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Offshore Barbados: a critical analysis

1. INTRODUCTION

Barbados' standing as one of the most advanced economies in the Caribbean has been cemented, to a large extent, by ongoing efforts to attract and retain a vibrant international business sector.[1] This broad sector encompasses a range of businesses including call centers, medical transcription, manufacturing, offshore banking, trusts, mutual funds, exempt insurance, exempt insurance management, and international shipping companies. The intention to develop Barbados as a competitive offshore centre has catalyzed the creation of myriad infrastructural systems and institutional arrangements designed to facilitate the sector's growth.

However, due in large measure to data availability

[1] For example, Barbados had the highest UN Human Development Index (HDI) ranking among its Caribbean counterparts in 2009.

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constraints, there has been a dearth of comprehensive academic research into the sector and its attendant dynamics. Given its growing importance, taking stock of the industry and clearly identifying both successes and weaknesses within the existing structure is paramount. Furthermore, as more regional economies set their sights on capturing a share of the international business sector and the associated 126 billion of USD in annual foreign direct investment (FDI) inflows into the Latin American and the Caribbean region,[2] it is crucial to identify potential challenges to the sector.

With this in mind, the current paper attempts to answer two broad questions; namely, how has Barbados' international business environment performed vis-à-vis its regional counterparts and, of equal importance, what mechanisms are necessary to ensure that the country can be competitive in an increasingly dynamic environment.

To address these issues, the paper proceeds as follows. Section 2 consists of a theoretical overview of the major dimensions of international business environments and the dynamics that influence firms' decision-making. Section 3 provides a brief review of the systematic strategy that has been employed to attract international business to Barbados with specific reference to the dynamics identified in the section 2. Section 4 attempts to answer the question of how Barbados international business sector has performed by analyzing various indicators of the growth and health of the sector. The final section, section 5, provides some concluding remarks.

2. THE INTERNATIONAL BUSINESS ENVIRONMENT

Despite, or perhaps as a result of, the ubiquity of research into various countries' relative attractiveness within the international business literature, finding a single, consistent and widely accepted definition for what constitutes an *attractive* business environment is a rather elusive undertaking. One of the major reasons for this is that there are myriad interactions upon which the viability of a specific business in a particular territory is contingent. It would be unreasonable,

[2] UNCTAD World Investment Report (2008).

for example, to expect a German pharmaceutical firm seeking a highly educated overseas workforce and a United States of America (USA) clothing company desirous of outsourcing shoe production to a low-cost jurisdiction to have identical or even very similar considerations when choosing an overseas market in which to invest.

It is evident, however, that in order for meaningful comparisons to be made between and among destinations, it is necessary to have a range of general categories under which it is possible to analyze the attractiveness of international business environments in different countries. As such, the academic literature generally identifies four broad dimensions which determine the attractiveness of international business environments; namely political, economic, legal and sociocultural.

2.1. The political dimension

The political dimension of the international business environment is addressed from the perspective of political risk to commercial enterprises. Fitzpatrick (1983) argues that the term political risk encompasses a range of approaches to the definition, measurement and analysis of risk. Among these is the proposition that political risks are associated with direct government market intervention and political occurrences, such as elections or other changes in administration.

Perhaps more importantly for the current research, Fitzpatrick points to a more in-depth approach in which political risk is assessed not simply as a probability of changes in administration or policy, but rather the potential for these changes to impact both the general business environment and specific firms. More specifically, institutional country analyses of the political impacts on business climates include indicators of variables such as corruption, bureaucratic quality; social unrest, relationships among political parties, politically motivated violence and external conflicts. These factors' impact on the business environment can be arranged along a continuum of increasingly direct and destructive intervention, ranging from minor policy changes to more authoritarian actions

While, as Fitzpatrick notes, there may be a *laissez faire*

approach to political risk, in which firms acknowledge this type of risk but fail to quantify its potential impact, research by Shafa et al. (1995) and Busse and Hefeker (2007) conclude that firms' cross-border investment decisions continue to be strongly influenced by the political climate in the host country, making the political dimension a critical aspect of the business environment.

2.2. The economic dimensions

Given that government policy is a major determinant of economic conditions, it is infeasible to consider the political dimension without specific reference to the economy. The economic dimension encompasses an array of internal and external factors that influence the business environment. Internal influences are those over which a domestic administration has control such as money supply and monetary stability, fiscal balance and exchange rate policies. External factors, less susceptible to the direct influence of the country's economic actors, include external supply/demand shocks, exchange rate volatility, natural disasters and global economic conditions.

As with the political influence on the business climate, the importance of the economy is regarded as a function of the level of underlying macroeconomic risk and the probability of these risks impacting the firms' operations. Country-level economic risk is regarded as the likelihood that events, including governmental economic mismanagement, will cause drastic changes in a country's business environment that would adversely affect profits and other goals of a particular business enterprise (Price, 2005). Moreover, it is often through the macroeconomy that much of the political dimension will influence a nation's business climate.

The impact of the macroeconomy on the business environment is also heavily determined by firm-level factors such as the type of industry, commercial orientation (domestic or export-dependent), capital/labor ratios and the firm's cost structure. Dunning (1992) points out that the ownership-specific advantages of the firm –its ability to use its unique internal strengths to compete in a given environment– is as important to firm success as is the firm's choice of location.

Thus, in essence, the impact of macroeconomic fluctuations on a specific firm is as much a function of the fluctuations themselves as it is the firm's ability to adjust to these changes.

2.3. Legal dimensions

Daniels et al.'s (2007) broad review of sovereign legal frameworks highlights five distinct legal systems: common law, based on tradition, precedents, custom, and usage; civil law, which is based on a comprehensive code that includes rules for conducting business; theocratic law, which is derived from religious ideology and in which ultimate legal authority rests with religious leaders; customary law, which is based on the knowledge of "daily experience or great spiritual or philosophical traditions"; and the mixed legal system which is essentially a merger of two or more of the types of legal systems used within a single country. Many countries in the Western Hemisphere employ a mixed system of civil and common law while there is a strong leaning toward theocratic and customary law throughout Asia and the African continent.

Daniels et al. provide a brief but comprehensive overview of how the legal and business environments interact, identifying three broad areas of concern for business. Specifically, the authors highlight intellectual property concerns; operational concerns, which relate to entry, contract enforcement and labor laws; and strategic concerns, which involve the laws that directly impact value creation and include issues such as product safety, rules of origin and arbitration.

It is important to note, however, that globalization and the rise of multi-national firms have led to a decrease in the differences among the laws governing business environments in different countries. Specifically, the emergence and growth in international standards, laws and regulations in accounting, corporate governance and labor standards have led to a convergence in legal frameworks pertaining to businesses. Despite this, there still remain significant differences in legal systems from country to country.

2.4. Socio-cultural dimensions

A growing body of research has examined the impact of

cultural differences, often referred to as cultural distance or cultural friction (Shenkar, 2001), on international business from various perspectives. In general, cultural impacts on the international business environment are related to the level of social stratification, general motivation to work, preferences for specific types of relationships, appetites for risk, and information processing and communication methods (Daniels et al., 2007).

Using a range of cultural frameworks, including those produced by Hofstede (1980) and Schwartz (1990), it has been shown that cultural distance impacts a range of conditions in the international business environment, ultimately influencing FDI decisions (Siegel et al., 2008), entry modes (Tihanyi et al., 2005) and firm profitability (Metters, 2008).

3. BARBADOS' APPROACH TO THE OFFSHORE SECTOR

3.1. Legal system

Barbados' legal system is based principally on English Common Law. The first apparent advantage of this approach is that, as noted, many developed countries –including the United Kingdom (UK), United States (USA) and Canadian firms– practice this type of law and are therefore more comfortable in jurisdictions that rely on Common Law (Marshall Capital, 2007). Indeed, it is somewhat predictable nature reduces risk with respect to the resolution of potential legal disputes in the host country.

The Companies Act (1982) of Barbados, for instance, modeled on the Canadian Business Corporation Act, provides a broad framework within which offshore companies can function and addresses issues ranging from company-types, ownership structures, foreign-domestic company interaction and required capital base. Once incorporated under the Act, offshore companies then register formally under one of a number of offshore legislative acts tailored to their specific business model, among them, the International Business Companies (IBC) Act (1992), the Financial Institutions Act (1997), the International Trust Act (1995) and the Mutual Funds Act (2002). These pieces of legislation create a very

specialized and detailed framework clearly outlining the requirements and obligations related to capital base, operations, directorship, property, and business dissolution.

There are also a number of regulatory agencies that are given legal scope to oversee and regulate through registration, capital monitoring, auditing and analysis of the relevant segments of the industry; specifically, the Central Bank of Barbados (CBB), the Ministry of International Business, the Barbados Investment Development Cooperation (BIDC), Invest Barbados, and the Supervisor of Insurance.

The development of these legal and institutional frameworks has had two opposing impacts on Barbados' business environment. The initial impact was that these systems enhanced the oversight and regulatory ability of government by ensuring that offshore companies provide an array of timely and accurate information. This is perhaps most evident in the offshore financial services sub-sector which is regulated by the CBB and faces more stringent reporting requirements and is subject to greater oversight than the other sub-sectors. Conversely, while the start-up of new offshore business has been deemed simple, the added layers of red tape for repatriation of funds, financial statements, license renewal fees and various registration requirements creates added costs and reduces the level of investment freedom.

In line with other offshore business centres, including the Bahamas and Belize, a host of incentives are addressed within each regulatory Act. The various Acts specify levels of corporate income tax and personal tax for employees of offshore companies, exchange control regulations, import and other expenditure-related tax-free allowances and privacy entitlements.

Table 1 provides a summary comparison of some of the major incentives embodied in Barbados' 14 governing acts with those in other offshore centres.[3]

From table 1 it is apparent that there are a number of areas of convergence with respect to the incentives enshrined in the

[3] The Bahamas, Bermuda and Cayman Islands were chosen for comparison since they were among the countries in the region identified as part of the IMF Offshore Financial Centres (OFCs): IMF Staff Assessments Programme.

