EUROPEAN CENTRAL BANK

EUROSYSTEM

WORKING PAPER SERIES

NO 958 / NOVEMBER 2008

OIL EXPORTERS

IN SEARCH OF AN EXTERNAL ANCHOR

by Maurizio Michael Habib
and Jan Stráský

EUROPEAN CENTRAL BANK

EUROSYSTEM

WORKING PAPER SERIES

NO 958 / NOVEMBER 2008

OIL EXPORTERS

IN SEARCH OF AN EXTERNAL ANCHOR[1]

by Maurizio Michael Habib
and Jan Stráský[2]

In 2008 all ECB publications feature a motif taken from the €10 banknote.

1 Revised version of the paper prepared for the 6th ESCB Workshop on Emerging Markets, Bank of Finland, BOFIT. Institute for Economies in Transition, Helsinki, May 8-9, 2008. The authors are grateful to Thierry Bracke, Alberto Musso, Jirka Slačálek, Roland Straub and Michael Sturm for useful comments and discussions. The views expressed in this paper are those of the authors and do not necessarily reflect those of the European Central Bank.

2 European Central Bank, Directorate General International and European Relations, Kaiserstrasse 29, D-60311 Frankfurt am Main, Germany; e-mail: maurizio.habib@ecb.europa.eu and jan.strasky@ecb.europa.eu

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Website
http://www.ecb.europa.eu

Fax
+49 69 1344 6000

ISSN 1561-0810 (print)
ISSN 1725-2806 (online)

CONTENTS

Abstract 4

Non-technical summary 5

1 Introduction 7

2 The choice of the anchor currency. An analysis of optimum currency area criteria for oil exporting countries 9

2.1 Fixing or floating? Degree of openness, diversification of exports and labour market flexibility 10

2.2 Which anchor? Direction of trade and synchronisation of business cycles 12

2.3 Overall assessment of optimum currency area criteria 15

3 Modelling the stabilisation properties of a currency basket 16

3.1 The model 17

3.2 Parameterisation for an oil-exporting economy 19

3.3 Taking the model to the data 21

3.3.1 Implied residuals for the two oil-exporting economies 22

3.3.2 The model fit 23

3.4 The impulse response functions 25

4 The search for an optimal currency basket 29

5 Concluding remarks 33

References 34

Tables 36

European Central Bank Working Paper Series 40

Abstract

This paper discusses the choice of an optimal external anchor for oil exporting economies, using optimum currency area criteria and simulations of a simple model of a small open economy pegging to a basket of two currencies. Oil exporting countries – in particular those of the Gulf Cooperation Council - satisfy a number of key optimum currency area criteria to adopt a peg. However, direction of trade and synchronisation of business cycle of oil exporters suggest that there is no single "ideal" external anchor among the major international currencies. Model simulations - parameterised for an oil exporting economy - indicate that a currency basket is generally preferable to a single currency peg, especially when some weight is placed by the policy maker on output stabilisation. Only when inflation becomes the only policy objective and external trade is mostly conducted in one currency that a peg to a single currency becomes optimal.

Keywords: oil exporting countries, exchange rate regimes, basket, model simulation

JEL classification: F31, C30, C51, C61, O24

Non-technical summary

The volatility of oil prices poses a serious test for the resilience of the macroeconomic and monetary policy framework of resource rich economies. For the majority of oil exporters, the cornerstone of this framework is an external anchor through a more or less rigid peg to the US dollar or, in a few cases, the euro or a basket of currencies, with a track record of low inflation. The US dollar usually prevails as external anchor in oil exporting economies since it is the invoicing currency of the main source of export revenues. In addition, the status of the dollar as an international currency allows oil producers to invest oil revenues in deep and liquid financial markets denominated in US dollar. More recently, however, the appeal of the US dollar peg started to fade as loose monetary policies in the US and the depreciation of the US dollar came along the positive oil price shock, resulting in procyclical monetary policies and inflationary pressures in oil exporting countries. At the same time, other potential alternative monetary exchange rate regimes, such as inflation targeting, seem to encounter practical obstacles, at least at present, to their implementation in less developed oil exporting countries.

In this paper, it is assumed that policy-makers in oil exporting countries have a strong preference towards exchange rate pegs and their decision set is restricted to the choice of what form of peg should be adopted. Subject to this assumption, we explore the potential benefits of anchoring to a basket of different currencies with respect to a single currency peg. We pursue two different approaches to answer this question. First, we review the optimum currency area criteria for a sample of eight large oil exporting economies and control to what extent oil exporters are natural candidates to a peg to the US dollar. Second, we update a simple macroeconomic model that allows studying the implications of the adoption of a basket of two currencies on the volatility of output and inflation.

In the first part of the paper, the analysis of optimum currency area criteria shows that the countries of the Gulf Co-operation Council - small open economies with flexible labour markets, and scarce ability to run an independent monetary policy - represent natural candidates for a peg to an external anchor. Other African countries share similar features, even though more rigid labour markets could hamper the long-run sustainability of fixed pegs. The direction of trade and the correlation of business cycle with major currency areas indicate that the US dollar is not necessarily the best anchor, but other candidates, such as the euro, are not clearly superior compared to the US currency.

In the second part, we address the issue of the most appropriate external anchor for oil exporters by looking at a simple reduced-form model of a small open economy pegging to a basket of two currencies. The model is essentially a Keynesian aggregate demand model where improving competitiveness increases demand for exports and reduces demand for imports. The model is parameterised to account for the specific features of oil exporting countries. Using quarterly data for Saudi Arabia and Russia we derive implied residuals from the calibrated model and use them to gauge the relative size of an aggregate demand shock, a domestic inflation shock and an exchange rate shock in the oil-exporting countries. We find that standard deviations of demand shocks and inflationary shocks in Saudi Arabia are about a half of those in Russia, but the relative size of the two shocks within each country is roughly similar.

The choice of an optimal external anchor for an oil exporting country is examined in terms of minimisation of the unconditional variances of GDP and CPI inflation, assuming (i) different weights for the two foreign prices in the domestic CPI basket and (ii) different relative weight placed on inflation and output variability by the policy maker. The relationship between the optimal external anchor and the import shares in the domestic CPI basket is positive; however, it becomes weaker as the weight placed on output stabilisation increases. A currency basket consisting of more than one currency seems to be generally preferable, except for the limiting case of the CPI share biased towards one foreign currency and a strong preference of the policy maker for the stabilisation of inflation.

Summing up, oil exporting countries - in particular those of the Gulf Co-operation Council - satisfy a number of key optimum currency area criteria to adopt a fixed exchange rate regime, even though the reliance of their economies on one single sector would call for greater exchange rate flexibility. The direction of trade and the synchronisation of business cycle of oil exporters suggest that there is not an "ideal" external anchor among the major international currencies. As an alternative, oil exporters could anchor to a basket of currencies, instead of a single currency, which would better reflect a diversified currency structure of import prices. The parameterisation of a simple reduced-form model of a small-open economy pegging to a basket of two currencies indicates that, in general, the optimal external anchor may consist of more than one currency, in particular if the policy-maker does care about the stabilisation of output. The fact that some oil exporting countries such as Kuwait, Libya and Russia have adopted the peg to a basket suggests that this policy choice does not rest in the realm of theoretical options.

1 Introduction: The debate on exchange rate policies in oil exporting economies

Since the turn of the century, oil rich economies have been enjoying a period of robust economic growth spurred by the surge in oil prices. Such a large external shock naturally poses a serious test for the resilience of the macroeconomic and monetary policy framework of resource rich economies. For the majority of oil exporters, the cornerstone of this framework is an external anchor through a more or less rigid peg to the US dollar or, in a few cases, the euro or a basket of currencies. According to the IMF classification of exchange rate regimes, 14 out of 24 fuel exporters - economies where fuels constitute more than 50 per cent of their exports - adopted a conventional peg to the US dollar. Other seven oil exporters peg to a basket of currencies including the US dollar and the euro or have a managed float regime, again usually de facto targeting the US dollar and the euro. Only three oil exporters in the CFA franc zone peg to the euro.[1]

Two factors explain the predominance of the US dollar as external anchor: first, oil is invoiced in US dollar and the peg stabilises revenues in domestic currency terms when the oil price is stable; second, the status of the dollar as an international currency allows oil producers to invest oil revenues in deep and liquid financial markets denominated in US dollar, minimising the currency risk and offering superior risk-adjusted returns. Usually, the peg to a single currency is preferred to the anchoring to a basket of currencies because of its greater transparency.

A nominal peg to the currency of another country with a track record of low inflation allows a small open economy to anchor domestic inflation expectations and import monetary stability.[2] For long-standing US dollar peggers, such as the countries of the Gulf Cooperation Council (GCC), this anchor seems to have delivered the expected benefits, contributing to low inflation over the long-term.[3]

However, more recently, the appeal of the US dollar peg started to fade as loose monetary policies in the US and the depreciation of the US dollar came along the positive oil price shock, resulting in procyclical monetary policies and inflationary pressures in oil exporting countries. In particular, Setser (2007) notes that the real interest rate in oil exporting countries regularly

[1] According to the IMF World Economic Outlook, April 2008, and the IMF Annual Report on Exchange Arrangements and Exchange Restrictions, 2007, fuel exporters include Ecuador (dollarised); Angola Bahrain, Kuwait, Nigeria, Oman, Qatar, Saudi Arabia, Syria, Trinidad and Tobago, Turkmenistan, United Arab Emirates, Venezuela and Yemen (conventional fixed peg to US dollar); Iran and Libya (peg to basket); Azerbaijan (crawling peg to US dollar); Republic of Congo, Equatorial Guinea and Gabon (peg to euro); Algeria, Kazakhstan, Russia, Sudan (managed float with no-predetermined path for the exchange rate). In 2007, Nigeria moved to a managed float still targeting the US dollar and Kuwait shifted to basket, where the US dollar plays a dominant role.

[2] See Tavlas (2000) for a critical review of the literature.

[3] See Jadresic (2002) and Abed et al. (2003).

turned out to be out of sync with the business cycle, namely too high in the 1990s when oil prices where low and inflation falling, and negative since the beginning of 2000 with high oil prices and rising inflation. In this situation, the burden of absorbing external shocks and smoothing output and price volatility is entirely borne by the fiscal policy.[4]

A number of alternative monetary exchange rate regimes are available for oil exporting countries, including the adoption of an external anchor different from the US dollar, pegging to the real price of oil, introducing exchange rate flexibility through a managed float or, finally, adopting an internal anchor, such as an inflation target and let the exchange rate free floating. Some of these proposals, such as the peg to the real oil price and inflation targeting, have theoretical appeal, but seem to encounter practical obstacles to their implementation in less developed oil exporting countries.

Frankel (2005) proposes targeting the export price index - fixing the price of the single commodity, such as oil, or a basket of commodities, in terms of local currency - for countries that are specialised in the production of one or few commodities. The main advantage of this regime would be to stabilise export revenues in domestic currency terms, irrespective of the fluctuations of commodity prices in the world markets. In particular, this regime would produce optimal automatic responses to adverse terms of trade shocks affecting export prices, with a fall in export prices, for instance, generating a depreciation of the domestic currency and vice versa. Nevertheless, this comes with a serious drawback, in particular for oil exporters, since a peg to the real price of oil would pass on the volatility of price of oil (in US dollar) to the nominal exchange rate. In case of sharp nominal appreciations, the costs would fall on the other exports sectors or the domestic sectors competing with foreign products. Vice versa, large drops in the nominal exchange rate could undermine monetary stability through sharp deterioration in the terms of trade.

Inflation targeting is another potentially attractive alternative, at least over the medium-term, once oil exporting countries build up money and financial markets and develop the technical ability to run this policy. Indeed, inflation targeting has been adopted by several emerging and developed commodity exporters such as Australia, Canada, Chile, New Zealand, South Africa and, in particular, an oil exporting country such as Norway. The announcement of a quantitative target for inflation gives a clear and transparent nominal anchor to the economy.

[4] In general, fiscal policy played an important role in absorbing shocks in oil exporting countries, irrespective of the more or less flexible exchange rate regime. Habib and Kalamova (2007) show that the sterilisation of oil revenues by the public sector avoided positive oil price shocks resulting in an excessive appreciation of the real exchange rate in Norway (free float) and Saudi Arabia (peg to the USD), at least until 2006. As the size of these foreign assets and of budget surpluses tend to increase, though, the political pressure to increase public expenditure often mounts, forcing, as it has been recently the case in GCC countries, wage increases in the public administration and scale up investment projects, creating pressures on limited domestic resources and, eventually, inflationary pressures.(Sturm et al. 2008).

The achievement of price stability over the medium-term increases the credibility of the central bank and its ability to stabilise output and employment over the short run. At present, in the case of oil exporting countries, inflation targeting is only a "potential" alternative. Inflation targeting requires institutional central bank independence, a well developed technical infrastructure, and effective inflation control through developed money markets and financial markets (Mishkin 2000). Many oil exporting countries - in particular the GCC and African countries - seem to lack the technical expertise, deep and developed money and financial markets, and the policy instruments to run an independent monetary policy.

