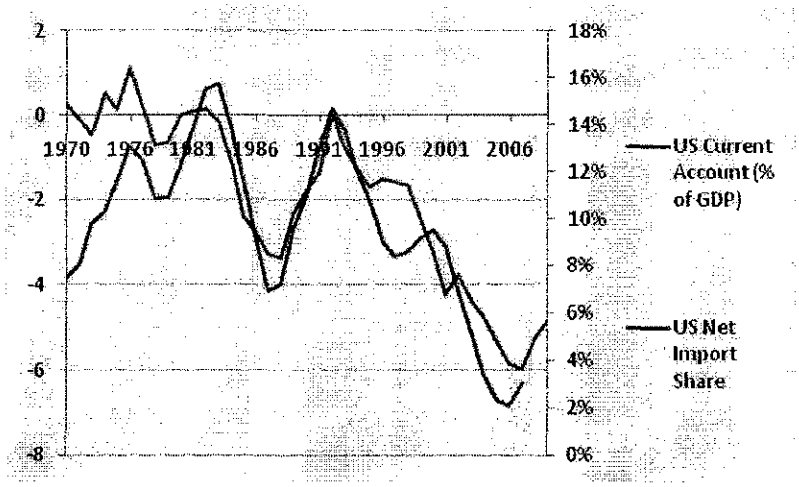
Chart 3: Export Shares of World Trade, selected countries



Source: WTO, Merchandise trade 5 year moving averages

2) Current Account effects. Whilst trends in world trade may help explain the changing pattern of Norway's imports, net imports may also be influenced by other countries net trade positions To investigate this possibility we have looked at the relationship between net import shares and current account positions as a share of GDP. Chart 4 shows the remarkably strong relationship between the US current account position and Norway's net import share with the US. Although the relationship is not so strong for other countries, there is some evidence of an overall current account effect. A simple fixed effect estimate (same period as above but only Canada, Denmark, Euro Zone, Japan, Sweden, Switzerland, UK and US) of the current account and import share relationship yields a coefficient of almost 0.2 (a 1 percentage point increase in the current account surplus as a % of GDP increase Norwegian net imports from that country by 0.2 of a percentage point) which is significant at the 1% level Clearly, there is likely to be some interaction between the current account effect and the world trade effect though estimates including both gives an almost identical current account effect but a reduced world trade effect of 0.7 (both still significant at the 1% level)

Chart 4: US Current Account and Net Import Share



Source: Statistics Norway and OECD Economic Outlook Database

3) Distance effects. Given increased globalization and decreased transportation costs it seems plausible that Norway should find that trade is less influenced by physical distances (i.e. trade with more distant trading partners should increase). However an analysis of distance of trading partners (great circle distance Oslo to partner capital city) shows that distances travelled by net imports have not changed significantly over the period 1960-2008. We find that the average net import travels 10 miles less in the five year period 2004-2008 than they did in 1960-1964 (though excluding commodities the distance has increased 78 miles). Overall, this simple analysis suggests that distance effects have not been an important influence on net import shares. Note that since geographical distances have almost no time series variation we cannot include them in a fixed effect regression.

4) Real Exchange rate effects. Another possible influence on net imports is of course the real exchange rate itself. If Norway's exchange rate depreciates against a trading partner in real terms, this is likely to increase Norway's exports to that country and decrease it imports. In fact, the size of this effect is important to the net import approach since if Norwegian consumers can easily substitute between countries in the face of real exchange rate shocks then hedging against these shocks has less value. Defining the real exchange rate as export prices expressed in Krone divided by Norwegian CPI we estimated the relationship between bilateral real exchange rates and import shares through a number of specifications. As Table 4 shows, a simple levels specification give a significant positive impact from real exchange rate changes on import share - the opposite of what one might expect. As well as the simple levels relationships shown in Table 4 we also tried first differences and various lag structures which either gave an insignificant real exchange rate effect or a significantly positive one. This, admittedly partial, analysis therefore suggests that real exchange appreciation (of the exporting country) does not seem to results in a decline in net imports to Norway and in fact suggests the opposite. This counter-intuitive result may reflect inadequate quality adjustment in the export price series such that countries with rapidly improving quality of exports will observe both a rising price

and rising demand for their products.