TABLE 1. COMPARISON OF INCENTIVES OFFERED IN SELECT OFFSHORE CENTRES

Taxes	*Barbados*	*Bahamas*	*Bermuda*	*Cayman Islands*
Corporate income tax rate	1%-2.5%	0%	0%	0%
Consumer tax rate	15% (VAT)	0%	0%	0%
Import duties	YI	Y	Y	Y
Withholding tax	YI	Y	Y	Y
Exchange controls	YI	Y	Y	Y

NOTES: Y - Incentives exist. YI - Incentives are dependent on type of company.

legal frameworks of a number of the industry leading offshore centres. In particular, the general absence of exchange controls, withholding tax and import duties are common to most of the jurisdictions and provide a tremendous incentive for offshore companies as it relates to revenue management, repatriation of funds and operational costs.

There are, however, a number of areas of divergence. Unlike many of the other jurisdictions that have zero rates of income tax, Barbados' tax system includes income taxes, but provides for substantially reduced tax rates of 1%-2.5% for companies in the offshore sector. This arguably provides a competitive tax-related advantage for other financial centres in which companies are not subject to any form of taxation. However, there are also a number of double taxation agreements which reduce potential tax burdens and which may serve to counterbalance some of the disincentive impact of the business income tax.[4]

3.2. Labor-related legal issues

While not specific to the international business sector, the institutional labor arrangements are also critical considerations since labor dynamics play a significant role in determining FDI flows. Barbados has a strong history of collective bargaining and unionization and labor unions are relatively strong players in the domestic economy (Fashoyin, 2001). Conventional wisdom has suggested that pervasive unionization is a persistent deterrent of FDI inflows. Cooke (1997) and

[4] These treaties currently exist with the Belgium-Luxembourg Economic Union, Canada, China, Cuba, Germany, Italy, Mauritius, Switzerland, the UK and Venezuela.

Cooke and Noble (1998) provide support for this view, suggesting that union density and centralized bargaining are inversely related to FDI inflows. However, the main strength of Barbados' unions lie in the high level of social dialogue with stakeholders, primarily through The Social Partnership agreement between the trade unions, government and private employers which aims to ensure economic stability through a series of agreements on price and incomes stabilization, preservation of employment and collective negotiation (Fashoyin 2001). Seen as an alternative to the potentially onerous cost-cutting measures prescribed by the International Monetary Fund (IMF) during the early 1990s, this Partnership has been credited with stabilizing the economy, reducing unemployment and stimulating economic growth and development. Through the Social Partnership and successive government and union commitment to increasing the level of FDI, it is possible that the coordination of policy may have counterbalanced the deterrent influence of the strong union culture.

3.3. Political system

Barbados is a parliamentary democracy modeled on the bicameral system of the UK. This system has existed almost entirely intact since 1639. The country has had seven Prime Ministers from the two dominant political parties [the Barbados Labor Party (BLP) and the Democratic Labor Party (DLP)], each selected by the party holding parliamentary majority in the House of Assembly. Each government is elected for a maximum five-year term; over the 44 years since independence, parties have held office for, on average, seven years.

A democratic structure is, in itself, an incentive for FDI (Jensen and McGillivray, 2005) since the level of political stability created by democracy relative to other forms of government inherently reduces country-specific risk for international investors. Moreover, while the two major parties in Barbados campaign on unique platforms, there are substantial similarities in their international business sector policies. This continuity of sectoral policy is critical since it diminishes the uncertainty associated with frequently varying policies

and reduces the level of risk associated with changes in administration.

The democratic culture, coupled with the strength of legislation and the successive governmental focus on enabling international business also implies a reduced risk of expropriation. Indeed, there have been no recorded incidents of offshore companies being taken over by the Barbados government.

As noted in the section 2.1, the level of corruption within a jurisdiction also influences the attractiveness of its business climate. Dohlstrom and Johnson (2007), has suggested that there are increased set-up and operating costs associated with corruption and, as such, corruption is inversely related to FDI inflows. As a corollary, a strong anti-corruption climate will facilitate international business. Barbados' strong legislative framework appears to foster such an atmosphere, having earned the country a reputation as a strong global, anti-corruption destination.[5]

3.4. Economy

The importance of socio-economic factors in determining FDI and the growth of offshore sectors is well-documented (see Nonnemberg and de Mendonça, 2004, for a detailed review of the literature). While there are both push and pull economic factors, in the current context, we are only concerned with the latter.

First among these is the level of domestic output, proxied by the country's gross domestic product (GDP), the most widely used measure of economic growth. Traditional theory suggests that this indicator is of particular relevance where international businesses are engaged in trading with the host country and, as such, domestic income provides a key indicator of potential demand. However, as with many of its competitors, Barbados' offshore sector is dominated by services such as data processing, non-resident banking and other services produced for export (non-resident consumption). This

[5] Barbados was ranked 20th out of 180 countries (the highest in the Caribbean region) in Transparency International's Corruption Perceptions Index (CPI), 2009.

is compounded by the restriction on offshore companies in Barbados which generally prohibits them from offering their products or services commercially to residents of Barbados.

As Nunnenkamp (2002) has noted, services offered by offshore firms are unlike most FDI in that they are not local market-seeking but are aimed at taking advantage of export or efficiency gains.[6] As a result, the link between these factors and the international business climate may not function in the traditional way. Early work by Doyle and Johnson (1999) suggested that nominal GDP is correlated with offshore banking GDP and that offshore banking activity responds to factors in the local economy, though the authors do not explicitly pinpoint these factors.

It is likely that one of the major mechanisms through which economic activity may aid in attracting international business is through capital formation. As Dunning (1992) points out, there is an inextricable link between government spending on infrastructure such as roads, utilities and communications and the attractiveness of a jurisdiction to international business. Empirical work has lent support to this view on the grounds that this infrastructure, particularly in the case of developing economies, exerts a *pull* on international business and positively affects location decisions (see Loree and Guisinger, 1995; Vijayakumar, 2010).

Consequently, levels of infrastructural investment, rather than broad output aggregates, may provide a more relevant proxy of the output-pull dynamic. A comparison of the ratio of gross capital formation –outlays on additions to the fixed assets of the economy plus net changes in the level of inventories including land improvements, plant, machinery, and equipment purchases and the construction of transport infrastructure– to GDP provides a useful gauge of this dynamic.

Data for the period 2005-2008 indicates Barbados' gross capital formation ratio appears to be on par with a number of territories in the region, but notably below countries such as the Bahamas and St. Kitts and Nevis, suggesting that capital and infrastructural development as a percentage of total output is behind some of the countries in the region (table 2).

[6] For more on this, see Invest Barbados (2010), "A Guide to Doing Business in Barbados."

TABLE 2. GROSS CAPITAL FORMATION (% OF GDP) IN SELECTED JURISDICTIONS, 2005-2008

	2005	*2006*	*2007*	*2008*
Bahamas	34.2	39.3	38.7	0.0
Barbados	24.0	21.7	22.0	22.5
Dominica	28.7	28.9	31.1	32.7
Saint Lucia	23.2	29.2	27.2	25.9
Saint Kitts and Nevis	42.3	37.8	40.9	41.6
Saint Vincent and the Grenadines	31.7	35.0	36.4	37.9
Trinidad and Tobago	30.4	15.6	12.9	12.8
United States	19.6	19.7	18.3	0.0
United Kingdom	17.2	17.6	18.2	16.8
Venezuela	23.0	25.3	28.0	24.5

SOURCE: World Bank World Development Indicators online database.

However, Barbados' capital accumulation ratio exceeds many developed countries such as the USA and the UK. This is perhaps not unexpected given that these countries are have more well-developed infrastructure than countries in the Caribbean and, as such, current levels of capital formation are likely to be lower in developed countries than in those that are in earlier stages of development. Nevertheless, these ratios provide a useful measure of the level of infrastructural development and suggest that Barbados' infrastructural development accounts for nearly one quarter of annual output (averaging 23% between 2005 and 2008). As a result, Barbados is regarded among the leaders in the region with respect to transport and communications infrastructure (see Kumar, 1994; the United Nations World Public Sector Report, 2003).

In addition to infrastructure, Garibaldi et al. (2001), MacCarthy and Atthirawong (2003), and Nonemberg (2004), among others, also identified a number of critical socio-economic determinants of host country attractiveness for FDI. Among these are the quality and availability of the labor force, wage rates, sovereign debt risk and exchange rate regimes.

With regard to labor, the principal argument is that efficiency-seeking firms are attracted to countries which possess labor force characteristics that coincide with their strategic objectives. In general, these are related to either reducing costs associated with wage expenditure or seeking out knowledge workers for service-based industries. Arguably for offshore

companies involved in areas such as information technology (IT), financial services and data management services, both of these factors are critical determinants of offshoring decisions.

An examination of the indicators related to the issue of costs is prohibited by the limited amount of comparable available data on minimum wages and average costs per worker across the region. As such, we examine the changes in inflation as a broad proxy for operational costs facing companies doing business in Barbados.[7]

From 2000-2009, Barbados' inflation rate was well below many of its regional counterparts, averaging 3.5% over the period (see table 3). However, it was notably above the rates recorded in the Bahamas–one of its main rivals for the offshore market. Moreover, the volatility in prices also appeared to be more significant in Barbados relative to its neighbors, suggesting a somewhat larger risk with respect to the costs facing offshoring firms.

Turning to the quality of the labor force, various indicators have been put forward to measure the quality of workers in a knowledge-based services sector. Among the most widely used indicators are literacy rates and government spending on education. In each of these indicators (see tables 4 and 5), Barbados appears to have a distinct advantage over its comparators, recording the highest literacy rate (lowest rate of illiteracy) and one of the highest percentage expenditures on education.

Assessing macroeconomic and financial risk also relies heavily on the availability of foreign exchange for profit remittances and operational payments (Haner and Ewing, 1985 in Chako et al., 2001). Barbados' foreign reserves have remained well above one billion of USD since 2001, driven primarily by tourism receipts and inflows from the international business sector itself.