Eventually, in spite of the drawbacks of adopting an external anchor and the monetary policy of another country, oil exporters's "fear of floating" is de facto revealing a strong preference for this exchange rate regime. Therefore, in this paper we assume that policy-makers in oil exporting countries have a strong positive bias towards exchange rate pegs and their decision set is restricted to the choice of what form of peg should be adopted. Subject to this assumption, we explore the potential benefits of anchoring to a basket of different currencies with respect to a single currency peg. We pursue two different approaches to answer this question: first, we review the optimum currency area criteria for a sample of eight large oil exporting economies and control to what extent oil exporters are natural candidates to a peg to the US dollar; second, we use a simple macroeconomic model that allows us to study the implications of the adoption of a basket of two currencies on the volatility of output and inflation. This model is parameterised to account for the specific features of an oil exporting economy and derive tractable policy results. The paper is structured as follows. In the next section, we analyse the optimum currency area criteria. In Section 3, we present the macroeconomic model to study the implications of the introduction of a basket and its parameterisation for an oil exporting economy. In section 4, we use this model to simulate the impact of shocks to aggregate demand, inflation and exchange rate and address the issue of the optimal composition of the currency basket. Section 5 summarises the results and concludes.

2 The choice of the anchor currency. An analysis of optimum currency area criteria for oil exporting countries

The literature on optimum currency areas identifies a number of economic criteria that should be satisfied before relinquishing part of the monetary sovereignty by pegging to another currency.[5] This set of criteria still represents a useful compass in the choice of the exchange rate regime.

[5]See Tavlas (1993) for a review of optimum currency area criteria.

Table 1: Oil exporters, GDP at PPP, oil exports and exchange rate regimes (2007).

	GDP at PPP		Value of oil exports	Exchange rate regime	
	USD billion	share of world GDP %	USD billion	IMF classification	Comments
Algeria	225	0.4	59	Managed float	De facto targeting USD
Libya	75	0.1	43	Peg to SDR	
Nigeria	293	0.4	54	Peg to USD	Managed float since mid-2007
Russia	2088	3.2	173	Managed float	Basket 55% USD; 45% EUR
Kuwait	130	0.2	60	Peg to a basket	Basket with estimated USD share of around 75%-80%
Saudi Arabia	565	0.9	203	Peg to USD	
U.A.E.	167	0.3	80	Peg to USD	
Total	3542	5.4	672		

Sources: IMF WEO and Annual Report on Exchange Arrangements and Exchange Restrictions database.

In particular, in this section, we distinguish between those criteria - degree of openness to trade, diversification of export structures and labour market flexibility - that indicate how costly is to abandon exchange rate flexibility, irrespective of the chosen anchor currency, and those criteria - direction of trade and synchronisation of business cycles - that are helpful in identifying the best anchor currency. We limit our analysis to these widely used criteria for which it was possible to find a complete dataset for a sample of seven important oil exporting countries. These include three African countries (Algeria, Libya and Nigeria), Russia and the three largest GCC countries (Kuwait, Saudi Arabia and United Arab Emirates). These are all relatively small economies with the level of GDP at purchasing power parity always inferior to 1% of world GDP in 2007, with the exception of Russia (3.2%). As already noted, the US dollar plays an important role in their exchange rate regimes, whether explicitly as in Saudi Arabia and U.A.E., or implicitly as in the case of Algeria, Nigeria and Kuwait where there is no conventional peg but where the US currency remains de facto the main external anchor. Libya and Russia include the US dollar in their basket (see Table 1).[6]

2.1 Fixing or floating? Degree of openness, diversification of exports and labour market flexibility

The theory of optimum currency area maintains that countries that are small and open to trade, with diversified export structures, and flexible labour markets, may take full advantage from an exchange rate peg or a currency union.

Openness to trade is a proxy of the degree of exchange rate pass-through from changes in

[6] Libya pegs to the SDR. Following the latest IMF review, on 1st January 2006, the weights of the currencies in the SDR basket were the following: US dollar, 44%, euro 34%, Japanese yen 11% and pound sterling 11%. Since 2006, the US dollar share declined to around 39% because of its depreciation against the euro.

Table 2: Degree of openness to trade in goods and services and reliance on oil exports (2007).

	Exports % of GDP	Imports % of GDP	Trade % of GDP	Oil exports % of total goods exports
Algeria	47.3	24.4	71.7	98.5
Libya	80.1	38.2	118.3	97.5
Nigeria	38.6	29.8	68.4	88.3
Russia	30.1	21.6	51.7	48.8
Kuwait	67.6	30.5	98.1	95.0
Saudi Arabia	62.3	34.0	96.3	89.9
U.A.E.	86.0	62.6	148.6	50.8
United States	11.8	16.9	28.6	3.3
Euro area	22.5	21.3	43.8	3.3*
Japan	18.4	16.5	34.9	0.0

* Estimate based on Euro area aggregate. Source: IMF World Economic Outlook database.

the price of tradable goods to domestic prices. The higher the openness, the higher the expected pass-through of exchange rate depreciations, the less effective the nominal exchange rate as shock absorber, the lower the cost of adopting a fixed peg. All oil exporting countries are very open to trade. In 2007, the sum of exports and imports of goods and services as share of GDP ranged from around 52% in Russia to more than 100% in Libya, up to around 150% in the United Arab Emirates (see Table 2). However, in the absence of better data on the weight of imported goods in the CPI basket of oil exporting countries, the share of total imports to GDP should better approximate the degree of pass-through. This share is not particularly high, hovering between 20% and 40% of GDP in most of the countries. Some lower income countries such as Algeria, Libya and Nigeria may have a higher share of tradable goods in their consumption basket and therefore have a higher pass-through to domestic prices - for a given degree of openness - and dislike large exchange rate fluctuations.[7]

Another important criterion is the degree of diversification of exports. The greater this diversification, the lower the impact on the whole economy of sector specific shocks that should be accommodated by an exchange rate change. By definition, oil exporters rely on exports of one or few commodities[8] (see last column of Table 2). Such highly specialised economies may wish to retain some monetary independence in order to face sector specific shocks, such as a large rise or drop in oil prices. In addition, potential anchor countries - such as US, euro area and Japan - are all net energy importers and their macroeconomic policies may react to an oil price shock in the opposite direction with respect to the desired policy response of oil exporters.

The lack of currency flexibility implies that the burden of adjustment to exogenous shocks

[7] See Ho and McCauley (2003).
[8] Gas is particularly important in Algeria and Russia.

Table 3: Indices of labour market flexibility.

	All indicators (Ave. ranking, 131 countries)	Hiring and firing practices Score 1 to 7	Hiring and firing practices (Ranking)	Flexibility of wage determination* Score 1 to 7	Flexibility of wage determination* (Ranking)	Non-wage labour costs** as % of the salary	Non-wage labour costs** (Ranking)
U.A.E.	(26)	4.8	(19)	5.9	(10)	12.5	(47)
Kuwait	(33)	4.1	(53)	6.0	(7)	11.0	(38)
Nigeria	(36)	5.0	(13)	5.2	(70)	8.5	(25)
Saudi Arabia	(44)	4.0	(60)	5.6	(32)	11.0	(38)
Russia	(53)	5.0	(15)	5.6	(31)	31.0	(107)
Algeria	(102)	3.5	(89)	4.2	(110)	27.5	(100)
Libya	(116)	2.8	(116)	3.6	(116)	na	na
Oil exporters	(53)	4.2	(52)	5.2	(54)	16.9	(59)
United States	(17)	5.3	(9)	5.7	(24)	8.5	(25)
Euro area	(113)	2.9	(112)	3.7	(114)	30.3	(97)
Japan	(50)	3.5	(85)	5.8	(14)	12.7	(48)

* Executive Opinion Survey Indices range from 1 (maximum rigidity in the labour market) to 7 (maximum flexibility). Ranking based on 131 countries.

** Hard data from World Bank, Doing Business 2007: How to reform. Ranking based on 124 countries.

Source: The Global Competitiveness Report 2007-2008, World Economic Forum 2007.

falls on real wages. If real wages are rigid this burden falls on employment. Therefore, a flexible labour market reduces the cost of giving up exchange rate flexibility and is one of the most important prerequisites for adopting a fixed peg. The Global Competitiveness Report of the World Economic Forum provides some indication on the degree of labour market flexibility in a number of oil exporting countries, allowing for a cross country comparison (see Table 3). Oil exporting countries may be roughly divided in two groups. On one side, the GCC countries, as well as Nigeria and Russia, rank high in terms of labour market flexibility and are clearly above the median of all, around 130, countries which are covered by the survey. On the other side, Algeria and Libya do not score particularly well according to the reported indicators, suggesting that in these countries labour market rigidities may raise the cost of adopting a fixed peg.

2.2 Which anchor? Direction of trade and synchronisation of business cycles

Oil exporting countries may wish to anchor to the currency of the country with which they trade the most. High trade openness with the country to which the domestic currency of oil exporters is pegged may in fact lead to greater business cycle synchronisation and reduce the need for domestic stabilisation policies. Frankel and Rose (1998) find a strong positive relationship between bilateral trade intensity and correlation of business cycles. In theory, all currencies of main trading partners of oil exporting countries are natural candidates for an external anchor. In practice, the choice of the anchor currency is intertwined with the currency composition

Table 4: Direction of merchandise trade of oil exporting countries (2006).

	Major export destinations (% of total exports)						Major import sources (% of total imports)					
	US	Euro area	UK	Japan	China	Other Asia	US	Euro area	UK	Japan	China	Other Asia
Algeria	27.2	48.4	3.0	0.2	0.2	1.8	4.8	50.4	1.4	1.9	8.5	4.8
Libya	6.1	72.9	2.5	0.0	3.9	0.3	4.7	42.6	4.0	2.0	7.5	8.8
Nigeria	48.9	22.3	0.7	1.6	0.5	3.3	8.3	24.8	5.8	2.1	10.7	10.6
Russia	3.6	39.3	3.4	1.7	5.4	3.2	4.0	38.2	2.7	5.3	9.4	8.0
Kuwait	9.0	7.5	3.1	20.4	4.1	50.4	14.1	22.7	5.4	7.8	5.7	13.7
S. Arabia	15.8	13.3	1.1	17.7	7.2	27.5	12.2	27.1	4.8	7.3	7.9	14.3
U.A.E.	1.2	4.0	1.4	25.8	2.3	32.0	11.5	21.7	5.5	5.8	11.0	25.1

Source: IMF DOTS and authors' calculations.

of foreign exchange reserves, restricting the sample of potential anchor currencies to the major international currencies, the US dollar and the euro.[9] For this reason, in our analysis, we focus on the direction of trade and correlation of business cycles with these two currency areas, including that of third most important international currency, the Japanese yen.[10]

Statistics on trade directions reveal that, to some extent, current exchange rate regimes already reflect the fact the United States are not the main trading partners and the US dollar, in some cases, may not be the best anchor currency (see Table 4). In fact, in Libya and Russia, the euro is already part of the basket to which they are pegged reflecting the greater share of trade with the euro area of these two countries. In the GCC countries, instead, the euro area is an important trading partner, but it does not emerge as the main one, since the direction of trade is diversified across all the three main currency areas with a prevalence of the Asian region. Indeed, China and other emerging Asian economies gained important market shares in the GCC countries over the past years. It is also important to remember that Asian countries mainly invoice their exports in US dollar (Goldberg and Tille 2005) and, therefore, the terms of trade of oil exporting countries - on the imports' side - are affected by changes in their exchange rate against this currency, not the Asian ones. Only in the case of Nigeria, the United States are the major destination of exports, accounting for around half of total exports.[11]

[9] In countries with large net external assets, such as oil exporting countries, the importance of portfolio motives for the currency denomination of currency reserves dominates that of transaction motives – e.g. the need to intervene, cover imports or finance external debt in given currency. Optimal portfolio theory suggests investing foreign reserves according to market capitalisation and in currencies that minimise the variance of returns in local currency terms. The decision to anchor to a certain currency decreases this variance and, simultaneously, increases the optimal share of the anchor currency in the composition of reserves (Beck and Rahbari 2008).

[10] We include also the British pound, since this is part of the SDR basket of the IMF. The SDR includes the four "freely usable currencies" issued by Fund members, whose exports of goods and services had the largest value during the review period. According to the Art. XXX (f) of Agreement of the IMF, "freely usable currencies" are those currencies "widely used to make payments for international transactions" and "widely traded in the principal exchange rate markets".

[11] For the United States, Nigeria is the fourth most important source of imported oil, Saudi Arabia the second. Canada is the main exporter of oil into the United States.

Table 5: Correlation of oil exporters' business cycles (GDP) with the United States, euro area and Japan.