Table 4: Net Import Share Equations

	(1)	(2)	(3)
log(Real Exchange Rate)	0.02	0.01	0.05
	(8.2)	(2.3)	(6.8)
Share of World Trade		1.06	0.37
		(21.4)	(4.4)
Current Account as a share of GDP			0.21
			(5.2)

Fixed effects regressions 1989-2008 T-statistics in brackets. Note that specification (3) is based on a smaller panel as defined in the text above

Overall, the analysis in this section suggests that net import shares are relatively stable and, to some extent, explicable by trends in world trade and balance of payments. In practice, these results might suggest that medium term predictions of Norway's net import shares could be constructed using medium terms projections of world trade and balance of payments such as those produced by the IMF.

B. Historical Performance of the Net import portfolio

In order to assess the historical performance of the net import portfolio we have constructed 20 years of bond and equity returns for the relevant countries. Equity returns are measured using the MSCI total return indices, whist bond returns are estimated using Citigroup (formerly Salomon) fixed income total return indices. Countries with a net import share of less than 1% (in absolute terms) over the whole sample are not included in the analysis In some cases (for example. Brazil) a full set of returns data are not available - especially in the case of fixed income. In these cases we either use money market returns as a proxy for fixed income returns (in cases where a money market portfolio would be a realistic alternative to a bond portfolio), or when that is not realistic we substitute returns for the most appropriate major market (e.g. for Brazil we use US returns until 1994). Although this procedure is somewhat subjective, it does not have a significant influence on the results as the missing markets constitute a limited share of net imports. (less than 1%).

In both the net import portfolio and the net import portfolio excluding commodities, the portfolio share varies over time in line with the average net import share for the previous 5 years. For the purposes of comparison, we construct an estimate of the current country allocation of the GPF. Although the GPF only specifies a regional allocation we estimate a detailed country allocation within that by looking at the actual country breakdown in 2008 (we experimented with other breakdowns consistent with the funds regional allocation, but these did not change the results much). Table 5 shows these estimated allocations for 2008, the most dramatic differences are the considerably lower weights on the US and UK and higher weights on Denmark, Sweden and China in the net import allocation. The net import allocation also has a greater exposure to other developing countries (as

well as China)

Table 5: Estimated Country Asset Allocation (2008)

	Current		Net Import		Exc. Comm.	
	Equity	Bond	Equity	Bond	Equity	Bond
Brazil	0%	0%	1%	1%	0%	0%
Canada	2%	2%	8%	8%	0%	0%
Switzerland	6%	0%	2%	2%	2%	2%
China	0%	0%	13%	13%	12%	12%
Czech	0%	0%	2%	2%	2%	2%
Denmark	0%	1%	8%	8%	8%	8%
Eurozone	28%	51%	32%	32%	46%	46%
UK	14%	8%	1%	1%	4%	4%
Hong Kong	1%	0%	0%	0%	0%	0%
Japan	10%	5%	3%	3%	3%	3%
S. Korea	1%	0%	-2%	-2%	-1%	-1%
Poland	0%	0%	2%	2%	2%	2%
Russia	0%	0%	3%	3%	-2%	-2%
Sweden	2%	0%	21%	21%	18%	18%
Taiwan	1%	0%	2%	2%	2%	2%
US	33%	33%	3%	3%	5%	5%

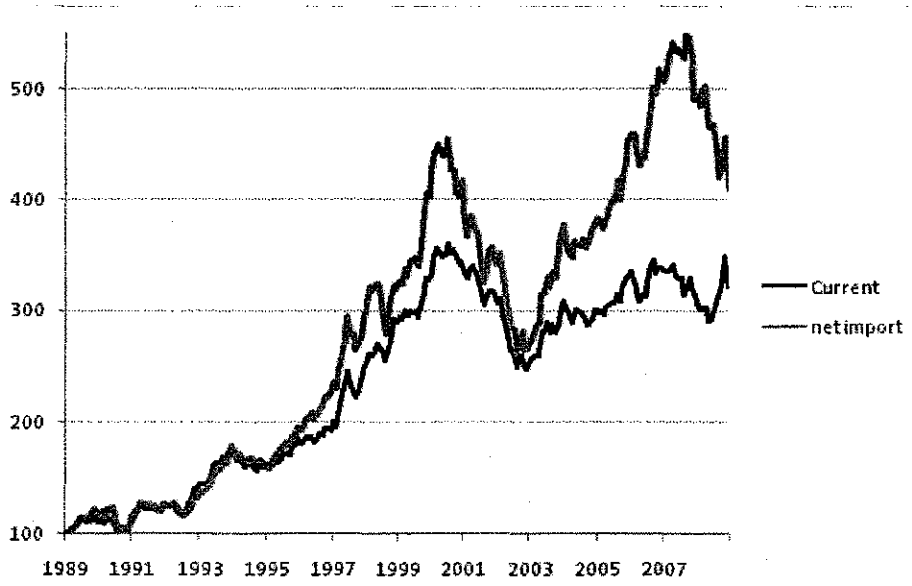
On the basis of these allocations and using the return data described above we have estimated historical returns based on our three currency allocations. Table 6 gives some summary statistics for these three portfolios, and chart 5 shows cumulative returns for the two key portfolios .