The external debt position is of particular relevance to the analysis of offshore sectors because it is indicative of the foreign claims on reserves and provides a measure of the economic

[7] Due to limited data on wholesale prices, movements in the consumer price index were used. This is justified on the basis that while the magnitudes of the changes vary, the direction of change is likely to be similar and should provide a useful indicator of changes in the cost of doing business.

TABLE 3. INFLATION RATE, ANNUAL AVERAGE (%), 2000-2009

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*Average*
Bahamas	1.6	2.1	2.1	3.0	1.2	1.9	1.8	2.4	4.0	1.9	2.2
Barbados	2.4	2.8	0.2	1.6	1.1	6.1	7.3	4.3	7.1	2.3	3.5
Jamaica	2.7	12.7	7.1	10.3	13.6	15.3	8.6	7.2	–35.9	9.0	5.1
Saint Lucia	1.9	5.3	–0.3	1.0	1.5	3.9	2.3	3.1	6.7	NA	2.8
Trinidad and Tobago	3.6	5.5	4.2	3.8	3.7	6.9	8.2	8.0	11.4	6.9	6.2
Venezuela	16.2	12.5	22.4	31.1	21.7	16.0	13.7	18.7	31.4	28.6	21.2

SOURCE: ECLAC CEPALSTAT.

TABLE 4. ILLITERACY RATE (%), PERSONS AGED 15 AND OVER, 1970-2005

	1970	*1980*	*1990*	*1995*	*2000*	*2005*
Bahamas	9.0	3.9	5.6	5.0	4.3	4.2
Barbados	2.1	1.2	0.6	0.2	0.3	0.3
Belize	25.0	17.5	10.9	8.4	6.8	5.3
Guyana	9.3	5.4	2.8	2.1	1.5	1.0
Jamaica	31.9	23.7	17.8	15.2	13.1	11.3
Trinidad and Tobago	9.0	5.3	3.2	2.3	1.7	1.2
Venezuela	23.7	16.1	11.1	9.1	7.5	6.0
Latin America and the Caribbean	26.3	20.0	14.9	12.8	11.1	9.5

SOURCE: Institute for Statistics of the UNESCO: UIS online database.

TABLE 5. PUBLIC EXPENDITURE ON EDUCATION, 2000-2007 (% OF GDP)

	2000	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*
Bahamas	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Barbados	5.6	7.2	7.0	7.8	7.2	6.9	0.0	6.9
Belize	5.0	5.8	5.5	5.2	5.3	0.0	0.0	5.1
Cayman Islands	0.0	0.0	0.0	0.0	0.0	2.8	2.6	0.0
Grenada	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0
Guyana	8.5	8.6	8.4	7.0	5.5	8.5	8.0	6.1
Jamaica	5.0	5.4	5.4	4.3	3.9	4.6	0.0	5.5
Saint Lucia	7.8	8.3	7.5	4.8	4.6	5.5	6.5	0.0
Saint Vincent and the Grenadines	9.4	9.5	9.9	10.9	10.7	8.0	0.0	7.0
Trinidad and Tobago	3.8	4.2	4.2	0.0	0.0	0.0	0.0	0.0
Venezuela	0.0	0.0	0.0	0.0	0.0	0.0	3.6	3.7

SOURCE: Institute for Statistics of the UNESCO: UIS online database.

risk associated with the jurisdiction. Higher debt, in general, implies higher debt service costs and raises the probability of debt default and foreign exchange controls –both of which have negative implications for repatriation of funds and profitability.

Barbados' external debt position has deteriorated over the last decade, with the country's external debt-to-GDP ratio, doubling between 1998 and 2008 (see table 6). Moreover, the five-year average from 2004-2008 of 44.8% is well above that for the entire Caribbean region of 28.0%. Although Barbados' external debt ratio is well below some of its regional counterparts including Antigua, Jamaica, and Saint Vincent and the Grenadines, it remains particularly high when compared to other offshore centres such as the Bahamas, which recorded an average ratio of 5% over the comparative period.

TABLE 6. TOTAL EXTERNAL DEBT, 1998-2008 (% OF GDP)

	1998	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*5-Yr Avg.*
Antigua and Barbuda	63.6	61.1	70.0	70.8	75.6	80.6	86.6	54.2	48.6	43.4	43.5	55.3
Bahamas	7.0	6.7	6.2	5.7	5.1	5.9	5.6	5.0	4.6	4.3	5.6	5.0
Barbados	22.8	26.3	37.2	44.4	47.0	46.0	43.4	45.0	47.0	45.5	43.2	44.8
Dominica	35.2	50.9	56.8	68.2	82.1	87.5	78.5	80.9	78.9	71.7	66.3	75.6
Guyana	207.2	174.2	167.4	168.1	171.7	146.0	136.0	147.2	114.1	66.8	71.9	107.2
Jamaica	37.6	34.5	37.7	45.5	44.9	44.6	50.5	48.1	48.5	47.3	45.2	47.9
Saint Lucia	20.3	22.1	25.3	31.0	37.1	45.8	46.1	45.2	43.4	43.4	42.1	44.0
Saint Kitts and Nevis	43.0	50.0	49.2	62.4	75.5	87.6	79.4	70.8	62.8	55.4	52.0	64.1
Saint Vincent and the Grenadines	31.8	48.4	48.1	49.2	46.4	53.4	57.8	56.0	51.2	39.6	41.2	49.2
Trinidad and Tobago	24.3	23.3	20.6	18.9	17.2	13.9	10.4	8.5	7.1	6.1	5.6	7.5
Caribbean	31.1	29.1	31.4	34.4	34.9	33.0	33.0	30.0	28.0	25.4	23.4	28.0

SOURCE: Central Bank of Barbados.

It should be noted, however, that while Barbados' external debt ratio is measurably larger than some of its comparators, much of the debt is concessional, multilateral lending and, as a result, external debt service obligations as a ratio of output are relatively low, averaging approximately 2.5% of GDP over the period. This, combined with the limited controls on foreign exchange for offshore firms outlined earlier, suggest a lower financial risk for firms accessing foreign exchange for profit repatriation and operational expenses than the stock of debt might suggest.

Barbados' total debt to GDP averaged 67% between 2003 and 2007 (see table 7). While Barbados' debt to GDP is well below many its Caribbean neighbors, it is notably above the ratios for some of its major rivals for international business, including the Bahamas and the Cayman Islands, where total debt to GDP averaged 33.3% and 7.2%, respectively over the same period. The level of debt is of concern as ratings agencies have persistently alluded to the need for Barbados to reduce the claims on its fiscal revenues and foreign reserves.[8]

TABLE 7. SELECT ECONOMIC INDICATORS OF OFFSHORE CENTERS, 2003-2007

	2003	*2004*	*2005*	*2006*	*2007*	*Average*
Bahamas	31.3	33.9	32.9	32.8	35.2	33.2
Barbados	67.1	66.4	66.9	64.6	70.6	67.1
Cayman Islands	0.0	8.6	9.0	8.6	9.8	7.2

SOURCE: IMF International Financial Statistics online database.

It is also important to consider Barbados' exchange rate regime which, since 1975, has fixed (or *pegged*) the value of the Barbadian dollar (BBD) to that of the USA dollar (USD), at a rate of BBD 2 to USD 1. Due to the longstanding integrity of the peg, there is reduced foreign exchange risk associated with potential currency fluctuations that could affect the real value of revenues and profits in USD terms. This is important not only for USA investors but for companies that conduct business in USD.

Generally speaking, the peg is also valuable for countries

[8] See, for example, Moody's Global Credit Research, "Moody's downgrades Barbados' ratings", October 13, 2009.

whose domestic currency value fluctuates vis-à-vis the USA dollar, since the currency peg to the USD makes it is easy for these firms to use traditional money market and over the counter currency hedges to address foreign currency risk. There is, however, a body of research which suggests that FDI is attracted to currencies that are expected to strengthen against the USD, since this raises the value of any profits generated in the host country in home-country terms. However, given the broad differences in the degree to which exchange rate regimes determine attractiveness, it would appear that a regime in which exchange rate volatility is limited would provide the most favorable climate for investment (Ramirez, 2006).[9]

3.5. Cultural

The theoretical importance of culture to the offshoring decisions and successes of international business firms has been documented (Hofstede, 1980; Dunning, 1992). Barbados has built on its comparative advantage of low cultural distance relative to a number of major economies, including the USA, Canada and the UK. Additionally, human resource development has been found to have a positive impact on FDI inflows (Tavares and Teixeira, 2006), since human resource quality impacts efficiencies and performance potential in offshore operations.

Barbados' expenditure on human resource development, reflected in spending on education and skills training, has expanded significantly over the past two decades, with current spending at both secondary and tertiary levels increasing year-on-year. On the other hand, while research in these areas in the context of Barbados' offshore sector is limited, there is some evidence that Barbados' culture contributes to its attractiveness. In a qualitative, comparative study of the impact of culture on the performance of a USA airline subsidiary in Barbados, Metters (2008) found that both cultural and structural similarities (particularly high-quality education) between the home and host country were important factors in determining firm success.

[9] For empirical work on the relationship between exchange rate volatility and FDI, see Kyereboah-Coleman and Agyire-Tettey (2008).

4. BARBADOS AS AN OFFSHORE CENTRE

Business environment indices, such as those provided by ratings agencies (for example, Moody's, Standard & Poors) are widely seen as indicators of the risk associated with investing in a particular jurisdiction. The conventional instruments employ available historical data on political, economic, business and other dimensions to provide a general probability of relative risk in the future. As such, these measures can be regarded as compendia to facilitate short- to medium-term forecasting.

The current research, though, attempts to use these data to determine the extent to which they have already impacted the attractiveness of the business environment and, more critically, how that level of attractiveness has determined the performance of the industry. The challenge posed by this approach lies principally with data availability. In pursuing any analysis of international business centers in the Caribbean, various authors (Doyle and Johnson, 1999; Williams et al., 2005) have found that the determination of traditional measures of sectoral performance –such as real value-added, employment and growth– is constrained by the paucity of relevant indicators.