Annual data: 1971 - 2007							
Business cycle lag	Algeria	Libya	Nigeria	Russia*	Kuwait	Saudi Arabia	U.A.E.
Contemporaneous	Japan 0.33	US 0.38	Japan 0.12	JP/US 0.49	US 0.50	Euro area 0.36	Japan 0.46
One year	US 0.04	—	Japan 0.29	Euro area 0.38	US 0.06	Japan 0.61	JP/EA 0.34

Quarterly data: 1991Q1 - 2007Q4							
Business cycle lag	Algeria	Libya	Nigeria	Russia*	Kuwait**	Saudi Arabia	U.A.E.
Contemporaneous	Japan 0.29	Japan 0.38	Japan 0.60	Japan 0.37	Euro area 0.36	Japan 0.52	Japan 0.46
One quarter	Japan 0.17	Japan 0.54	Japan 0.64	Japan 0.33	Euro area 0.30	Japan 0.54	US/JP 0.37
Four quarters	—	Japan 0.71	Japan 0.36	Euro area 0.07	US 0.20	Japan 0.36	US 0.11

Note: The table reports for each oil exporting country the reference currency area (US, Euro area, Japan) with the greatest positive synchronisation of the business cycle. Reported values are correlation coefficients of detrended GDP series (in logs) from HP filtering procedure. Symbol (—) indicates that the correlation was always negative.*For Russia the sample starts in 1995. **For Kuwait the quarterly sample starts in 1994Q1.
Sources: IMF WEO database, OECD, Global Insight and authors' calculations

Finally, it is crucial to check whether the business cycle of oil exporting countries is more closely correlated with that of the United States or other currency areas, such as the euro area or Japan, which may offer a better chance to import the appropriate monetary policy. Following the literature on business cycle synchronisation, we applied a Hodrick-Prescott filter to the (logarithm of) GDP series and then measured cross-country correlations of the filtered data over two different samples: (i) a long-term sample of annual data from 1971 to 2007 and (ii) a relatively shorter sample of quarterly data from 1991Q1 to 2007Q4.[12] The sample for Russia starts in 1995. The results of this exercise are reported in Table 5 where we indicate for each oil exporting country the currency area with the greatest, positive, correlation coefficient, allowing also for different time lags in the transmission of the business cycle.

According to annual data starting from the 1970s, the euro area never emerges as the best match for business cycle synchronisation. Libya, and Kuwait share the highest business cycle synchronisation with the United States. Algeria, Nigeria, Saudi Arabia and United Arab Emirates seem to be better correlated with the Japanese business cycle, with positive coefficients ranging between 0.3 and 0.6 (see the upper panel of Table 5). With quarterly data starting from 1991, instead, Japan emerges as the country with the highest correlation coefficient for all oil

[12] See, for instance, Fidrmuc and Korhonen (2004) for a survey or Darvas and Szapáry (2005) for an application of different filtering methods.

exporting countries, with the exception of Kuwait. Correlation coefficients of business cycle with Japan range between 0.3 in Algeria, 0.5 in Saudi Arabia and U.A.E. and 0.7 in Libya (see the lower panel of Table 5). The full set of results of this analysis, which is available in the Appendix, shows that the correlation of business cycles of oil exporting economies with the United States since the 1990s was often negative or close to zero, confirming the conclusion of Setser (2007) that oil exporting countries pegging to the US dollar imported an inappropriate monetary policy.

2.3 Overall assessment of optimum currency area criteria

The optimum currency area criteria confirm that the countries of the Gulf Cooperation Council - small open economies with flexible labour markets, and scarce ability to run an independent monetary policy - represent natural candidates for a peg to an external anchor. The perspective creation of the GCC monetary union, set to be launched in 2010, could modify this assessment over the medium-term and favour the adoption of an internal anchor. Other African countries share similar features, even though the apparent rigidity of labour markets in Algeria and Libya sheds some doubts on the long-run sustainability of a rigid peg. Indeed, both countries do not rigidly peg to the US dollar. It is important to reiterate that oil exporting countries are subject to sector specific shocks and therefore a fixed exchange rate regime remains a second best solution compared to an autonomous monetary policy able to accommodate sharp fluctuations in the oil price.

As regards the choice of the specific anchor currency, the analysis of the direction of trade and the correlation of business cycle with major currency areas suggests that the US dollar, in general, may not be the best option for oil exporting countries. However, there is no evidence that a peg to the euro would give a clear advantage in terms of higher correlation of business cycles, with the exception of countries mainly trading with the euro area, such as North African countries and Russia. This seems to be already reflected in the decision by Libya and Russia to include the euro in the reference basket to which they are pegged. Trade direction and synchronisation of business cycle, instead, indicate that an “Asian” external anchor would merit at least some consideration in the case of the GCC countries. Nevertheless, this Asian anchor does not seem currently available, since the international role of the Japanese yen is fading, whereas the Chinese renminbi, not fully convertible, remains anchored to the US dollar.

Even though no clear and valid alternative to the US dollar emerges from the analysis of currency area criteria, oil exporting countries may gradually move from a bilateral peg to the US dollar to the adoption of a peg to a composite basket of currencies. The simple peg is often preferred on the grounds of greater transparency and better ability to anchor inflationary expectations. This advantage comes at the cost of greater likelihood of importing the inappropriate monetary policy. The adoption of a basket, even though less transparent, may better reflect the direction of trade towards different currency areas. The consumer price index of oil exporting economies includes goods that are imported and may be invoiced in currencies different from the US dollar. A peg to a basket of currencies reflecting the different currency shares in the imported basket of goods may minimise the fluctuations of import prices in local currency terms.

3 Modelling the stabilisation properties of a currency basket

We address the issue of the most appropriate external anchor for oil-exporters by looking at a simple reduced-form model of a small open economy pegging to a basket of two currencies. As discussed in the previous sections, we assume that the option of pegging the nominal exchange rate is the only feasible way of conducting monetary policy due to the institutional setting or the lack of technical expertise to run an independent monetary policy. The model is essentially a Keynesian aggregate demand model where improving competitiveness increases demand for exports and reduces demand for imports. For this reason, the main focus of the model is on the short-term fluctuations of the economy, neglecting other considerations which may be relevant for oil-exporting countries, such as the accumulation of foreign assets and the search for an optimal depletion rate of natural resources.

The literature on optimal composition of the currency basket has at least two strands. First, there are the conventional trade models based on a static and partial equilibrium analysis of the import and export shares and their implications for the shares of various currencies in basket to which the exchange rate is pegged. Studies of this type include Branson and Katseli-Papaefstratiou (1981), Connolly and Yousef (1982), and Edison and Vardal (1990). Depending on the exact assumptions about pricing in the export and import markets, the existence of traded as opposed to non-traded goods, and the policy objective of the policy maker, these papers find an optimal external anchor to be a basket with the weights of individual currencies proportional to the trade shares. The determinants of trade shares as such, however, are derived from past observations and taken as given.

Second, there are models based on a complete macroeconomic description of the economy and the presence of multiple stochastic shocks, such as Turnovsky (1982) and Daniels et al. (2001), its recent restatement in a context including internationally traded bonds. These models are appealing as they provide a general equilibrium framework that takes into account relationships left aside by simple partial equilibrium models. In what follows we focus on this second strand of literature and develop a simple extension of Turnovsky (1982) parameterised for oil exporting countries.

3.1 The model

We depart from the original specification in the specification of domestic price level and domestically-generated inflation. We replace the wage indexation framework of Gray (1976) used in Turnovsky (1982) by a forward-looking Phillips curve along the lines suggested by Clarida et al. (1999). Both approaches can be indeed derived from their respective optimisation problems, but the approach of Gray (1976), assuming that labour supply and demand depend on unexpected changes of *price level*, may require a downward flexibility of prices, an empirically unappealing assumption.[13]

Clarida et al. (1999) show that a Phillips curve consistent with the Calvo (1983) pricing can be written as

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t \tag{1}$$

where π_t is the domestically-produced goods inflation, $E_t\pi_{t+1}$ is the expected inflation one period hence, and the output gap x_t is linked to the real marginal cost mc_t by a proportionate relation, $mc_t = \kappa x_t$.[14] Equation (1) differs substantially from a traditional expectations-augmented Phillips curve comparable to the approach in Gray (1976). The reason is that it can be solved forward, showing that today's inflation is a weighted sum of the present and expected future output gaps, $\pi_t = E_t \sum_{i=0}^{\infty} \beta^i \lambda x_{t+i}$, while the expectations-augmented Phillips curve models inflation as a function of the (weighted) sum of the *past* output gaps.

The macroeconomic model in log-levels can be summarised by the following relationships

$$\begin{aligned}
Y_t^d &= d_1 Y_{t-1}^d - d_2[r_t - (C_{t+1,t}^* - C_t)] + d_{31}(E_{1t} + Q_{1t} - P_t) + \\
&\quad + d_{32}(E_{2t} + Q_{2t} - P_t) + u_t && (2)\\
C_t &= \delta_0 P_t + \delta_1(Q_{1t} + E_{1t}) + \delta_2(Q_{2t} + E_{2t}) && (3)\\
P_t &= P_{t-1} + \beta(P_{t+1,t}^* - P_t) + \theta(Y_t^d - \bar{Y}) + \eta_t && (4)\\
r_t &= \Omega_{1t} + E_{1,t+1,t}^* - E_{1t} = \Omega_{2t} + E_{2,t+1,t}^* - E_{2t} && (5)\\
E_{2t} &= E_{1t} + \nu_t && (6)\\
\bar{E} &= \mu_1 E_{1t} + (1 - \mu_1) E_{2t} && (7)
\end{aligned}$$

and for all variables $X_{s,t}^* = E_t(X_s)$ where $E_t(\cdot)$ is the expectations operator, conditional on information at time t.

[13] In principle, the supply curve of Gray (1976) can be replaced by a traditional expectations-augmented Phillips curve. The general conclusions would still hold, although the dynamics of the system would change through the introduction of additional lags. This is, however, not the main point of our modification, which aims to introduce a forward-looking framework into the formation of inflation expectations.

[14] The original analysis is one of the closed economy, but π_t can be re-interpreted in terms of CPI inflation relevant for an open economy.

Equation (2) is an aggregate demand function where Y^d is the (logarithm of) aggregate demand, r is the domestic nominal interest rate, C is the (logarithm of) CPI index measuring domestic cost of living, Q_i is the (logarithm of) price of good produced in country i expressed in terms of the country's i currency, E_i is the (logarithm of) exchange rate between domestic currency and country's i currency (expressed in units of domestic currency per unit of currency i), P is the (logarithm of) price of domestically produced goods and services, and $d_1, d_2, d_{31}, d_{32} > 0$. The equation is a standard open economy IS curve except for making the net exports a function of the relative price of imports from both foreign countries.

Equation (3) defines the domestic cost of living index as a weighted average of the (logarithm of) price of the domestically produced goods and services, P_t, and the domestic-currency prices of imports from the two foreign currency areas where $0 \leq \delta_i \leq 1$ and $\delta_0 + \delta_1 + \delta_2 = 1$.

Equation (4) is a version of the Phillips curve for domestic prices where $\bar{Y}$ is the (logarithm of) constant level of capacity output, $\beta > 0$, and $\theta > 0$. The term $Y_t^d - \bar{Y}$ is the output gap, a difference between actual and capacity output expressed as a fraction of the latter. The Phillips curve is forward-looking as the current domestic inflation, $P_t - P_{t-1}$, depends on the expected domestic inflation, $P^*_{t+1,t} - P_t$ and the current period's output gap, $Y^d - \bar{Y}$.

Equation (5) is the uncovered interest rate parity condition vis-à-vis both foreign countries where Ω_i is the nominal interest rate in country i. Equation (6) introduces shocks to the bilateral nominal exchange rate between the currencies of the two foreign countries and equation (7) introduces the fixed nominal exchange rate as a basket of two currencies with shares μ_1 and $\mu_2 = 1 - \mu_1$ respectively.

There are three shocks in the model: an aggregate demand shock u_t, a domestic inflation shock η_t, and a cross-exchange rate shock ν_t. In the case of the aggregate demand shock, the data justify an autoregressive process. The cross-correlations of the shocks are zero.

Although the model is relatively simple, it contains two features specific to the oil-exporting countries. First, a persistent aggregate demand shock u_t can be interpreted as capturing the effects of an unexpected change in the world demand for domestic exports, mainly oil. In our simple model, such a favourable increase in the world demand results in higher domestic inflation due to the positive output gap.[15] This is, however, not an unrealistic assumption in the case of oil exporting countries as their production capacity with which they can react to positive demand shocks is seriously limited, perhaps with the exception of Saudi Arabia. The second important feature of the model is the conduct of monetary policy through the nominal exchange rate peg, as it is the case in several oil-exporting countries. Our task is hence to analyse the optimal choice

[15] A less trivial analysis would require a model with *stock* variables, such as domestic and foreign bonds. We would like to explore this possibility in the future work.

of the weights μ_1 and $(1-\mu_1)$ in this framework.