Table 6: Portfolio Characteristics (1989-2009) annualized monthly performance in NOK terms

	Current Benchmark			Net Import Portfolio			Net Import exc. Com.		
	Bond	Equity	Total	Bond	Equity	Total	Bond	Equity	Total
Return	7.8%	4.5%	6.1%	7.8%	6.0%	6.8%	8.4%	6.5%	7.4%
Standard Dev	2.2%	3.7%	2.7%	1.9%	5.3%	3.5%	1.9%	5.1%	3.5%
Excess Return*	1.1%	-2.0%	-0.6%	1.1%	-0.6%	0.1%	1.7%	-0.2%	0.7%
Sharpe Ratio	0.5	-0.5	-0.2	0.9	-0.0	0.2	0.5	-0.1	0.0

* Excess to one month NIBOR

Chart 5: Cumulative returns on alternative portfolios (NOK terms)



The most notable difference between the current benchmark and the net import portfolio is the higher returns of the net import portfolios. Although not statistically significant, it is an important feature that deserves some analysis. There are three possible explanations (other than chance) for the outperformance of the net import weighted portfolio.

1) Higher Risk. The net import portfolios both display higher volatility than the current portfolio - possibly reflecting their higher exposure to developing countries. Higher return could simply reflect this risk.

2) The Exorbitant Privilege. Portes and Rey (1998) highlight the tendency foreign investors in the US to earn returns that are substantially lower than those earned by US investors overseas. They attribute this to the position of the dollar as the key international currency which results in it attracting a liquidity premium. However, although the current benchmark implies a significantly

higher dollar weight than the net import weighted scheme, the return differential on the dollar over this period is too small to explain the performance difference

3) Market capitalisation weighting. As discussed above, a number of papers (e.g. Arnott et al (2008)) have noted the tendency for market capitalisation weighted benchmarks to under perform other schemes in the presence of market imperfections. In essence weighting by market capitalisation will tend to give higher weight to overvalued assets and lower weight to undervalued ones. Since the GPF benchmark is partially determined by market capitalisation, such an effect may be present in our sample.

B.1. Performance relative to Liability Proxies

Although overall portfolio performance is important, the key metric in the ALM approach is the correlation of assets and liabilities As discussed above, the true measure of liabilities in this case is the present value of future net imports, something that cannot be directly observed. Therefore we employ four liability proxies to assess the liability matching properties of net import portfolios

1) **Change in net non-oil imports.** As discussed above the most natural measure of the return on the funds liabilities is the change in the value of net imports. Here we take the difference between imports and non-oil exports of goods.

2) **Change in Net import weighted export prices.** Since the key risk that a net import weighted portfolio can be expected hedge against is real exchange rate risk, the portfolio should correlate well with import price changes. Our first import price measure is net import-weighted export prices expressed in Krone.

3) **Change in Import Prices.** Although not net import weighted, import prices as measured in Norway should also have some exposure to exchange rate risk and perhaps allow for pricing to market effects. So for example if UK export prices fall that need not mean that the price of goods that they export to Norway fall if UK exporters have different pricing policies toward different markets. Import Prices measured in Norway will allow for this effect.

4) **Change in Non-oil terms of trade** Although Import price volatility is likely to be the key route through which exchange rate volatility is translated through into changes in the present value of future net imports, it is also the case the Norwegian export prices may play a role so we look also at inverted terms of trade (Price of Norwegian imports divided by price of Norwegian exports) as a liability proxy.