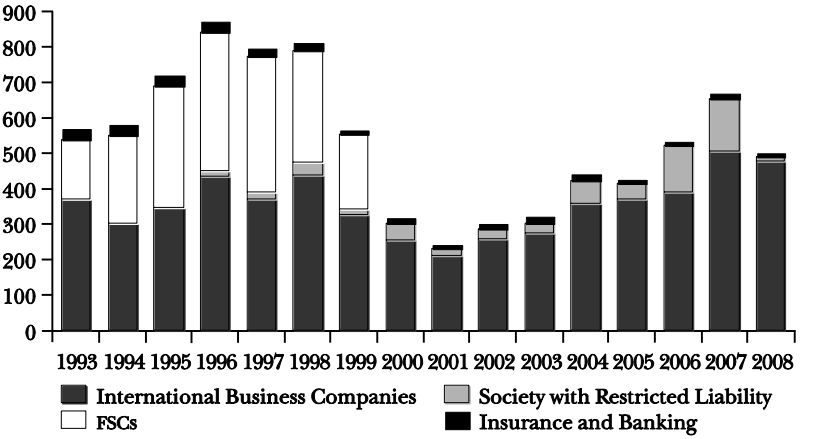
However, there are a number of other indicators that are sufficiently robust gauges of sectoral performance and attractiveness. One such indicator, generally not considered by various regulatory authorities in offshore centers, is the growth in new licenses issued in the sector. Intuitively, new licenses issued provide an unbiased indicator of the extent to which new foreign firms are investing in a given jurisdiction in order to take advantage of incentives.

Figure 1 reveals two distinct dimensions of the growth in new licenses. The first is the structural break in 1999/2000, which resulted in the elimination of the foreign sales company (FSC) vehicle, which had been the leading driver of new licenses.[10] At the same time, there was a level of uncertainty of

[10] The FSC was dissolved after the World Trade Organisation (WTO) ruled against this form of company on the grounds that it represented an illegal export subsidy under the General Agreement on Trade and Tariffs (GATT).

the outcome of the "Harmful Taxation Competition" initiative by the Organization for Economic Cooperation and Development (OECD) which resulted in substantial declines in both FSCs and international business companies (IBCs).

FIGURE 1. NEW OFFSHORE COMPANIES REGISTERED IN BARBADOS, 1993-2008



SOURCE: Barbados Investment Development Corporation (BIDC).

It is clear that there has been a general upward trend in new license growth since 2000, with new entrants to the market expanding by 12% per year, on average, from 2001-2007. Of equal relevance is the composition of new licenses. Since the dissolution of FSCs, IBCs have become and remain the largest component of the growth in licenses and the ratio has remained relatively stable, between 75% and 85% of new licenses.

Societies with restricted liability (SRLs) have grown substantially over the period, both in volume and contribution to overall new licenses. New SRL licenses grew from 14 in 1996 to 151 in 2007, contributing to an increase in the share of new licenses from 5% to 22% over the same period. It is conceivable that this is as a result of the attractiveness of this form of company, which is similar to that of the USA limited liability company (LLC) and provides limited liability for its principals as well as easy dissolution of the business. Under the domestic legislation, SRLs also double the time period for guaranteed incentives and exemptions from 15 years, as in IBCs, to 30 years.

On the other hand, there has been limited growth in

insurance, trusts and mutual funds. Indeed, Williams et al. (2005) pointed out that Barbados has attracted only one-tenth the numbers of offshore banks as the Bahamas or Cayman Islands and has also lagged in its attraction of trust companies and mutual funds companies. There are a number of potential reasons for this, including the later entrance of Barbados into the offshore banking sector and the higher tax rates in Barbados relative to other offshore jurisdictions.

It is more likely that the domestic offshore banking industry has focused on attracting high-quality firms as opposed to higher quantities of entrants, which would inevitably lead to fewer, large entities (Blackman, 1982). Indeed, while the increase in licenses issued provides some insight into the attractiveness of the sector for new investors, it should be noted that this may belie the size, scope and contribution of the industry to the economy. For example, Doyle and Johnson (1999) found that the number of licensed banks in Barbados' offshore sector did not provide a sufficient litmus test of output and contribution of the sector to the economy. The authors concluded that this was primarily because roughly 5% of the banks accounted for over 85% of the industry's operating surplus and new entrants did not necessarily contribute substantially to sectoral output. The growth in new licenses, however, is still a useful indicator of how effective concessions have been in attracting new investment.

Another potentially useful measure of the performance of the business environment can be calculated using the return on capital employed (ROCE). The ROCE ratio assesses the returns generated by each unit of capital employed in order for the business to carry out its operations. A higher return on capital implies greater firm-level efficiencies in generating revenue since it means that fewer units of capital have to be invested in order to generate the required revenue.

Using this principle, a similar ratio can be calculated for government's returns from the international business environment. Specifically, employing an aggregate variable designed by Williams et al. (2005) to estimate the costs associated with maintaining an offshore financial sector,[11] and the

[11] This variable is the sum of a series of costs including the cost of auditing banks, general business costs for the offshore centres including

annual fees collected from the sector, we can calculate a ratio return on investment measuring the return on every monetary unit invested by government. This unit-return variable will capture the level of efficiency in collecting fee and can be represented as:

$$R = \frac{E_t}{C_t} \tag{1}$$

where R represents the return; E the fee-related earnings from the sector; and C is the cost of generating those earnings in period t. $R > 1$ implies that government's investment is efficient while $R < 1$ implies that government's investment is inefficient. A comparison of R for a number of Caribbean offshore centers is given in table 8.

TABLE 8. RETURN ON GOVERNMENT EXPENDITURE IN SELECT OFFSHORE BANKING SECTORS, 2000

Country	*Earnings*	*Cost*	*R*
Bahamas	20.8	5.2	4.00
Barbados	48.1	3.5	13.74
British Virgin Islands	261.3	6.5	40.20
Cayman Islands	134.2	7.1	18.90
Antigua and Barbuda	2.4	0.9	2.67

SOURCE: Williams et al. (2005) and authors' own calculations.

The interpretation, from the host country perspective, is intuitive: higher values indicate that each monetary unit invested generates a higher level of fees, that is, greater government efficiency; while lower values indicate that each monetary unit invested generates a lower level of fees, that is, less government efficiency. Table 8 indicates that while the level of return on spending in Barbados is higher than in the Bahamas and Antigua and Barbados, it remains slightly below the Cayman Islands and well below the British Virgin Islands.

There are several limitations to this analysis. First, the data only represents one period and, as such, the inter-temporal interaction of the earnings and expenditure is unknown.

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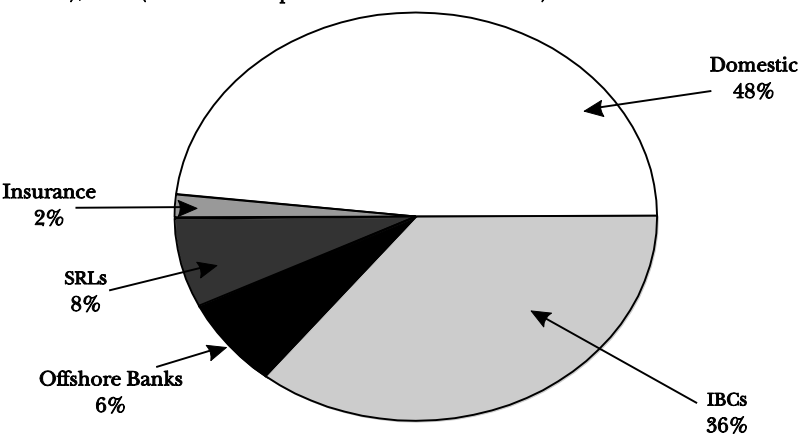
advertising, office supplies, utility payments, and hiring of employees. The variable is comparable across countries since the same components are used to calculate total costs.

Second, this ratio is only calculated relative to offshore financial services, which only represents a proportion of the overall sector. Finally, as many of these centres are zero-tax locations, this measure does not include corporate taxes received, which, when included, would push Barbados' earnings-to-cost ratio significantly higher.

Data for foreign exchange earnings, proxied by corporate taxes collected from the offshore sector, is limited, though the available data also provides a strong indicator of the performance of the individual segments of the offshore sector. Figure 2 provides the most up-to-date annual corporate tax receipts data and indicates that offshore sector taxes accounted for more than half of total corporate receipts during 2008. This is substantial, particularly in light of the fact that corporate taxes account for nearly 20% of total tax revenue. This figure understates the true contribution of the sector to total taxes to the extent that it fails to account for the personal income taxes extracted from residents who work in the sector; this data is currently unavailable.

FIGURE 2. OFFSHORE CORPORATE TAX RECEIPTS (% OF TOTAL CORPORATE TAXES), 2008 (Offshore Companies 52% - Domestic 48%)



SOURCE: Department of Inland Revenue, Barbados.

Table 9 provides data on offshore corporate tax collections for 2008 as a ratio to the number of firms in each sector. This data provides an indicator of the tax yield per firm and, by extension, the extent to which individual firms contribute to fiscal revenue.

Although IBCs account for the bulk of receipts from the sector, table 9 reveals that the profitability per firm is substantially higher in offshore banking and SRLs. In other words, the offshore banking sector provides the most revenue per firm among the various sectors in the offshore industry. In fact, it takes about nine IBCs to generate the taxes generated by a single offshore bank. Similarly, each SRL generates on average more revenue that the average IBC. This, combined with the data pointing to the relatively low costs associated with monitoring and regulating the offshore banking sector, suggests that this sector is performing well. Furthermore, efforts should continue to be directed toward encouraging high quality, profitable firms that will generate strong fiscal revenues.

TABLE 9. AVERAGE (PER FIRM) TAX RECEIPTS, 2005-2008

Company Type	*2005*	*2006*	*2007*	*2008*
IBC	63,277.9	57,638.5	68,185.7	51,098.6
SRL	212,749.8	251,541.0	162,349.4	61,530.9
Offshore Banks	393,597.9	518,488.5	461,578.6	460,087.0
Insurance	41,965.8	52,183.1	94,639.1	45,125.6

SOURCE: Ministry of International Business, Inland Revenue, Barbados, and authors' own calculations.