Aggregate demand shock propagates through the model by pushing up first aggregate demand and then the prices of domestically produced goods and services. The domestic price dynamics represented by the Phillips curve results in a period of higher domestic prices as the output gap returns to zero. The shock to domestic inflation affects CPI inflation and triggers a reduction of aggregate demand through a loss in competitiveness. The exchange rate shock ν_t has a twofold effect in the model. It diverts the aggregate demand from imports from one currency area to those from the other currency area. It also affects the aggregate demand through changes in the CPI and the real interest rate. In fact, the exchange rate shock has a direct impact on the CPI inflation, since import price changes are immediately reflected in the CPI. An additional effect works through the output gap term in the Phillips curve as an increase in domestic prices is ultimately also reflected in the CPI.

The model can be re-written in terms of deviations from the initial equilibrium levels where all expectations are realised and setting all random disturbances to zero

$$\begin{aligned} y_t^d &= d_1 y_{t-1}^d - d_2[\omega_{1t} + (e_{1,t+1,t}^* - e_{1t}) - (c_{t+1,t}^* - c_t)] \\ &\quad + d_{31}(e_{1t} + q_{1t} - p_t) + d_{32}(e_{2t} + q_{2t} - p_t) + u_t \qquad (8) \\ c_t &= \delta_0 p_t + \delta_1(q_{1t} + e_{1t}) + \delta_2(q_{2t} + e_{2t}) \qquad (9) \\ p_t &= p_{t-1} + \beta(p_{t+1,t}^* - p_t) + \theta y_t^d + \eta_t \qquad (10) \\ e_{2t} &= e_{1t} + \nu_t \qquad (11) \\ 0 &= \mu_1 e_{1t} + \mu_2 e_{2t} \qquad (12) \end{aligned}$$

where lower case letters denote variables measured in deviation from equilibrium levels and the domestic nominal interest rate r has been eliminated using the uncovered interest rate parity condition vis-à-vis country 1. This is the formulation we use to solve and simulate the model, studying the combined impact of shocks to aggregate demand y_t^d, domestic inflation $p_t - p_{t-1}$, and the bilateral exchange rate between the two foreign exchanges, $e_2 - e_1$.[16]

3.2 Parameterisation for an oil-exporting economy

The solution of the model depends on the choice of parameter values. This section reviews the existing literature in search for a plausible parameterisation of the model. Estimates of an open-economy IS curve for the GCC countries or Russia are, to our best knowledge, still unavailable. For Russia, some guidance may be derived from the parameterisation used in a small quarterly

[16]The model was solved and simulated using DYNARE, a Matlab toolbox developed by Michel Juillard.

model of the Bank of Russia reported in Borodin et al. (2008); it is in line with the existing empirical evidence from small open economies. In other cases we have to resort to empirical research on other commodity exporters, including developed economies such as Australia and Canada.

A positive value of parameter d_1 allows for some persistence in domestic demand that is often observed in the data and can be motivated by the existence of credit constraints or habit persistence on the side of consumers. In the simulations, we set d_1 to 0.5.

Estimates of d_2, the real interest rate elasticity of aggregate demand, specific to the oil-exporters are, to our best knowledge, non-existent. For South Africa, Harjes and Ricci (2008) report a value of 0.086 using quarterly data from 1994 to 2005. Nimark (2007) estimates the elasticity at 0.038, using the quarterly data for Australia from 1991 to 2006. The Bank of Israel uses the value of 0.4 in its quarterly prediction model of the Israeli economy (Argov et al. 2007). We set $d_2 = 0.15$, a value roughly in the middle of this interval.

The key feature of the model is the peg to two different currency areas, say the US dollar, denoted by the subscript 1, and an alternative foreign currency, denoted by the subscript 2. There are two empirical studies of exchange rate regimes for the GCC countries that attempt to estimate the real exchange rate elasticity of exports and imports with respect to various currencies. Both studies employ estimation equations with several bilateral real exchange rates, including the US dollar, the SDR and the euro. First, Iqbal and Erbas (1997) examine the import and export stability under the US dollar and the SDR pegs and estimate import, export and trade balance equations for the six GCC countries using annual data from 1976 to 1994. While their import equation is standard and includes the two bilateral real exchange rates and a measure of domestic income, the export and the trade balance equations do not allow for scaling by foreign output. Their results for Saudi Arabia imply that the depreciation against the US dollar has a negative effect on trade balance, while that against the German mark has a positive effect. Second, Abed et al. (2003) repeat the analysis of Iqbal and Erbas (1997) using annual data from 1987 to 2001 and an estimation equation in first differences rather than in (log) levels. They report trade balance elasticities of 1.3 for the US dollar and 0.09 for the euro, suggesting that domestic output is more than *ten times* more sensitive to the changes in the real exchange rate of the dollar than the euro.[17] In our parameterisation, the two net export elasticities, d_{31} and d_{32}, are set to 0.9 and 0.7, allowing for a slightly higher elasticity of net exports to changes

[17] Considering commodity exporting countries more generally, there is some evidence that the real exchange rate elasticity of exports is lower than that of imports. Using Bayesian techniques and quarterly data from 1991:1 to 2006:2, Nimark (2007) estimates a small open economy model for Australia. Despite the identical normally distributed prior of 1, with a standard error 0.1, the estimated values of the two elasticities differ considerably. The real exchange rate elasticity of imports is estimated at 0.93, while that of exports only at 0.02. The result, however, says little about the different elasticities accross currencies.

in the bilateral exchange rate against the US dollar, because most exports and a substantial part of imports of oil-exporting countries are priced in this currency.[18]

In order to parameterise equation (9), we need some information on the relative weights of the domestically produced goods and imported goods and services in the CPI index. Small open economies often have a ratio of imports to GDP around 0.6, but the openness of the oil exporting countries is usually much lower than this, ranging from 0.2 to 0.4; see Table 2 in the previous section. Pradhan (2008) reports that the weights of imports in CPI indices reach from about 0.25 in Kuwait (proxied by the share of food that is mostly imported) to 0.35 in Saudi Arabia and 0.8 in Qatar. We treat Qatar as an extreme case and set $\delta_0 = 0.5$, leaving to total imports a share of 50% of the domestic CPI basket. We then assume that the share of the two foreign currency areas in the CPI is the same - both at 0.25. This assumption is used to derive the impulse response functions, but relaxed in the simulations of the optimal basket where we look at relative weights of both currencies in the CPI, varying the weight of the US dollar from 10 to 90% of import prices, with the rest invoiced in the other currency.

There is very little evidence on the determinants of inflation in either Russia or Saudi Arabia. Hasan and Alogeel (2008) have analysed the inflationary process in Saudi Arabia and Kuwait in the framework of a cointegrating model, but the coefficients they estimated are not directly transferrable to the Phillips curve setting. In order to overcome the lack of specific data, we use values from the more general estimates for commodity-exporting small open economies. Karam and Pagan (2008) report an output gap coefficient of 0.075 for the Phillips curve estimated on Canadian data from 1980 to 2005. For South Africa, however, Harjes and Ricci (2008) report a much higher value of 0.228. Similarly, Gruen et al. (1999) using quarterly Australian data from 1966 to 1997 estimate the aggregate demand elasticity of inflation to be 0.388. In transition economies, the estimated value of this parameter often exceeds 0.4. We thus set $\theta = 0.2$, a value that seems to be conservative enough and yet allows for a substantial role of the output gap in affecting domestic inflation. Table 6 summarises the parameterisation of the model.

3.3 Taking the model to the data

Ideally, the theoretical model should be estimated for each oil exporting economy, using the standard deviations of residuals in the model to obtain a measure of the relative size of the structural shocks. However, a full-fledged estimation of the model country by country is complicated by data limitations and goes well beyond the scope of this paper. An alternative would be to use standard deviations of the residuals from similar models that have been estimated for these or

[18] Since the relative sensitivity of net exports to the real exchange rate is one of the key parameters of the model, we would like to check the sensitivity of the optimal external anchor to the ratio d_{31}/d_{32} in the future work.

Parameter	Value
d_1	0.5
d_2	0.15
d_{31}	0.9
d_{32}	0.7
δ_0	0.5
δ_1	0.25
δ_2	0.25
β	0.95
θ	0.2

Table 6: Parameter values capturing some features of oil-exporting countries.

other economies. As noted in the previous sub-section, specific studies on oil exporting economies are rare. While the use of results from various studies is not ideal due to different methodologies, data samples, etc. many parameters are structural and should not vary much over time. Finally, it is also possible to calculate the implied residuals from calibrated model equations and the historical data, using therefore all available country-specific information together with the information from other studies to calibrate the model. This is the approach followed in this paper, focusing on two key oil exporting economies: Saudi Arabia and Russia.

3.3.1 Implied residuals for the two oil-exporting economies

In the absence of any decisive empirical evidence regarding the relative size of shocks in the oil-exporting countries, we therefore resort to the calculation of the implied residuals from the calibrated model using the quarterly data for Saudi Arabia and Russia. For Saudi Arabia, we used data from 1993:2 to 2007:4 and for Russia from 2000:1 to 2007:3. Data are seasonally adjusted and all the gap variables have been obtained by applying the Hodrick-Prescott filter with $\lambda = 1600$.

For the open economy IS curve, the following equation has been fitted to the quarterly data for the two countries

$$\hat{\epsilon}_t = y_t^{gap} - 0.5y_{t-1}^{gap} + 0.15r_{t-1}^{gap} - 0.9zgap_{t-1}^{usd} - 0.7zgap_{t-1}^{eur} \tag{13}$$

where y^{gap} is the output gap in percentage points of capacity output, r^{gap} is the real interest rate (measured ex-post as $i_t - \pi_t$) gap, and $zgap^{usd}$ and $zgap^{eur}$ is a bilateral real exchange rate (deflated by CPI) gap in percentage points of its trend value with respect to the US dollar and the euro, respectively. It turns out that $\hat{\epsilon}_t$ can be modelled as an autoregressive process of order 1. The autoregressive structure may reflect the absence of the world output as a proxy for external demand in equation (13). The estimated value of the persistence coefficient $\hat{\gamma}$ in the

		Saudi Arabia 1993:2 to 2007:4	Russia 2000:1 to 2007:3
IS curve	AR(1) coeff. γ	0.7298	0.4141
	Std. dev. Res. η_t	0.00961	0.01817
Phillips curve	Std. dev. Res. ϑ_t	0.00807	0.01838
Dollar/euro shock	Std. dev. shock ν_t	0.12104	0.14676

Table 7: Residuals from the calibrated model fitted to the data for Saudi Arabia and Russia (Quarterly, HP-filtered data where appropriate).

AR(1) equation

$$\hat{\epsilon}_t = \gamma\hat{\epsilon}_{t-1} + \eta_t \tag{14}$$

is 0.7298 (0.089) for Saudi Arabia and 0.4141 (0.086) for Russia (standard errors in parentheses).

As regards the Phillips curve, the following equation has been fitted

$$\hat{\varepsilon}_t = \pi_t - 0.95\pi_{t+1} - 0.2y_t^{gap} \tag{15}$$

where π_t is the rate of change in the GDP deflator (Russia) or the rate of change of producer prices (Saudi Arabia). The rational expectations hypothesis is imposed rather than tested for by assuming that $E_t\pi_{t+1} = \pi_{t+1}$ on average. The results of calculations for both the IS curve and the Phillips curve are summarised in Table 7.

Standard deviations of demand shocks (adjusted for the autocorrelation) and inflationary shocks in Saudi Arabia are about 50% smaller than in Russia. As a result, the relative size of the output and inflation shocks is roughly 1 in both countries. The main difference between the two constructed shocks in Saudi Arabia and Russia thus seems to be their *persistence and absolute size,* but not their relative size within each country.

The residuals reported in Table 7 were constructed using several strong assumptions. A high forward-looking coefficient of the Phillips curve, β, may be too strong an assumption in the emerging market context. The model also implies that the uncovered interest rate parity holds instantaneously and the pass-through to domestic prices is complete and instantaneous. The overall fit of the model, as measured by standard errors of the variables and their correlation coefficients is analysed in the following section.

3.3.2 The model fit

Because the model should be able to replicate data *given* the exchange rate policy followed by the policy makers, assessing the fit of the model requires some assumption about the actual

	Saudi Arabia		Russia	
Variable	Data	Model	Data	Model
y^{gap}	0.01387	0.0656	0.01154	0.0352
π^{y}	0.00545	0.0140	0.01213	0.0130
π^{cpi}	0.00389	0.0475	0.00314	0.0065
e_1	0.00019	0	0.02549	0.0734
e_2	0.12015	0.1210	0.05876	0.0734

Table 8: Standard deviations of the historical data and their model counterparts.

exchange rate regime. For Saudi Arabia, a peg to US dollar has been in place for the whole sample period and the reported model outcomes assume the currency basket with a 100% weight on the US dollar. In the case of Russia, the situation is less clear. The share of the euro in the trade-weighted real effective exchange rate officially computed by the Central Bank of Russia gradually increased up to 60% in 2007. However, the share of the euro in the basket that has been *de facto* targeted by the authorities could be lower. For this reason, we assume that a currency basket with 50% weight on the US dollar and 50% weight on the euro reasonably approximates the actual policy between 2000 and 2007 in Russia.