Table 7: Asset-Liability return correlations 1989-2008

Liability measure	Asset Measure	Quarterly	1 year	5 year
Net imports	Current	0.17	0.15	0.19
	Net Import	0.20	0.27	0.46
	Net Import exc.	0.23	0.29	0.42
Net import weighted export Price	Current	0.71	0.65	0.46
	Net Import	0.49	0.54	0.61
	Net Import exc.	0.52	0.54	0.58
Import Prices	Current	0.06	0.27	-0.16
	Net Import	0.07	0.35	0.14
	Net Import exc.	0.08	0.35	0.09
Terms of Trade	Current	-0.10	0.1	0.01
	Net Import	-0.07	0.16	0.19
	Net Import exc.	-0.05	0.11	0.15

Table 7 shows the correlation between the change in our four liability proxies and the returns on our three portfolios over three different horizons. Other than in the case of the net import weighted export price measure at a quarterly and 1 year horizon, the two net import portfolios consistently outperform the current benchmark in terms of correlation with liabilities. Also, the greater correlation of the net import portfolio is most noticeable at the 5 year horizon indicating perhaps that real exchange rate risk is indeed a medium to long run phenomenon. When comparing the two net import portfolios the pattern is less clear with very similar performance for both measures.

Overall, the correlation results seems to indicate the net import portfolio has some power to hedge against real exchange rate risk compared with the current currency allocation adopted by the GPF. However, since none of the correlations presented here are significantly different from one another, that conclusion can only be tentative.

B.2. Currency Hedging

The net import portfolio analysed above is based on the simple appraoch of assuming the funds actual allocation of bond and equity holding followed a net import scheme. However, an alternative approach to currency allocation of equity funds (often called passive currency overlay) is based on the idea that currency exposure can be created through the currency market without actually holding equities in markets that correspond to that allocation. Such an approach is inapproriate in this case for two reasons

1) Little/No hedging demand Passive currency overlay is used in a situation where an equity fund would like to diversify its portfolio into overseas markets but does not want to be exposed to the significant currency risk that such an allocation creates. In the case currency hedging solves the problem of how to diversify overseas but recieve returns that are more stable in domestic currency. Such a problem does not exist in this case since the GPF must not (by design) and should not hedge

it expure back into Norwegian Krone. Therefore overlay in the case of the GPF would only be used in the case where the net import allocation is problematic for some reason. Although there are a few cases where the net import allocation does present problems (e.g. it delivers a high exposure to Swedish equity that would constitute over 10% of the market capitalization of the OMX) and so overlay or some other adjustment may be approriate in those cases. Overall, however, it is hard to see a general case for hedging (which is of course not costless)

2) Hedging Inflation Risk. Our portfolio is designed to help mitigate real exchange rate risk in Norwegian imports. Such risk can manifest itself both through movement in nominal exchange rate and movements in relative local currency prices (relative inflation). Since conventional currency hedging only hedges nominal exchange rate risk, relative inflation would still present a potential (though almost certainly smaller) risk. By holding equity on a net import weighted basis this inflation risk can potentially be mitigated since equity returns may reflect inflation (higher nominal equity returns in countries with high inflation) Although the evidence on the inflation hedging properties of equities is mixed we find that over longer horizons (i.e. 5 year equity returns and 5 year inflation) there has been a high correlation between equity returns and inflation between Norway's tradiong partners suggesting that an equity exposure may be beneficial.

Of course a more effective way the manage real exchange rate risk is through inflation-indexed bonds (since these can be used to hedge real exchange rate risk directly). However, the market for such bonds is currently too small to be employed to any significant extent by the GPF.

IV. Conclusion

This report analyzes theoretically and empirically the case for making the currency allocation of a Sovereign Wealth Fund (such as the Norwegian Government Pension Fund (GPF)) partly dependent on the home country's projected net import weights. Our review of the literature illustrates that market-capitalization weighting - which is currently an important input into the GPF's regional allocation - is not optimal in richer theoretical models and that it is not supported by recent empirical evidence. This leads us to the analysis of optimal currency allocations in an asset-liability framework and the liability matching role of currency allocations. To our knowledge, we are the first to examine the role of optimal currency allocations in the context of the asset liability matching problem represented by a country's net foreign assets and net exports over time. We describe the conditions under which the optimal currency allocation is a function of the net imports. We derive proxies for liabilities based on net import weights and analyse the risk and return of financial asset portfolios that are dependent on historical net imports weights. Our empirical results show that the historical performance of the trade-weighted portfolio has been superior to the market weighted benchmark portfolio. Thus our analysis supports recent work on 'fundamental indexation'

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