Employment in the offshore sector is often regarded as one of the major determinants of the importance of the industry in a given jurisdiction (Williams, 2005). While previous research has sought to estimate employment in specific subsectors such as informatics (Haynes et al., 1997), the paucity of sectoral employment data makes it difficult to ascertain accurate estimates of employment in the entire sector.

Figures from the BIDC, which capture mainly firms in the IBC sub-sector which account for the largest portion of employment in the sector, suggests that overall, there has been an increase in employment in the offshore sector during the last decade (see table 10). Information services remain the largest contributor to employment, accounting for approximately 72% of total employment in 2009, up from 61% in 2000. Accounting services contribute roughly 20% of the remainder of employment, with engineering, advertising and other services contributing less than 10% of the remaining jobs in the sector.

TABLE 10. ANNUAL ESTIMATES OF IBC EMPLOYMENT BY SUB-SECTOR, 2000-2009

Sub-Sector	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Accounting and financial services employment	373	398	377	382	437	411	404	469	462	481
Advertising & public relations	39	34	39	40	64	65	48	77	67	45
Engineering services	14	14	14	14	17	18	19	21	23	19
Information services employment	830	749	701	986	1,432	1,491	1,555	1,727	1,957	2,003
Other services employment	104	26	21	45	85	100	81	91	70	52
Total	*1,360*	*1,221*	*1,152*	*1,467*	*2,035*	*2,085*	*2,107*	*2,385*	*2,579*	*2,600*

SOURCE: Barbados Investment Development Corporation (BIDC).

There are a number of important points to note with respect to the division of labor. The first is that the offshore business sector remains highly dependent on information services for employment. The second is that while accounting and financial services account for the second highest levels of employment, the numbers employed in this sub-sector account for less than 25% of those in the information services (IS) sub-sector, while advertising and engineering work remains extremely low.

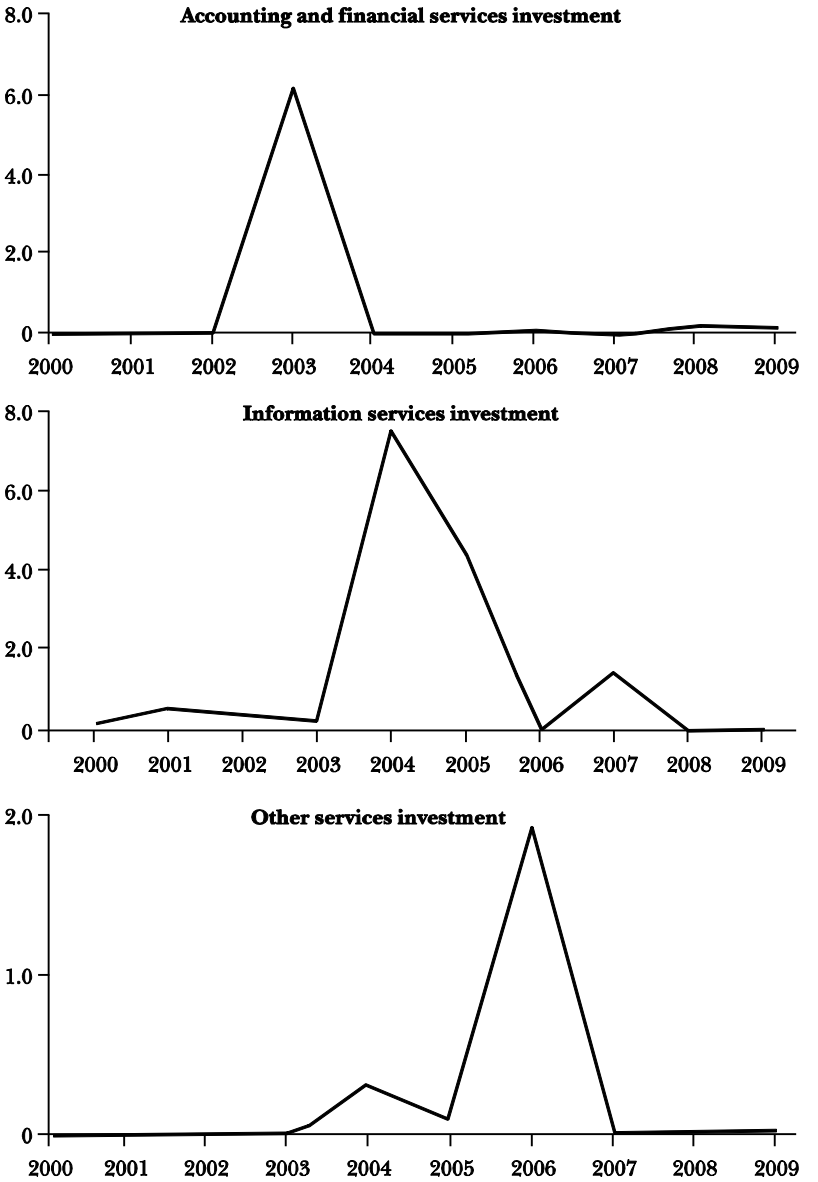
Given the wage differential between the employment opportunities in the IS sub-sector and those in the financial, advertising and engineering sub-sectors, it appears that growth in high-earning, professional jobs continues to be outpaced by growth in lower-wage employment. Furthermore, while there is limited data on the labor divisions within the sub-sector, preliminary estimates suggest that the sector remains heavily dependent on lower-skilled, lower-wage jobs in call-centers and data processing (mainly medical transcription) services.[12]

Therefore, the need to strengthen information technology training in Barbados as identified by Doyle and Johnson (1999), remains unattained and in order to take advantage of these high-earning opportunities presented by software development and IT engineering, Barbados must move beyond the current IT training framework and provide greater opportunities and incentives for the development of these highly technical skills. Nonetheless, it is important to note that despite increasing competition from other low-cost, low-wage jurisdictions, employment in the sector has grown at over 10% per annum since 2000, suggesting that Barbados remains somewhat competitive in this area.

A similar finding emerges from the analysis of the composition of investment within the sector. Estimates of investment in the offshore sector indicate that of the BBD 24 million invested between 2000 and 2009, investment in IS accounted for over 60%, while financial service investment (dominated by Canadian and USA firms) was 27% (see figure 3). This provides further support for the notion expressed in

[12] These estimates were calculated by the Barbados Investment Development Corporation (BIDC) and Invest Barbados.

FIGURE 3. ANNUAL ESTIMATES OF IBC INVESTMENT BY SUB-SECTOR, 2000-2009
In millions of BBD



SOURCE: Barbados Investment Development Corporation (BIDC).

the preceding section that the legal, tax and other incentives provided by Barbados' offshore sector are most attractive to investors from these countries.

5. CONCLUSION

The preceding analysis suggests that in general, Barbados offshore sector is well-regulated and provides an attractive environment for offshore business. The evolution of the sector in the face of competition from other lower-cost jurisdictions as well as international challenges to the structure of offshore centers from the OECD and other international organizations suggests that effective tax, regulatory and legislative systems have contributed to the sustained growth in the sector over time. However, the performance of the offshore sector still lags behind that of other major offshore centers. These outcomes seem to indicate that the underlying stability in the political, legal and economic environment is a necessary but perhaps not sufficient condition for attracting offshore firms.

Barbados' offshore sector continues to be characterized by a heavy reliance on a relatively narrow range of sub-sectors for employment and investment. Specifically, the IBC sector remains dominated by low-wage opportunities that, despite the sector's resilience, are more susceptible to competition from lower-cost jurisdictions. It has become increasingly important to focus IT training on equipping the labor force with the skills to generate new forms of high-skilled employment in IT and engineering. This will not only create opportunities for individuals employed in the field, but given that skills and knowledge transfer is highly dependent on *absorptive capacity* (Cohen and Levinthal, 1990), improved skills will allow the country to benefit substantially more from the inflow of FDI. Additional incentives for export and manufacturing firms as well as emerging offshoring opportunities should form a major part of diversification efforts within the IBC sub-sector. The sustained move to ensure that the offshore banking sector attracts high-quality firms appears to be yielding success, as average earnings per firm are higher than any other subsector and employment in the sector is second only to the IBC sub-sector.

As a corollary, an important finding of this research is that a heterogeneous approach to the sub-sectors may be necessary to ensure their individual success. The offshore banking industry has thrived, contributing strongly to foreign exchange earnings and high income, albeit limited levels of

employment, with only a few, large players in the industry which are well-regulated, while the IBC sector is characterized by substantially more companies, less revenue per firm, but substantially more employment. Marketing efforts should therefore continue to focus on ensuring quality in the banking industry while, simultaneously, encouraging both low- and high-skilled opportunities in the IBC sub-sector.

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Estimations of the natural rate of interest in Colombia

1. INTRODUCTION

In monetary policy regimes, where the nominal short run interest rate is used as the policy instrument, as is the case of Colombia since 2001, the natural rate of interest, NIR, plays an important role in order to determine the stance of monetary policy. Thus, the gap between the instrument rate of the Central Bank and the NIR can be a useful guideline for the position of the monetary policy and can also be helpful to make policy decisions (Laubach and Williams, 2001).

There are several definitions of the natural or neutral interest rate, however the standard definition states that the natural interest rate is the short run interest rate which makes

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the output to converge to its potential keeping inflation stable (Bomfim, 1997).

In the literature, different approaches have been used to estimate the NIR. From simple statistical methodologies to structural economic models. Basdenvant et al. (2004) used a multivariate Hodrick-Prescott filter, HPMV, to estimate the NIR in New Zealand; Crespo Cuaresma et al. (2003) used an unobserved components models, UCM, to estimate the NIR for the euro area. More complex methodologies such as stochastic dynamic general equilibrium models were used by Neiss and Nelson (2001) for the UK and Giammarioli and Valla (2003) for the euro area; some semi-structural or more parsimonious models have been used by Laubach and Williams (2001) for USA. They jointly estimate the trend growth of the economy, the NIR and the potential output by the Kalman filter.