Table 8 reports standard deviations of variables and compares them to the standard deviations implied by the calibrated model. For Russia, the model fits some variables, such as the domestic inflation and the variability of the rouble-euro exchange rate (e_2), very well. In the case of Saudi Arabia, the results are less favourable. Indeed, the peg to the dollar is clearly detectable in the data, but the remaining standard deviations implied by the model are further from their data counterparts than for Russia. The difference between the data and the model is most pronounced in the case of the CPI inflation in Saudi Arabia where the standard deviation implied by the model is more than 12 times the size of the observed standard deviation.

The *upper* triangle of Table 9 reports contemporaneous correlations in the data, while the *lower* triangle shows the correlation coefficients implied by the solved model. The variables included in the analysis are the output gap, the domestic and the CPI inflation rates and the two bilateral nominal exchange rates. The model correlations come from the calculation of the second order approximation of the model solution around the steady state.

The model for Saudi Arabia assumes that the riyal-dollar rate is constant which is represented by the line of zeros in the table. Turning to the data, observed tiny oscillations in the Saudi peg to the dollar are large enough to generate negative correlations with e_1 and the remaining model variables (-0.32 with the euro rate e_1, -0.23 with the output gap and the CPI inflation, and -0.13 with the domestic inflation), although the historical movements in the riyal-dollar rate are minimal. On the other hand, we find correlations close to those predicted by the model for the

Saudi Arabia					
	Data				
Model	y^{gap}	π^y	π^{cpi}	e_1	e_2
y^{gap}	1	-0.1565	-0.1483	-0.2287	0.1255
π^y	0.8241	1	0.7403	-0.1253	0.2744
π^{cpi}	0.5876	0.7107	1	-0.2282	0.4303
e_1	0	0	0	1	-0.3241
e_2	0.9422	0.8145	0.7575	0	1
Russia					
	Data				
Model	y^{gap}	π^y	π^{cpi}	e_1	e_2
y^{gap}	1	-0.1962	-0.1182	-0.0624	-0.2801
π^y	0.1940	1	0.3201	0.0252	-0.1179
π^{cpi}	0.1940	1.0000	1	0.1781	-0.5451
e_1	0.5631	0.2817	0.2817	1	-0.1835
e_2	-0.5631	-0.2817	-0.2817	-1.0000	1

Table 9: Contemporaneous correlation coefficients of the historical data and their model counterparts.

domestic and the CPI inflations and riyal-euro rate and the CPI inflation.

In the case of Russia, both the assumed CPI and the currency basket contain similar the US dollar and the euro in the same proportion $(1:1)$, producing a perfect positive correlation between the domestic and the CPI inflation in the model, as the effect of import prices cancels out. The construction of the Russian currency basket in the world of only two foreign currencies also implies a perfect negative correlation between e_1 and e_2 in the model. Model correlations resemble those in the data, for example between CPI inflation and both e_1 and e_2; indeed the model for Russia seems to fit even better than for Saudi Arabia.

For both countries, the major problem is the negative contemporaneous correlation between the output gap and inflation, which is not captured by the model. This is due to the delayed transmission mechanism. Indeed, the positive correlation appears in the data when the output gap is lagged by two to four quarters, implying that output leads inflation.[19]

3.4 The impulse response functions

The model contains three uncorrelated shocks - an aggregate demand shock, a domestic inflation shock and an exchange rate shock. Their variability and persistence have been derived in the previous sub-section. The aggregate demand shock has an autoregressive structure capturing persistence (0.73 for Saudi Arabia and 0.41 for Russia); inflation and exchange rate shocks are not persistent. The exact values of standard errors are those reported in Table 7. All panels in

[19] While *annual* data often show positive contemporaneous correlation, and Saudi Arabia and Russia are no exceptions in this regard, when turning to the *quarterly* data, output gap and inflation often become negatively correlated.

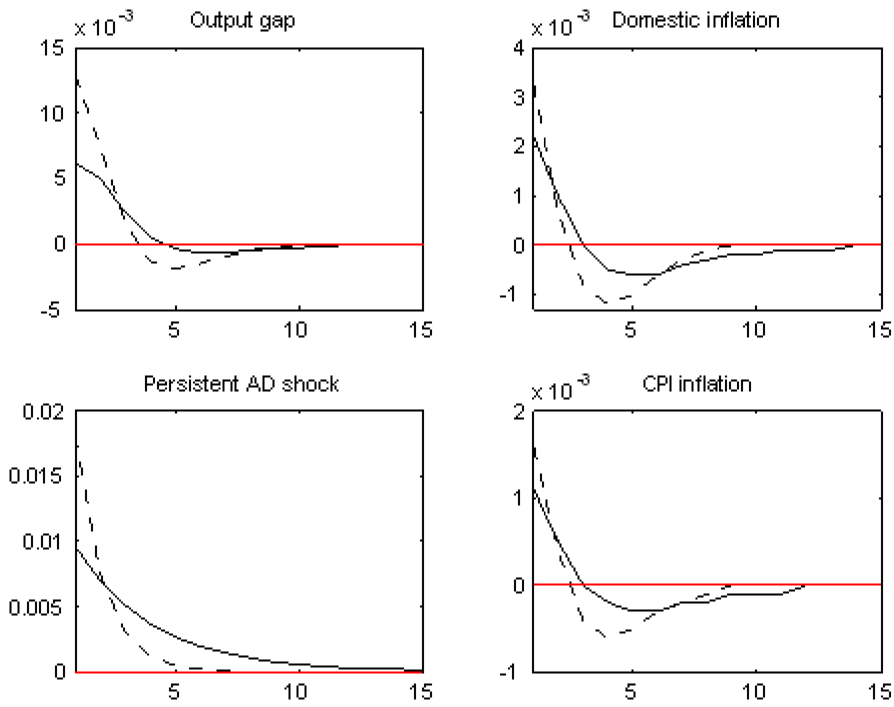

Figure 1: Aggregate demand shock: Impulse response functions for Saudi Arabia (full line) and Russia (dotted line) in per centage point deviations from steady state.

the following graphs show units of time (quarters) on the horizontal axis and the per centage point deviations from the steady state (0.01 is 1%) on the vertical axis. Recall that an increase in the nominal exchange rate e_1 means depreciation of the domestic currency against currency 1.

Figure 1 plots the impulse response functions for the aggregate demand shock. After a positive shock to domestic output, both domestic and the CPI inflation increase as the aggregate demand at home exceeds the (constant) capacity output. Higher inflation at home appreciates the real exchange rate, as the nominal exchange rate is assumed to remain constant, reducing the demand for exports and aggregate demand. Closing of the output gap then leads to a decrease in inflation bringing both the domestic and the CPI inflation back to their steady state values. Higher standard error and lower persistence of the demand shock in Russia is reflected in a faster but more variable adjustment process than in Saudi Arabia.

Figure 2 plots the impulse response functions for the domestic inflationary shock. A positive shock to the domestic inflation partially translates to the CPI inflation and, as the nominal exchange rate is prevented from changing, leads to the real appreciation of the domestic currency. This again reduces export demand and hence output. A period of negative output gap is required

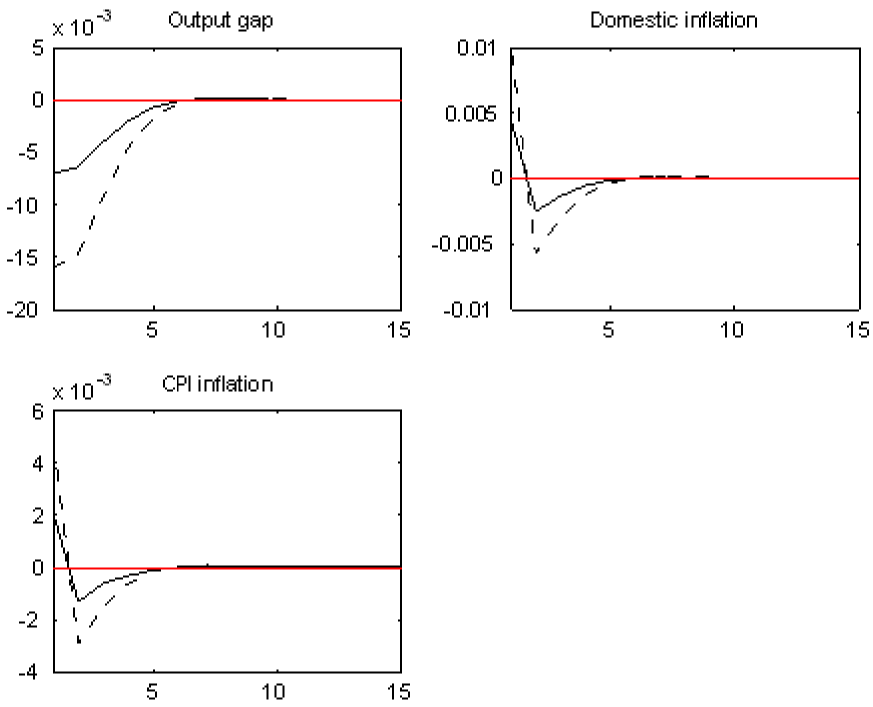

Figure 2: Domestic inflation shock: Impulse response functions for Saudi Arabia (full line) and Russia (dotted line) in per centage point deviations from steady state.

to achieve disinflation as both measures of inflation and the real exchange rate return to their steady state values. The magnitude of the shock is higher in Russia, implying that a bigger reduction in output is needed to stabilise the domestic and the CPI inflation than in Saudi Arabia.

Figure 3 plots the impulse responses of the exchange rate shock modelled as an unexpected increase in the value of currency 2 relative to currency 1, in our case the US dollar. This can be thus interpreted as *depreciation* of the US dollar relative to the other foreign exchange, for instance, the euro. Since the price levels in the two foreign currency areas are assumed constant, there is no difference between nominal and real depreciation. The impulse response functions in this case clearly depend on the exchange rate arrangement in place in each country.

In Saudi Arabia, with a 100% peg to the US dollar, the domestic currency depreciates one-to-one with the US dollar against the other foreign exchange. Given that the currency basket in this case does not require any action on the part of the monetary authority, the nominal depreciation of the US dollar relative to the euro translates into a real depreciation of the domestic currency vis-à-vis the euro. This stimulates exports and reduces the demand for imports. As a result, aggregate demand exceeds capacity output and a positive output gap opens up. Both the

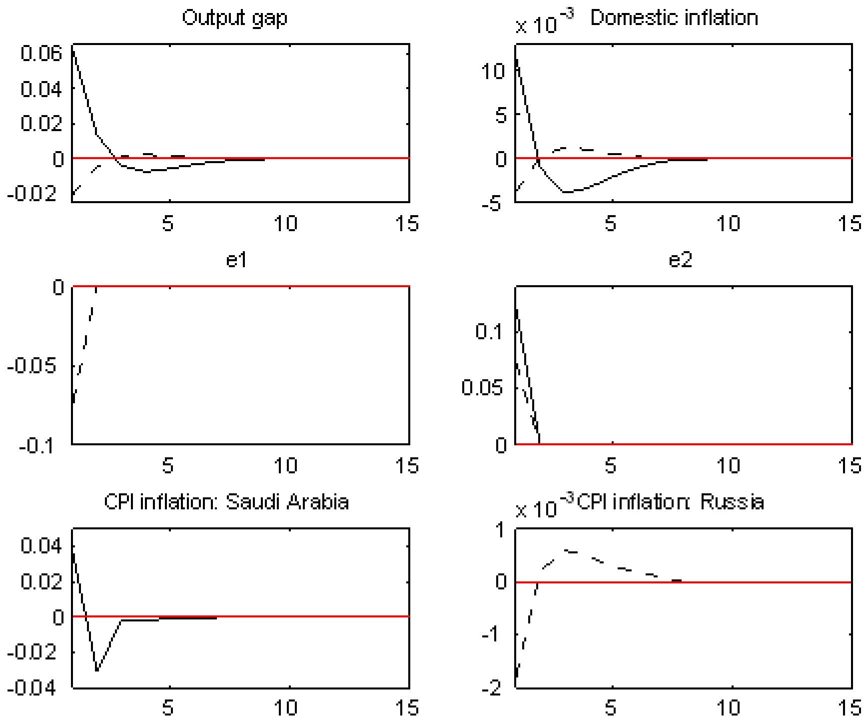

Figure 3: Exchange rate shock: Impulse response functions for Saudi Arabia (full line) and Russia (dotted line) in per centage point deviations from steady state.

domestic and the CPI inflation increase and the resulting real appreciation gradually wipes out the effects of the initial depreciation.

In the case of Russia, assuming a currency basket with weights of 50% for the US dollar and 50% for the euro, the reaction to the exchange rate shock is very different. When the euro appreciates against the US dollar, the domestic currency has to depreciate against the euro (e_2 must increase) and appreciate against the US dollar (e_1 must decrease), so as to keep the overall value of the currency basket constant. In our parameterisation of the model, the appreciation of the domestic currency against the US dollar implies a negative impact on aggregate demand that is larger than the positive effect of its depreciation against the euro, for the trade elasticity with respect to the US dollar is assumed to be larger than that with respect to the euro (the two coefficients $d_{31}$and d_{32} are 0.9 and 0.7, respectively). As a result, the output gap following the bilateral exchange rate shock is slightly negative. The direct impact of exchange rate movements on CPI inflation is zero in this case, as the CPI share of both the dollar and the euro is equal to 25% and the opposite movements in e_1 and e_2 offset each other. CPI inflation is therefore driven by the domestic inflation and the negative output gap translates into a short period of disinflation.

The impulse response functions are useful in providing an immediate insight into the mechanics of the model, but a full-fledged analysis of the optimal currency basket requires analysis of the stochastic shocks and calculation of unconditional variances of output and inflation for various weights of the two currencies in the basket. This is the topic of the next section.

4 The search for an optimal currency basket

We now turn our attention to the choice of an optimal external anchor for an oil exporting country. Unlike Turnovsky (1982) who defines the optimal currency basket as a fixed proportion of the two foreign exchanges that minimises the variance of domestic income, we focus on unconditional variances of *both* domestic income and CPI inflation, σ_{ygap} and σ_{π}. Since the model is one without microfoundations and an explicit welfare metrics, it is assumed that the policy maker's preferences can be captured by an ad-hoc loss function

$$\mathcal{L}_t = (\pi_t)^2 + \lambda(y_t^{gap})^2 \tag{16}$$

that defines total loss as a weighted sum of deviations of CPI inflation from an implicit zero inflation target and deviations of output gap from zero. The coefficient λ captures the weight put on output stabilisation relative to the stabilisation of inflation. When $\lambda = 0$, the policy-maker only cares about stabilising inflation; when $\lambda \to \infty$, output stabilisation is the only objective.[20] This is a standard formulation used, among others, in Ball (1999) and Svensson (1999). Taking unconditional expectations, equation (16) becomes

$$E[\mathcal{L}_t] = var(\pi_t) + \lambda var(y_t^{gap})$$

where $var(\pi_t)$ and $var(y_t^{gap})$ are the unconditional variances of CPI inflation and output gap, respectively.

The simulations are conducted for Saudi Arabia only, taking into account the variability and persistence of the three shocks discussed in the previous section. We simulate unconditional variances of inflation and output gap, assuming different weights for the two foreign prices in the domestic CPI basket and different weights for the two exchange rates in the currency basket. In particular, the relative weight of imports from the currency area e_1 with respect to the currency area e_2 in the CPI index ranges from 11% to 90% of total imports, corresponding to a ratio δ_1/δ_2 varying from from 0.11 to 9. The relative weight of the currency 1 in the currency basket - the coefficient μ_1 - ranges from 0, implying a complete disregard for the US dollar exchange rate and

[20] Note that under this specification of the loss function, future outcomes are *not* discounted.

a peg to the euro, to 1, implying a perfect peg of the Saudi riyal to the US dollar, with a step of 0.1. For each combination of δ_1/δ_2 and μ_1 we calculate unconditional variances of the CPI inflation and the output gap, which are reported in Table A2 and Table A3 in the appendix. Here we focus on the graphical representation of the results and their implications for the choice of the optimal external anchor.

The first result is simple and straightforward. Figure 4 shows that in order to minimise the unconditional variance of inflation, the external anchor should be made a function of the import shares δ_1 and δ_2. The higher the import share from the currency area 1 relative to that from currency area 2, the higher the share of the currency 1 in the optimal external anchor, a finding familiar with the literature based on trade models; see Connolly and Yousef (1982), and Branson and Katseli-Papaefstratiou (1981).

Figure 5 offers a different perspective. The relative weight of the two foreign prices in CPI basket has virtually no influence in the choice of an external anchor that minimises the output gap variance. The real interest rate channel of aggregate demand, working through the effect of the CPI index on the real interest rate and investment, is relatively unimportant for the external anchor considerations. The output gap variability is mainly affected by the ratio of the two net export elasticities, d_{31}/d_{32}. Since in our specification $d_{31} > d_{32}$, the basket that minimises output gap variability requires a larger weight for currency 1 ($\mu_1 = 0.6$) compared to currency 2.

The optimal external anchor ultimately depends on the relative weight placed on inflation and output variability, the parameter λ. This parameter may range from 0, i.e. no weight on output stabilisation, to $\lambda \to \infty$, i.e. solely the stabilisation of output. When λ is equal to 1, the policy maker assigns an equal weight to both output and inflation stabilisation. We trace the effect of these alternative preferences on the optimal share of currency 1, μ_1^*, that results in the smallest total unconditional variance (as weighted by λ), allowing again for different weights of the two foreign prices in the CPI index. This value, μ_1^*, is ultimately the *optimal external anchor* in our model.

Figure 6 plots the relative weight placed on the nominal exchange rate e_1 in the optimal currency basket for each given value of λ and the relative weight of imports in the CPI, δ_1/δ_2. The exact values of the optimal external anchor, μ_1^*, are reported in Table A5 in the appendix. First, it is obvious that when output stabilisation does not matter ($\lambda = 0$), the optimal external anchor is a straight-forward function of the relative import share in the CPI basket. For an 11% share of imports from e_1 corresponding to $\delta_1/\delta_2 = 0.11$, the optimal weight of e_1 in the external anchor is 0.2. The weight placed on e_1 in the optimal external anchor gradually increases, reaching 0.9 for the share of imports equal to 90% (i.e. $\delta_1/\delta_2 = 9$).

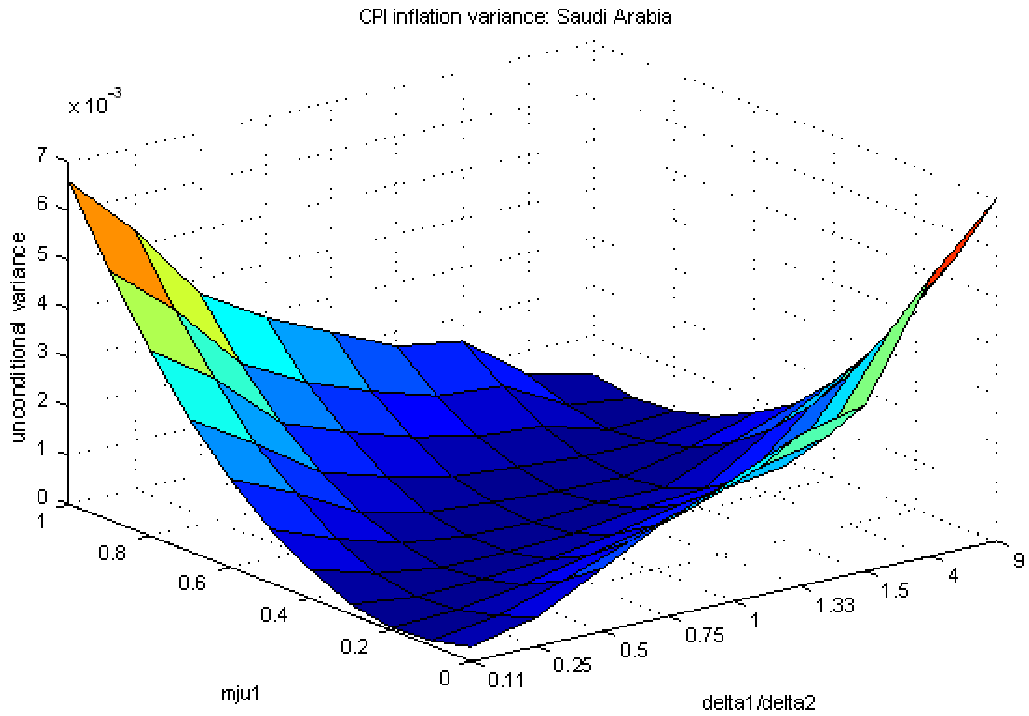

Figure 4: Unconditional variance of the CPI inflation as a function of the share of e_1 in the currency basket, μ_1, and the relative share of e_1 imports in CPI, δ_1/δ_2.

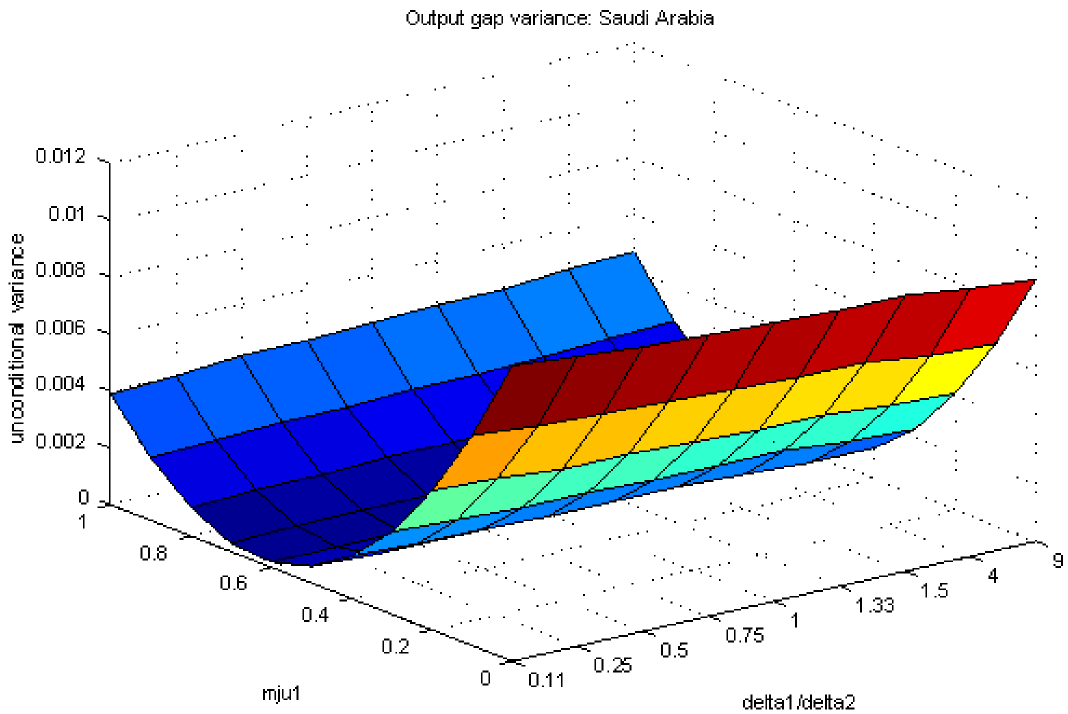

Figure 5: Unconditional variance of the output gap as a function of the share of e_1 in the currency basket, μ_1, and the relative share of e_1 imports in CPI, δ_1/δ_2.

Second, it is clear that this simple relationship changes as the weight put on output gap variability increases. The link between the import share and the optimal weight on e_1 becomes weaker and the optimal value of e_1 becomes "flatter". For $\lambda = 1$, an equal weight on output and inflation stabilisation, a virtually balanced currency basket with e_1 between 0.5 and 0.7 is the loss-minimising solution. When $\lambda \to \infty$ and only output stabilisation matter, the optimal weight on e_1 is independent from the currency composition of imports; it is always 0.6. Note that the optimal external anchor for $\lambda = 1$ is almost the same as that for a policy maker who only cares about output variability (see Table A5). There is virtually no change in optimal policy as the relative weight placed on output stabilisation increases from 1, an "equal treatment" of output and inflation variability, to infinity.

These findings can be interpreted in the following way: for a relatively wide spectrum of parameters, a currency basket that includes both foreign exchanges is superior to a basket comprised solely of one currency. Let us consider a hypothetical situation of a basket comprising only the US dollar, i.e. $\mu_1 = 1$. It is obvious that for such an arrangement to be optimal, we would need a policy maker that only cares about inflation variability ($\lambda = 0$) and a domestic economy where a vast majority of imports is invoiced in US dollars. This would mean that the relative CPI share δ_1/δ_2 is much higher than 1 and we would approach the furthest corner of the graph in Figure 4. If, however, the CPI shares of the two foreign exchanges are more balanced, as it could be the case in oil exporting countries where US dollar pricing of imports may dominate, but other currencies, such as the euro and the Japanese yen, may enter the terms of trade, a balanced basket including both the US dollar and other currencies would deliver a superior outcome in terms of output and inflation stabilisation.