There are several estimations of the natural rate of interest for Latin American economies. In particular, España (2008) used the methodology of Laubach and Williams (2001) for the Uruguayan economy; in the case of Peru, Castillo et al. (2006) estimated the NIR by Kalman filter using a semi-structural model for a small open economy. Calderon and Gallego (2002) estimated the neutral interest rate using two approaches for the Chilean economy; first, they considered theoretical rates that would prevail under equilibrium conditions in a closed and open economy and second, they used rates derived from expectations of the interest rate from the monetary authority and the financial market. Finally, for Venezuela, Cartaya et al. (2007) estimated the NIR from the marginal productivity of capital derived from a production function and by the Kalman filter using a small system of equations that includes a relation between the output gap and the interest rate gap and the dynamics of the potential output and the NIR.

In the Colombian case, Echavarría et al. (2006) estimate the NIR based on the work of Laubach and Williams (2001), using quarterly data for the period 1982 Q1 to 2005 Q4. It is a closed economy model since it does not incorporate relationships of the interest rates across countries. Although the model includes terms of trade and foreign growth.

Another study is the transmission mechanism model which is the model currently used by the central bank of Colombia for monetary policy simulation and long run forecasting (Gómez et al., 2002). It assumes that the NIR is constant at 4% for the last part of the sample. Additionally, for this model a neutral real interest rate is estimated. This neutral rate is defined as the transition rate that converges to the long run or stationary state. This path is used to obtain an estimation of the interest rate gap.

In this paper we obtain estimates of the time varying natural interest rate using three methodologies. Two statistical methods, based on the dynamic properties of the data, and a semi-structural model for a small open economy.

The statistical methods are based on UCM and HPMV models. For both methods, the NIR is estimated as the trend component of the real interest rate. First, two UCM versions are estimated, univariate and multivariate models. Second, a multivariate Hodrick-Prescott filter, proposed by Laxton and Tetlow (1992), is estimated. This method adds an economic relationship to the Hodrick-Prescott optimization problem in order to obtain the trend component.

On the other hand, a semi-structural model for a small open economy is considered. This methodology simultaneously estimate the output gap, potential output, core inflation and the NIR using the Kalman Filter. The model is based on the work of Castillo et al. (2006); with the advantage that inflation expectations are estimated within the system and the parameters estimates obtained by bayesian techniques. The parameters estimation were carried out with the methodology described in Bonaldi et al. (2010) using their FORTRAN95 procedures.[1]

The remainder of the paper is structured as follows. Section 2 describes the methodologies used to estimate the NIR. The description of the data used in this analysis is presented in section 3. Section 4 shows the estimates of the NIR. Finally, section 5 concludes.

[1] We gratefully acknowledge the authors for providing us their full codes.

2. METHODOLOGIES OF ESTIMATION OF THE NIR

This section briefly describes three methodologies that are used to estimate the Colombian NIR. The first two are based on statistical methods while the last one uses a semi-structural model for a small open economy. The statistical methods, unobserved components model and an augmented Hodrick-Prescott filter, extract the long-run trend of the real interest rate as a measure of the natural interest rate. On the other hand, the semistructural model considers the relations between the natural interest rate and different macroeconomic variables according to the economic theory. In the latter approach, the NIR is defined as the interest rate that does not affect the output dynamics in the short run and ensures output and inflation convergence to their long run equilibrium.

2.1. Unobserved components models

Unobserved components models decompose a time series into several components such as trend, season, cycle and irregular disturbance. These models have been intensively used in applied economic research and successfully applied in business cycle analysis. They are also useful in short-term monitoring of macroeconomic variables. Compared with other filtering procedures (Hodrick-Prescott, X-11 and X-12), the unobserved components models offer some advantages. It provides statistical tests, prediction algorithms, modeling of seasonality and introduction of additional features such as other explanatory variables, interventions and cyclical components.

The unobserved components models have been used in different economic applications, for estimating the natural level of the labor supply (Bull and Frydman, 1983), for modeling credibility of the monetary authority (Weber, 1991), for analyzing the GDP (Luginbuhl and Vos, 1999, Morley et al., 2003), the purchasing power parity (PPP) (Kleijn and van Dijk, 2001), consumption (Elwood, 1998), unemployment (Chung and Harvey, 2000, Berger and Everaert, 2010), for modeling tax revenues (Koopman and Ooms, 2003), cycles (Chambers and McGarry, 2002) and for analyzing financial series (Cowan and Joutz, 2006), among others.

2.1.1. Univariate model

In this section we introduce the unobserved component models (UCM) developed by Harvey (1989). Let y_t be the observed time series which is decomposed into several components in the following way:

$$(1) \qquad y_t = \mu_t + \gamma_t + \varphi_t + \in_t, \quad \in_t \sim NID(0, \sigma_\in^2), \quad t = 1,...,N,$$

where μ_t, γ_t, $\varphi_t \mu_t, \gamma_t, \varphi_t$ and $\in_t$ represent the trend, seasonal, cyclical and irregular components, respectively.

The trend is modeled by a linear stochastic process that may include a slope term. The seasonal components can be modeled by a linear stochastic process, trigonometric functions or deterministic components. The cycle is based on stochastic trigonometric functions.

The specification of the UCM depends on which components are included in the model and how they are modeled. Thus, the simplest form of UCM, the "local level model", is obtained from equation (1), with no cyclical and no seasonal components and by specifying the trend as a random walk process

$$(2) \qquad y_t = \mu_t + \in_t, \qquad \in_t \sim NID(0, \sigma_\varepsilon^2), \quad t = 1,...,N,$$

$$(3) \qquad \mu_{t+1} = \mu_t + \eta_{t+1}, \qquad \eta_t \sim NID(0, \sigma_\eta^2).$$

The *local linear trend model* is obtained from the previous model by adding a slope term β_t, which also follows a random walk process

$$(4) \qquad y_t = \mu_t + \in_t, \qquad \in_t \sim NID(0, \sigma_\in^2),$$

$$(5) \qquad \mu_{t+1} = \mu_t + \beta_t + \eta_{t+1}, \qquad \eta_t \sim NID(0, \sigma_\eta^2), \quad t = 1,...,N,$$

$$(6) \qquad \beta_{t+1} = \beta_t + \zeta_{t+1}, \qquad \zeta_t \sim NID(0, \sigma_\zeta^2),$$

where the trend and slope disturbances, η_t and ζ_t, are mutually uncorrelated Gaussian sequences with zero mean and variances σ_η^2 and σ_ζ^2. If σ_ζ^2 is zero then the trend μ_t follows a random walk process plus drift. Moreover, if $\sigma_\eta^2 = \sigma_\zeta^2 = 0$ then μ_t is a deterministic linear trend. A *smooth trend model* or an integrated random walk process is obtained when $\sigma_\eta^2 = 0$.

To take into account the seasonal variation in y_t, the seasonal component can be specified by a deterministic or stochastic component. The deterministic seasonal component satisfies the property that the seasonal coefficients sum zero within a year. This ensures that this component is not interpreted as a trend. In this case, the deterministic seasonal component is given by

$$\gamma_t = \sum_{j=1}^{s-1} \tilde{\gamma}_j z_{jt}, \tag{7}$$

where s is the number of seasons and z_{jt} is a dummy variable that indicates if observation t belongs to the $j-$season and $\tilde{\gamma}_j$ for $j = 1,..., s$ are the respective coefficients.

Finally, an alternative way of modeling seasonality is given by

$$\gamma_t = \sum_{j=1}^{[s/2]} (\alpha_j \cos \lambda_j t + \beta_j \sin \lambda_j t), \tag{8}$$

where $\lambda_j = 2\pi j / s$, $j = 1,..,[s/2]$, and [.] denotes rounding down to the nearest integer.

Time series are often subject to certain economic fluctuations that can be interpreted as business cycles. This can be implemented in UCM by including a stochastic cycle (ϕ_t) of the form

$$y_t = \mu_t + \varphi_t + \in_t, \qquad \in_t \sim NID(0, \sigma_\in^2), \quad t = 1,..., N, \tag{9}$$

$$\begin{pmatrix} \varphi_{t+1} \\ \varphi^*_{t+1} \end{pmatrix} = \rho \begin{pmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{pmatrix} \begin{pmatrix} \varphi_t \\ \varphi^*_t \end{pmatrix} + \begin{pmatrix} \kappa_{t+1} \\ \kappa^*_{t+1} \end{pmatrix}, \quad 0 \le \rho < 1, \tag{10}$$

where κ_t and κ_t^* are white noise disturbances mutually uncorrelated with common variance σ_κ^2, the trend μ_t can be specified by (3) or (5) and (6), ρ is a damping factor, λ is the frequency in radians corresponding to a period $2\pi / \lambda$ such that $0 < \lambda < \pi$. For more details see Harvey (1981).

2.1.2. Multivariate model

The multivariate version of unobserved components models extends the results of section 2.1.1 for a vector of variables.