It must be acknowledged that this result is driven by the fact that the price level in the model is rather flexible. The exchange rate pass-through from import prices to the CPI is immediate and the domestic prices are driven by a forward-looking Phillips curve. Aggregate demand, on the other hand, has a degree of inflexibility built in through the lagged dependent variable term in the IS curve, $d_1 y^d_{t-1}$, the main source of sluggish adjustment in the model.

Summing up, it is possible to draw two main conclusions from the simulation exercise. First, the relationship between the optimal external anchor and the import shares, proxying for the importance of different foreign currencies in the domestic CPI, is naturally positive but becomes weaker as the weight placed on relative output stabilisation increases. Second, a currency basket consisting of more than one currency seems to be generally preferable, except for the limiting case of the CPI share biased towards one foreign currency and a strong preference of the policy maker for the stabilisation of inflation.

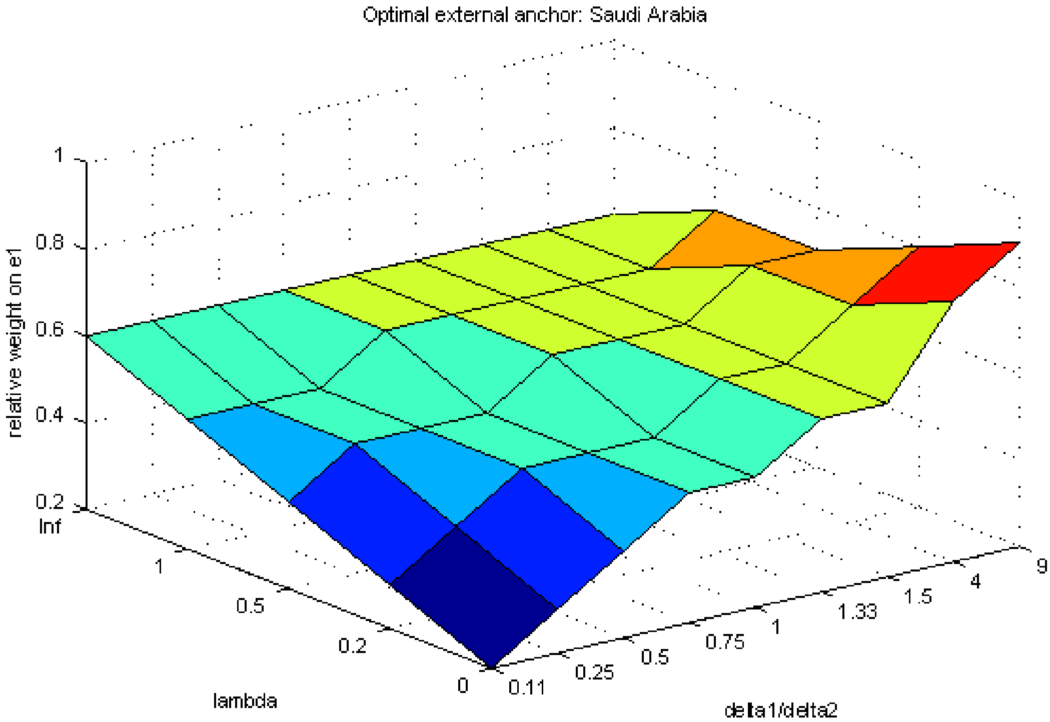

Figure 6: Optimal external anchor: relative weight placed on e_1 as a function of the relative weight put on output stabilisation, λ, and the relative share of imports in the CPI, δ_1/δ_2.

5 Concluding remarks

The peg to a single currency with a track record of low inflation and a credible monetary policy provides a transparent external anchor for small-open economies which are unable to run an independent monetary policy. In this paper, we have shown that oil exporting countries - in particular, the GCC countries - satisfy a number of key optimum currency area criteria to adopt a fixed exchange rate regime, even though the reliance of their economies on one single sector would call for greater exchange rate flexibility. Oil exporters may try to obtain greater exchange rate flexibility by anchoring to a basket of currencies, instead of a single currency. Indeed, the examination of the direction of trade and the synchronisation of business cycle of oil exporters suggests that there is not an "ideal" external anchor among the major international currencies. The adoption of a peg to a basket of currencies would better reflect a diversified currency structure of import prices and minimise the likelihood of importing the wrong monetary policy at the wrong time. The parameterisation of a simple reduced-form model of a small-open economy pegging to a basket of two currencies indicates that, in general, the optimal external anchor may consist of more than one currency, in particular if the policy-maker does care about the stabilisation of output. The fact that some oil exporting countries such as Kuwait, Libya and Russia have adopted the peg to a basket suggests that this policy choice does not rest in the realm of theoretical options.

References

Abed, G., N. Erbas, and B. Guerami (2003). The GCC monetary union: Some considerations for the exchange rate regime. IMF Working Paper WP/03/66, International Monetary Fund, Washington, D.C.

Argov, E., A. Binyamini, D. Elkayam, and I. Rozenshtrom (2007). A small macroeconomic model to support inflation targeting in Israel. Special report, Bank of Israel, Monetary Department.

Ball, L. (1999). Policy rules for open economies. In J. B. Taylor (Ed.), *Monetary policy rules*, pp. 127–156. Chicago: University of Chicago Press for NBER.

Beck, R. and E. Rahbari (2008). Optimal reserve composition in the presence of sudden stops: the euro and the dollar as safe haven currencies. ECB Working Paper 916, European Central Bank, Frankfurt am Main.

Borodin, A., E. Gorbova, S. Plotnikov, and Y. Plushchevskaya (2008). Estimating potential output and other unobservable variables using monetary transmission model: the case of Russia. Available at http://www.nbrb.by/engl/publications/Conferences/II/11.pdf.

Branson, W. H. and L. T. Katseli-Papaefstratiou (1981). Exchange rate policy for developing countries. In S. Grassman and E. Lundberg (Eds.), *The world economic order: Past and prospects*, pp. 391–419. London: Macmillan.

Calvo, G. (1983). Staggered prices in a utility maximising framework. *Journal of Monetary Economics 12*(3), 383–398.

Clarida, R., J. Galí, and M. Gertler (1999). The science of monetary policy: A new Keynesian perspective. *Journal of Economic Literature 37*(4), 1661–1707.

Connolly, M. B. and A. Yousef (1982). Optimum currency pegs for Arab countries. In M. B. Connolly (Ed.), *The international monetary system: Choices for the future*, pp. 135–155. New York: Preager Press.

Daniels, J., P. Toumanoff, and M. von der Ruhr (2001). Optimal currency basket pegs for developing and emerging economies. *Journal of Economic Integration 16*(1), 128–145.

Darvas, Z. and G. Szapáry (2005, August). Business cycle synchronization in the enlarged EU. CEPR Discussion Paper 5179, Centre for Economic Policy Research, London.

Edison, H. and E. Vardal (1990). Optimal currency baskets for small, developed economies. *Scandinavian Journal of Economics 92*(4), 559–571.

Fidrmuc, J. and I. Korhonen (2004). A meta-analysis of business cycle correlations. OeNB Focus on European Integration 02/04, Oesterreichische Nationalbank, Wien.

Frankel, J. A. (2005). Peg the export price index: A proposed monetary regime for small countries. *Journal of Policy Modelling 27*(4), 495–508.

Frankel, J. A. and A. K. Rose (1998). The endogeneity of the optimum currency area criteria. *Economic Journal 108*, 1009–1025.

Goldberg, L. S. and C. Tille (2005). Vehicle currency use in international trade. Staff Report 200, Federal Reserve Board of New York, New York.

Gray, J. A. (1976). Wage indexation: A macroeconomic approach. *Journal of Monetary Economics 2*(2), 221–235.

Gruen, D., A. Pagan, and C. Thompson (1999). The Phillips curve in Australia. Research Discussion Paper 1999-01, Reserve Bank of Australia, Canberra.

Habib, M. and M. Kalamova (2007). Are there oil currencies? The real exchange rate of oil exporting countries. ECB Working Paper 839, European Central Bank, Frankfurt am Main.

Harjes, T. and L. A. Ricci (2008). A Bayesian-estimated model of inflation targeting in South Africa. IMF Working Paper WP/08/48, International Monetary Fund, Washington, D.C.

Hasan, M. and H. Alogeel (2008). Understanding the inflationary process in the GCC region: The case of Saudi Arabia and Kuwait. IMF Working Paper WP/08/193, International Monetary Fund, Washington, D.C.

Ho, C. and R. N. McCauley (2003). Living with flexible exchange rates: Issues and recent experience in inflation targeting for emerging market economies. BIS Working Paper 130, Bank for International Settlements, Basel.

Iqbal, Z. and N. Erbas (1997). External stability under alternative nominal exchange rate anchors: An application to the GCC countries. IMF Working Paper WP/97/8, International Monetary Fund, Washington, D.C.

Jadresic, E. (2002). On a common currency for GCC countries. IMF Policy Discussion Paper 02/12, International Monetary Fund, Washington, D.C.

Karam, P. and A. Pagan (2008). A small structural monetary policy model for small open economies with debt accumulation. IMF Working Paper WP/08/64, International Monetary Fund, Washington, D.C.

Mishkin, F. S. (2000). Inflation targeting in emerging market countries. *American Economic Review 90*(2), 105–109.

Nimark, K. (2007). A structural model of Australia as a small open economy. Research Discussion Paper RDP 2007-01, Reserve Bank of Australia, Canberra.

Pradhan, S. R. (2008). Inflation in the GCC: Are subsidies the antidote? GRC Analysis, Gulf Research Center, Dubai.

Ravn, M. O. and H. Uhlig (2002). On adjusting the Hodrick-Prescott filter for the frequency of observations. *Review of Economics and Statistics 84*(2), 371–375.

Setser, B. (2007). The case fro exchange rate flexibility in oil-exporting economies. Policy brief 8, Peterson Institute for International Economics, Washington, D.C.

Sturm, M., J. Stráský, P. Adolf, and D. Peschel (2008). The Gulf Cooperation Council countries: Economic structures, recent developments and role in the global economy. ECB Occasional Paper 92, European Central Bank, Frankfurt am Main.

Svensson, L. E. O. (1999). Inflation targeting as a monetary policy rule. *Journal of Monetary Economics 43*(3), 607–654.

Tavlas, G. S. (1993). The 'new' theory of optimum currency areas. *World Economy 16*(6), 663–685.

Tavlas, G. S. (2000). On the exchange rate as a nominal anchor: The rise and fall of the credibility hypothesis. *Economic Record 76*, 183–201.

Turnovsky, S. J. (1982). A determination of the optimal currency basket. *Journal of International Economics 12*(3-4), 333–354.

A Additional Tables

Table A1 shows the correlations of oil exporters' business cycles (GDP) with the United States, euro area, United Kingdom and Japan. These are correlation coefficents of detrended GDP series (in logarithms) according to Hodrick-Prescott filtering procedure. For annual data, the smoothing parameter of the Hodrick-Prescott formula was set to 6.25 (power rule of 4) according to Ravn and Uhlig (2002).

Tables A2 and A3 report the exact values of the simulated unconditional variances of CPI inflation and aggregate demand (output) respectively. In both tables, we report variances for the alternative shares of imports in the CPI between 0.1 and 9 as well as for the currency baskets containing 0 to 100% of the currency of the two trading areas. The change in composition of the currency basket is given by the changing parameter μ_1 (the share of currency e_1 in the basket) that varies in 10% steps from 0 to 1.

The exact CPI shares assigned to imports from the area e_1 and e_2 - i.e. the parameters δ_1 and δ_2 respectively - are summarised in Table A4. The share of domestically produced goods and services in the CPI, δ_0, is kept at 50%, while the relative weight of imports from one currency area is varied between 0.11 and 9, implying the relative share of import prices from the dollar area varying, roughly, from 10 to 90% of total imports.

Finally, Table A5 reports the exact weight put on e_1 in the optimal currency basket for different values of the parameter λ that captures the relative weight put on stabilisation of output relative to inflation. Unless the weight put on output stabilisation is zero, the optimal weight of the US dollar, e_1^*, is always between 0.3 and 0.8, implying that pegging to a single currency results in higher loss from inflation and output variability than a peg to a diversified basket of currencies.

Annual data: 1971 - 2007							
Contemporaneous correlations							
	Algeria	Libya	Nigeria	Russia*	Kuwait	Saudi Arabia	U.A.E.
US	0.30	0.38	-0.24	0.20	0.50	-0.08	-0.03
Japan	0.33	0.09	0.12	0.49	-0.06	0.19	0.46
Euro area	0.21	0.08	0.02	0.49	-0.10	0.36	0.41
United Kingdom	0.21	0.26	-0.37	0.21	0.51	-0.22	-0.29
One lag in business cycle of reference currency area							
	Algeria	Libya	Nigeria	Russia*	Kuwait	Saudi Arabia	U.A.E.
US	0.04	-0.09	-0.08	0.27	0.06	0.29	0.17
Japan	0.01	-0.25	0.29	-0.19	-0.26	0.61	0.34
Euro area	-0.11	-0.31	0.17	0.38	-0.38	0.46	0.33
United Kingdom	0.07	-0.07	-0.05	-0.01	0.03	0.31	0.29
Quarterly data: 1991Q1 - 2007Q4							
Contemporaneous correlations							
	Algeria	Libya	Nigeria	Russia*	Kuwait**	Saudi Arabia	U.A.E.
US	0.06	-0.13	0.00	-0.08	0.14	0.26	0.33
Japan	0.29	0.38	0.60	0.37	0.08	0.52	0.46
Euro area	-0.21	0.01	-0.27	0.28	0.36	0.12	0.31
United Kingdom	0.29	-0.52	-0.27	0.18	0.47	-0.35	0.48
One lag in business cycle of reference currency area							
	Algeria	Libya	Nigeria	Russia*	Kuwait**	Saudi Arabia	U.A.E.
US	-0.09	-0.16	-0.09	0.04	0.24	0.18	0.36
Japan	0.17	0.54	0.64	0.33	0.04	0.54	0.37
Euro area	-0.13	-0.01	-0.22	0.24	0.30	0.12	0.19
United Kingdom	-0.19	-0.50	-0.24	0.17	0.35	-0.31	0.49
Four lags in business cycle of reference currency area							
	Algeria	Libya	Nigeria	Russia*	Kuwait**	Saudi Arabia	U.A.E.
US	-0.39	-0.15	-0.33	0.01	0.20	-0.16	0.11
Japan	-0.10	0.71	0.36	-0.30	-0.17	0.36	-0.21
Euro area	-0.05	0.16	-0.14	0.07	-0.13	-0.13	-0.41
United Kingdom	0.26	-0.46	-0.06	0.00	-0.21	-0.21	0.25

Table A1. Correlations of oil exporters' business cycles (HP filter detrended GDP) with the United States, euro area, United Kingdom and Japan.

*For Russia the sample starts in 1995. **For Kuwait the quarterly sample starts in 1994Q1.

Sources: IMF World Economic Outlook database, OECD, Global Insight and authors' calculations.

	$var(\pi)$								
	$\frac{\delta_1}{\delta_2}$=0.1	$\frac{\delta_1}{\delta_2}$=0.25	$\frac{\delta_1}{\delta_2}$=0.5	$\frac{\delta_1}{\delta_2}$=0.75	$\frac{\delta_1}{\delta_2}$=1	$\frac{\delta_1}{\delta_2}$=1.33	$\frac{\delta_1}{\delta_2}$=1.5	$\frac{\delta_1}{\delta_2}$=4	$\frac{\delta_1}{\delta_2}$=9
$\mu_1 = 0.0$	0.0003	0.0006	0.0013	0.0020	0.0025	0.0031	0.0034	0.0057	0.0070
$\mu_1 = 0.1$	0.0001	0.0003	0.0007	0.0012	0.0016	0.0021	0.0024	0.0043	0.0055
$\mu_1 = 0.2$	4.8×10^{-5}	0.0001	0.0003	0.0006	0.0009	0.0013	0.0015	0.0031	0.0042
$\mu_1 = 0.3$	0.0002	4.8×10^{-5}	0.0001	0.0002	0.0004	0.0007	0.0009	0.0021	0.0030
$\mu_1 = 0.4$	0.0006	0.0002	2.2×10^{-5}	3.8×10^{-5}	0.0001	0.0003	0.0004	0.0013	0.0020
$\mu_1 = 0.5$	0.0011	0.0006	0.0002	3.3×10^{-5}	1.2×10^{-5}	0.0001	0.0001	0.0007	0.0012
$\mu_1 = 0.6$	0.0018	0.0012	0.0005	0.0002	0.0001	1.5×10^{-5}	0.8×10^{-5}	0.0003	0.0007
$\mu_1 = 0.7$	0.0027	0.0019	0.0010	0.0006	0.0003	0.0002	0.0001	0.0001	0.0003
$\mu_1 = 0.8$	0.0038	0.0029	0.0017	0.0012	0.0008	0.0005	0.0004	2×10^{-5}	0.0001
$\mu_1 = 0.9$	0.0051	0.0040	0.0026	0.0019	0.0014	0.0010	0.0009	0.0002	3.4×10^{-5}
$\mu_1 = 1.0$	0.0066	0.0053	0.0037	0.0029	0.0023	0.0017	0.0015	0.0005	0.0002

Table A2. Inflation variance as a function of the CPI composition ($\delta_0 = 0.5$).

	$var(y^{gap})$								
	$\frac{\delta_1}{\delta_2}$=0.1	$\frac{\delta_1}{\delta_2}$=0.25	$\frac{\delta_1}{\delta_2}$=0.5	$\frac{\delta_1}{\delta_2}$=0.75	$\frac{\delta_1}{\delta_2}$=1	$\frac{\delta_1}{\delta_2}$=1.33	$\frac{\delta_1}{\delta_2}$=1.5	$\frac{\delta_1}{\delta_2}$=4	$\frac{\delta_1}{\delta_2}$=9
$\mu_1 = 0.0$	0.0104	0.0102	0.0100	0.0099	0.0098	0.0097	0.0097	0.0094	0.0092
$\mu_1 = 0.1$	0.0074	0.0072	0.0071	0.0070	0.0069	0.0068	0.0068	0.0065	0.0064
$\mu_1 = 0.2$	0.0049	0.0048	0.0046	0.0046	0.0045	0.0044	0.0044	0.0042	0.0041
$\mu_1 = 0.3$	0.0029	0.0028	0.0027	0.0027	0.0026	0.0026	0.0026	0.0024	0.0023
$\mu_1 = 0.4$	0.0015	0.0014	0.0014	0.0013	0.0013	0.0013	0.0012	0.0011	0.0011
$\mu_1 = 0.5$	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0004	0.0004
$\mu_1 = 0.6$	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
$\mu_1 = 0.7$	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005
$\mu_1 = 0.8$	0.0010	0.0011	0.0011	0.0012	0.0012	0.0012	0.0012	0.0013	0.0014
$\mu_1 = 0.9$	0.0022	0.0023	0.0024	0.0024	0.0025	0.0025	0.0026	0.0027	0.0028
$\mu_1 = 1.0$	0.0039	0.0040	0.0042	0.0042	0.0043	0.0044	0.0044	0.0046	0.0047

Table A3. Output variance as a function of the CPI composition ($\delta_0 = 0.5$).

δ_1/δ_2	δ_1	δ_2	δ_0	$\sum \delta_i$
0.11	0.05	0.45	0.5	1
0.25	0.1	0.4	0.5	1
0.5	0.17	0.33	0.5	1
0.75	0.215	0.285	0.5	1
1	0.25	0.25	0.5	1
1.33	0.285	0.215	0.5	1
1.5	0.3	0.2	0.5	1
4	0.4	0.1	0.5	1
9	0.45	0.05	0.5	1

Table A4. Exact weights of imports in the CPI used in the simulations.

	λ=0	λ=0.2	λ=0.5	λ=1	$\lambda \to \infty$
$\frac{\delta_1}{\delta_2}$=0.1	0.2	0.3	0.4	0.5	0.6
$\frac{\delta_1}{\delta_2}$=0.25	0.3	0.4	0.5	0.5	0.6
$\frac{\delta_1}{\delta_2}$=0.5	0.4	0.5	0.5	0.5	0.6
$\frac{\delta_1}{\delta_2}$=0.75	0.5	0.5	0.5	0.6	0.6
$\frac{\delta_1}{\delta_2}$=1	0.5	0.5	0.6	0.6	0.6
$\frac{\delta_1}{\delta_2}$=1.33	0.6	0.6	0.6	0.6	0.6
$\frac{\delta_1}{\delta_2}$=1.5	0.6	0.6	0.6	0.6	0.6
$\frac{\delta_1}{\delta_2}$=4	0.8	0.7	0.7	0.6	0.6
$\frac{\delta_1}{\delta_2}$=9	0.9	0.8	0.7	0.7	0.6

Table A5. Optimal external anchor as a function of the discounting parameter lambda and the CPI composition. (The values are the relative weight put on the currency $e1$)

European Central Bank Working Paper Series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (http://www.ecb.europa.eu).

923 "Resuscitating the wage channel in models with unemployment fluctuations" by K. Christoffel and K. Kuester, August 2008.

924 "Government spending volatility and the size of nations" by D. Furceri and M. Poplawski Ribeiro, August 2008.

925 "Flow on conjunctural information and forecast of euro area economic activity" by K. Drechsel and L. Maurin, August 2008.

926 "Euro area money demand and international portfolio allocation: a contribution to assessing risks to price stability" by R. A. De Santis, C. A. Favero and B. Roffia, August 2008.

927 "Monetary stabilisation in a currency union of small open economies" by M. Sánchez, August 2008.

928 "Corporate tax competition and the decline of public investment" by P. Gomes and F. Pouget, August 2008.

929 "Real convergence in Central and Eastern European EU Member States: which role for exchange rate volatility?" by O. Arratibel, D. Furceri and R. Martin, September 2008.

930 "Sticky information Phillips curves: European evidence" by J. Döpke, J. Dovern, U. Fritsche and J. Slacalek, September 2008.

931 "International stock return comovements" by G. Bekaert, R. J. Hodrick and X. Zhang, September 2008.

932 "How does competition affect efficiency and soundness in banking? New empirical evidence" by K. Schaeck and M. Čihák, September 2008.

933 "Import price dynamics in major advanced economies and heterogeneity in exchange rate pass-through" by S. Dées, M. Burgert and N. Parent, September 2008.

934 "Bank mergers and lending relationships" by J. Montoriol-Garriga, September 2008.

935 "Fiscal policies, the current account and Ricardian equivalence" by C. Nickel and I. Vansteenkiste, September 2008.

936 "Sparse and stable Markowitz portfolios" by J. Brodie, I. Daubechies, C. De Mol, D. Giannone and I. Loris, September 2008.

937 "Should quarterly government finance statistics be used for fiscal surveillance in Europe?" by D. J. Pedregal and J. J. Pérez, September 2008.

938 "Channels of international risk-sharing: capital gains versus income flows" by T. Bracke and M. Schmitz, September 2008.

939 "An application of index numbers theory to interest rates" by J. Huerga and L. Steklacova, September 2008.

940 "The effect of durable goods and ICT on euro area productivity growth?" by J. Jalava and I. K. Kavonius, September 2008.

941 "The euro's influence upon trade: Rose effect versus border effect" by G. Cafiso, September 2008.

942 "Towards a monetary policy evaluation framework" by S. Adjemian, M. Darracq Pariès and S. Moyen, September 2008.

943 "The impact of financial position on investment: an analysis for non-financial corporations in the euro area" by C. Martinez-Carrascal and A. Ferrando, September 2008.

944 "The New Area-Wide Model of the euro area: a micro-founded open-economy model for forecasting and policy analysis" by K. Christoffel, G. Coenen and A. Warne, October 2008.

945 "Wage and price dynamics in Portugal" by C. Robalo Marques, October 2008.

946 "Macroeconomic adjustment to monetary union" by G. Fagan and V. Gaspar, October 2008.

947 "Foreign-currency bonds: currency choice and the role of uncovered and covered interest parity" by M. M. Habib and M. Joy, October 2008.

948 "Clustering techniques applied to outlier detection of financial market series using a moving window filtering algorithm" by J. M. Puigvert Gutiérrez and J. Fortiana Gregori, October 2008.

949 "Short-term forecasts of euro area GDP growth" by E. Angelini, G. Camba-Méndez, D. Giannone, L. Reichlin and G. Rünstler, October 2008.

950 "Is forecasting with large models informative? Assessing the role of judgement in macroeconomic forecasts" by R. Mestre and P. McAdam, October 2008.

951 "Exchange rate pass-through in the global economy: the role of emerging market economies" by M. Bussière and T. Peltonen, October 2008.

952 "How successful is the G7 in managing exchange rates?" by M. Fratzscher, October 2008.

953 "Estimating and forecasting the euro area monthly national accounts from a dynamic factor model" by E. Angelini, M. Bańbura and G. Rünstler, October 2008.

954 "Fiscal policy responsiveness, persistence and discretion" by A. Afonso, L. Agnello and D. Furceri, October 2008.

955 "Monetary policy and stock market boom-bust cycles" by L. Christiano, C. Ilut, R. Motto and M. Rostagno, October 2008.

956 "The political economy under monetary union: has the euro made a difference?" by M. Fratzscher and L. Stracca, November 2008.

957 "Modeling autoregressive conditional skewness and kurtosis with multi-quantile CAViaR" by H. White, T.-H. Kim, and S. Manganelli, November 2008.

958 "Oil exporters: in search of an external anchor" by M. M. Habib and J. Stráský, November 2008.

ISSN 1561-0810

9 771561 081005