Let $\mathbf{y}_t$ be a vector of k observed variables. Then, the model can be written as the following additive form

$$\mathbf{y}_t = \boldsymbol{\mu}_t + \boldsymbol{\gamma}_t, \boldsymbol{\varphi}_t + \boldsymbol{\epsilon}_t, \quad \boldsymbol{\epsilon}_t \sim NID(\mathbf{0}, \sum_{\epsilon}), \quad t = 1, ..., N, \tag{11}$$

where $\boldsymbol{\mu}_t, \boldsymbol{\gamma}_y, \boldsymbol{\varphi}_t$ and $\boldsymbol{\epsilon}_t$ are $k \times 1$ vectors that correspond to the multivariate trend, seasonal, cycle and irregular components, respectively. A simple model includes a multivariate trend and cycle components and is given by

$$\mathbf{y}_t = \boldsymbol{\mu}_t + \boldsymbol{\varphi}_t + \boldsymbol{\epsilon}_t, \quad \boldsymbol{\epsilon}_t \sim NID(0, \sum_{\epsilon}), \quad t = 1, ..., N, \tag{12}$$

where $\boldsymbol{\mu}_t$ can be expressed either in a multivariate local level model or in a local linear trend model. The former has the following form

$$\boldsymbol{\mu}_{t+1} = \boldsymbol{\mu}_t + \boldsymbol{\eta}_{t+1}, \qquad \boldsymbol{\eta}_t \sim NID(\mathbf{0}, \sum_{\eta}). \tag{13}$$

And the multivariate local linear trend is given by

$$\boldsymbol{\mu}_{t+1} = \boldsymbol{\mu}_t + \boldsymbol{\beta}_t + \boldsymbol{\eta}_{t+1}, \qquad \boldsymbol{\eta}_t \sim NID(\mathbf{0}, \sum_{\eta}), \tag{14}$$

$$\boldsymbol{\beta}_{t+1} = \boldsymbol{\beta}_t + \boldsymbol{\zeta}_{t+1}, \qquad \boldsymbol{\zeta}_t \sim NID(\mathbf{0}, \sum_{\zeta}). \tag{15}$$

The equation of the cycle in both models is given by

$$\begin{pmatrix} \boldsymbol{\varphi}_{t+1} \\ \boldsymbol{\varphi}^*_{t+1} \end{pmatrix} = \rho \left[\begin{pmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{pmatrix} \otimes I_k \right] \begin{pmatrix} \boldsymbol{\varphi}_t \\ \boldsymbol{\varphi}^*_t \end{pmatrix} + \begin{pmatrix} \boldsymbol{\kappa}_{t+1} \\ \boldsymbol{\kappa}^*_{t+1} \end{pmatrix}, \quad V \begin{pmatrix} \boldsymbol{\kappa}_t \\ \boldsymbol{\kappa}^*_t \end{pmatrix} = I_2 \otimes \sum_{\kappa}, \tag{16}$$

where the cyclical frequency λ and the cycle damping factor ρ, $0 < \rho < 1$, are assumed to be equal for all variables. The disturbances, $\boldsymbol{\kappa}_t$ and $\boldsymbol{\kappa}^*_t$ are two orthogonal white noise processes.

In a simple multivariate local level model, when the rank of the Σ_{η} is $k^* < k$, the model has k^* common levels or common trends, μ^*_t. Then, equations (12) and (13), with no cycle component, becomes

$$\mathbf{y}_t = \Theta^* \boldsymbol{\mu}^*_t + \boldsymbol{\mu}_0 + \boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim NID(\mathbf{0}, \sum_{\epsilon}), \tag{17}$$

$$\boldsymbol{\mu}^*_{t+1} = \boldsymbol{\mu}^*_t + \boldsymbol{\eta}^*_{t+1}, \qquad \boldsymbol{\eta}^*_t \sim NID(\mathbf{0}, \sum_{\eta}), \tag{18}$$

where $\boldsymbol{\mu}^*_t$ is a $k^* \times 1$ vector of common trends, Θ^* is an $k \times k^*$ matrix of factor loadings, $\boldsymbol{\mu}_0$ is a $k-$dimensional vector which has zeros for the first k^* elements and the remaining elements are unconstrained ($\bar{\boldsymbol{\mu}}$). The presence of common

trends implies cointegration (Harvey, 1989). In the local level model, there are $r = k - k^*$ cointegration vectors. Equation (17) can also be expressed as

(19) $$\mathbf{y}_{1,t} = \boldsymbol{\mu}_t^* + \boldsymbol{\epsilon}_{1t},$$

(20) $$\mathbf{y}_{2,t} = \Theta^* \boldsymbol{\mu}_t^* + \bar{\boldsymbol{\mu}} + \boldsymbol{\epsilon}_{2t},$$

where $\mathbf{y}_t$ is partitioned into a $k^* \times 1$ vector $\mathbf{y}_{1t}$ and an $r \times 1$ vector $\mathbf{y}_{2t}$, $\boldsymbol{\epsilon}_t$ is partitioned in a similar way. The first set contains the common trends and the second set of equations consists of cointegrating relationships.

The model described in (17) and (18) can be written in the form of seemingly unrelated time series equations (SUTSE), this representation is a multivariate generalization of standard structural time series models and common components restrictions, such as common trends, common cycles and common seasonalities. For the previous model the SUTSE representation is given by

(21) $$\mathbf{y}_t = \boldsymbol{\mu}_t + \boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim NID(\mathbf{0}, \textstyle\sum_{\epsilon}),$$

(22) $$\boldsymbol{\mu}_{t+1} = \boldsymbol{\mu}_t + \boldsymbol{\eta}_{t+1}, \qquad \boldsymbol{\eta}_t \sim NID(\mathbf{0}, \textstyle\sum_{\eta}),$$

where $\boldsymbol{\mu}_t = \Theta^* \boldsymbol{\mu}_t^* + \boldsymbol{\mu}_0$, $\boldsymbol{\eta}_t = \Theta^* \boldsymbol{\eta}_t^*$ and $\sum_{\boldsymbol{\eta}} = \Theta^* \sum_{\boldsymbol{\eta}^*} \Theta^{*\prime}$ is a singular matrix of rank k^*.

The multivariate local linear trend model with cycles and common levels is given by

(23) $$\mathbf{y}_t = \Theta^* \boldsymbol{\mu}_t^* + \boldsymbol{\mu}_0 + \boldsymbol{\varphi}_t + \boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim NID(\mathbf{0}, \textstyle\sum_{\epsilon}),$$

(24) $$\boldsymbol{\mu}_{t+1}^* = \boldsymbol{\mu}_t^* + \boldsymbol{\beta}_t^* + \boldsymbol{\eta}_{t+1}^*, \qquad \boldsymbol{\eta}_t^* \sim NID(\mathbf{0}, \textstyle\sum_{\eta^*}),$$

(25) $$\boldsymbol{\beta}_{t+1}^* = \boldsymbol{\beta}_t^* + \boldsymbol{\zeta}_{t+1}^*, \qquad \boldsymbol{\zeta}_t^* \sim NID(\mathbf{0}, \textstyle\sum_{\zeta^*}).$$

The SUTSE representation of this model in given in the equations (12), (14), (15) and (16) when $\boldsymbol{\mu}_t = \Theta^* \boldsymbol{\mu}_t^* + \boldsymbol{\mu}_0$, $\boldsymbol{\beta}_t = \Theta^* \boldsymbol{\beta}_t^*$, $\boldsymbol{\zeta}_t = \Theta^* \boldsymbol{\zeta}_t^*$, $\sum_{\zeta} = \Theta^* \sum_{\zeta} \Theta^{*\prime}$ $\boldsymbol{\eta}_t = \Theta^* \boldsymbol{\eta}_t^*$ and $\sum_{\boldsymbol{\eta}} = \Theta^* \sum_{\boldsymbol{\eta}^*} \Theta^{*\prime}$ and Σ_{ζ} are singular matrices with rank k^*.

Then, SUTSE models allow to identify common factors through covariance matrices of the disturbances ($\Sigma_{\epsilon}, \Sigma_{\eta^*}, \Sigma_{\zeta^*}, \ldots$). An incomplete rank of any of these matrices implies a common component restriction. For example, if

the covariance matrix of the trend disturbance has incomplete rank, then there are common trends. Since SUTSE models may include cointegration relationships, they allow for economic interpretations and can also provide more efficient forecasts (Mazzi et al., 2005). Another advantage of these models is that they provide a useful framework for temporal disaggregation (Moauroand Savio, 2005).

As shown in Appendix C, both univariate and multivariate unobserved component models can be written in a state space form and estimated by maximum likelihood using the Kalman filter.

2.2. Multivariate Hodrick-Prescott filter

This alternative of estimating unobserved components, known as HPMV, was developed by Laxton and Tetlow (1992) to estimate potential output in Canada, and has also been used for estimating potential output in New Zealand (Conway and Hunt, 1997) and estimating the NAIRU for the OECD countries (OECD, 1999). This methodology is based on the Hodrick-Prescott filter, however, an additional economic equation related to the unobserved trend component is considered in the optimization problem. In this way, the minimization problem also depends on the fit of the economic relationship. The HPMV is obtain as the solution of the following problem

$$\min \sum \frac{1}{\sigma_0^2}(y_t - y_t^*)^2 + \frac{1}{\sigma_1^2}(\Delta\Delta y_t^*)^2 + \frac{1}{\sigma_2^2}\xi^2, \tag{26}$$

where $\sigma_0^2, \sigma_1^2, \sigma_2^2$ are the variances of the cyclical fluctuations $\left(y_t - y_t^*\right)$, the growth rate of the trend $\left(\Delta\Delta y_t^*\right)$ and the errors of the economic relationship $\left(\xi_t\right)$, respectively. Then, the smaller σ_2^2, the higher λ_2, the more importance is given to the information added by the economic relationship.

In this study, two economic equations are considered for the estimation of the NIR using this methodology.

First, an IS curve, which relates interest rates and income is considered. This equation represents the equilibrium of the market of goods and services. The relationship is given by

$$\tilde{y}_t = \alpha_0 + \alpha_1 \tilde{y}_{t-1} + \alpha_2 (r_{t-1} - \overline{r}_{t-1}) + \alpha_3 \tilde{q}_{t-1} + \xi_t, \tag{27}$$

where $\tilde{y}_t$ is the output gap, $\tilde{q}_t$ is the real exchange rate gap, r_t is the real interest rate, and $\bar{r}_t$ is the NIR.

Second, the following Taylor policy rule is also considered

$$(28) \quad i_t^{ON} = \rho i_{t-1}^{ON} + (1-\rho)[(\bar{r}_t + E_t\pi_{t+s} - \gamma_t) + \alpha_1(\pi_{t+s} - \bar{\pi}_{t+s}) + \alpha_2\tilde{y}_t] + \xi_t$$

where i_t^{ON} is the nominal overnight rate, $\bar{r}_t$ is the NIR, $E_t\pi_{t+s}$ is the inflation expectation for $s=12$ periods ahead, defined as the weighted average of past and future inflation, γ_t is the gap between the unobserved nominal natural overnight rate and nominal natural market rate (obtained from the 90-day deposit interest rate), $\gamma_t = \bar{i}_t^{90TD} - \bar{i}_t^{ON}$, and $\bar{\pi}_t$ is the inflation target.

There are two alternative methods to estimate the HPMV filter. Using optimization methods to solve the minimization problem and using the Kalman filter to estimate the respective state-space representation.

2.2.1. The optimization

To start the minimization problem, a proxy of the unobserved trend, usually obtained from the standard HP filter, is used to estimate the economic equation. Then, the residuals from this equation are plugged into the following minimization problem (26), with $\lambda_1 = \frac{\sigma_0^2}{\sigma_1^2}$ and $\lambda_2 = \frac{\sigma_0^2}{\sigma_2^2}$,

$$(29) \qquad \min \sum \left((r_t - \bar{r}_t)^2 + \lambda_1(\bar{r}_{t+1} - 2\bar{r}_t + -\bar{r}_{t-1})^2 + \lambda_2(z_t - f(\bar{r}_t))^2 \right).$$

Where z_t is the dependant variable of the economic relationship and $f(\bar{r}_t)$ is the linear function of the economic model.

As shown in Razzak and Dennis (1999), the first order conditions with respect to $\bar{r}_t$ for $t=1,..,T$, implies that

$$(30) \qquad \boldsymbol{c} = \lambda_1 F\bar{\boldsymbol{r}} + \lambda_2\boldsymbol{\xi}^*$$

where $\boldsymbol{c}$ is a $T\times1$ vector with $c_t = r_t - \bar{r}_t$, $\boldsymbol{\xi}^*$ is a vector of derivatives of $\sum(z_t - f(\bar{r}_t))^2$ with respect to $\bar{r}_t$, F is a $T\times T$ matrix of the following form

$$F = \begin{bmatrix} 1 & -2 & 1 & 0 & & & & \cdots & 0 \\ -2 & 5 & -4 & 1 & 0 & & & \cdots & 0 \\ 1 & -4 & 6 & -4 & 1 & 0 & & \cdots & 0 \\ 0 & 1 & -4 & 6 & -4 & 1 & 0 & \cdots & 0 \\ \vdots & & & & & & & & \vdots \\ 0 & \cdots & 0 & 1 & -4 & 6 & -4 & 1 & 0 \\ 0 & \cdots & & 0 & 1 & -4 & 6 & -4 & 1 \\ 0 & \cdots & & & 0 & 1 & -4 & 5 & -2 \\ 0 & \cdots & & & & 0 & 1 & -2 & 1 \end{bmatrix}. \tag{31}$$

For the IS curve, $\boldsymbol{\xi}^* = \alpha_2 \left[\xi_2, \xi_3, ..., \xi_T\right]'$, in this case F is a $T-1 \times T-1$ matrix. In the monetary policy rule exercise, $\boldsymbol{\xi}^* = -(1-\rho)\left[\xi_1, \xi_2, ..., \xi_{T-1}, \xi_T\right]'$.

Under this methodology the real interest rate is decomposed into the unobserved trend and cyclical residual components, $\boldsymbol{r} = \bar{\boldsymbol{r}} + \boldsymbol{c}$. Replacing $\boldsymbol{c}$ by (30) in the previous expression and solving for the trend component, $\bar{\boldsymbol{r}}$, the following result is obtained.[2]

$$\bar{\boldsymbol{r}} = (I + \lambda_1 F)^{-1} (\boldsymbol{r} - \lambda_2 \boldsymbol{\xi}^*). \tag{32}$$

Once the unobserved $\bar{\boldsymbol{r}}$ is obtained, an optimization algorithm is used to estimate the λs. Then, the economic relationship is estimated with the new estimate of $\bar{\boldsymbol{r}}$ using NLS. Several iterations of this three-step procedure are performed until convergence is reached.

2.2.2. The Kalman filter

The HPMV filter can be rewritten as a state space model with some restrictions imposed over the variances of the three components of the minimization problem. These restrictions are implemented in order to produce a balance among smoothness, bias and the fit of the economic relationship. Estimates of the trend component and the parameters are obtained by maximum likelihood methodology using Kalman filter.

The state space representation of the HPMV minimization

[2] See Reeves et al. (1996) and Conway and Hunt (1997) for details.

problem for the first economic relationship is given by:

Measurement equation

$$\mathbf{y}_t = d\boldsymbol{X}_t + z\boldsymbol{A}_t + \boldsymbol{\eta}_t, \qquad \boldsymbol{\eta}_t \overset{iid}{\sim} N(\mathbf{0}, GG'). \tag{33}$$

Transition equation

$$\boldsymbol{A}_t = T\boldsymbol{A}_{t-1} + \boldsymbol{\nu}_t, \qquad \boldsymbol{\nu}_t \overset{iid}{\sim} N(\mathbf{0}, HH'), \tag{34}$$

where

$$\mathbf{y}_t = \begin{bmatrix} r_t \\ \tilde{y}_t \end{bmatrix}; \quad d = \begin{bmatrix} 0 & 0 & 0 \\ \alpha_1 & \alpha_2 & \alpha_3 \end{bmatrix}; \quad \mathrm{X}_t = \begin{bmatrix} \overline{y}_{t-1} \\ r_{t-1} \\ \overline{q}_t 1 \end{bmatrix}; \quad z = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & -\alpha_2 \end{bmatrix};$$

$$\boldsymbol{A}_t = \begin{bmatrix} \overline{r}_t \\ g_t \\ \overline{r}_{t-1} \end{bmatrix}; \quad \boldsymbol{\eta}_t = \begin{bmatrix} e_t \\ \xi_t \end{bmatrix}; \quad \mathrm{V}(\boldsymbol{\eta}_t) = GG' = \begin{bmatrix} \sigma_0^2 & 0 \\ 0 & \sigma_2^2 \end{bmatrix}; \quad T = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix};$$

$$\boldsymbol{\nu}_t = \begin{bmatrix} \vartheta_{1t} \\ \vartheta_{2t} \\ 0 \end{bmatrix}; \quad \mathrm{V}(\boldsymbol{\nu}_t) = HH' \begin{bmatrix} 0 & 0 & 0 \\ 0 & \sigma_1^2 & 0 \\ 0 & 0 & 0 \end{bmatrix}.$$

The state space representation of the HPMV minimization problem for the second economic relationship assuming that γ_t follows a random walk process is given by the equations (33) and (34) with the following matrices and vectors:

$$\mathbf{y}_t = \begin{pmatrix} i_t^{90TD} \\ i_t^{ON} \end{pmatrix}; \quad d = \begin{bmatrix} 0 & 1 & 0 & 0 \\ \rho & (1-\rho) & (1-\rho)\alpha_1 & (1-\rho)\alpha_2 \end{bmatrix}; \quad \mathbf{X}_t = \begin{bmatrix} i_{t-1}^{ON} \\ E_t \pi_{t+s} \\ \pi_{t+s} - \overline{\pi}_{t+s} \\ \tilde{y}_t \end{bmatrix};$$

$$\boldsymbol{A}_t = \begin{pmatrix} \overline{r}_t \\ g_t \\ \gamma_t \end{pmatrix}; \quad z = \begin{bmatrix} 1 & 0 & 0 \\ 1-\rho & 0 & \rho - 1 \end{bmatrix}; \quad \boldsymbol{\eta}_t = \begin{bmatrix} e_t \\ \varepsilon_t \end{bmatrix}; \quad \mathrm{V}(\boldsymbol{\eta}_t) = GG' = \begin{bmatrix} \sigma_0^2 & 0 \\ 0 & \sigma_2^2 \end{bmatrix};$$

$$T = \begin{pmatrix} 1 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}; \quad \boldsymbol{\nu}_t = \begin{bmatrix} \vartheta_{1t} \\ \vartheta_{2t} \\ \vartheta_{3t} \end{bmatrix}; \quad \mathrm{V}(\boldsymbol{\nu}_t) = HH' \begin{bmatrix} 0 & 0 & 0 \\ 0 & \sigma_1^2 & 0 \\ 0 & 0 & \sigma_3^2 \end{bmatrix}.$$

These stat space representations assume, for both economic relationships, that the change in the trend component of the real interest rate, $\Delta\overline{r}_t$, is modeled as a random walk plus drift

$$\overline{r}_t = \overline{r}_{t-1} + g_{t-1} + \vartheta_{1t},$$

$$g_t = g_{t-1} + \vartheta_{2t}.$$

Empirical comparisons of the two estimation methods (optimization and Kalman filter) have found different results in term of the unobserved trend component (Boone, 2000). With respect to the optimization method, the state space approach has the advantage that the estimates of the parameters and the unobserved variable are obtained simultaneously, including also standard errors for the unobserved variable. Another advantage of the state space version is that it allows different representations for the unobserved component, not only the random walk implied by the HPMV representation.

For most empirical applications λ is fixed by the user. The most common values for these parameters are $\lambda_1 = 1,600$ for quarterly data and $14,400$ for monthly data and λ_2 is such that the ratio $\frac{\sigma_1^2}{\sigma_2^2}$ is between 0.1 and 0.5.

For this exercise we estimate the parameters of the economic relationships imposing restrictions that are implied by economic theory. A grid of values is used for λ_1 and λ_2 (or σ_0, σ_1 y σ_2). However, the estimated parameters are similar to the most common values.

2.3. A Semi-structural model

This approach is based on a semi-structural model for a small open economy, following the work of Castillo et al. (2006) who estimated the NIR for Peru. We used the same system of equations, even though our version considers inflation expectations as an endogenous variable.

In this context, the NIR is defined as the interest rate that does not affect the output dynamics in the short run and assures output and inflation convergence to their long run equilibriums. This definition differs from the ones mentioned in previous subsections as it does not represent any

trend component of the interest rate. In fact, as noted by Laubach and Williams (2001), the interest rate could deviate for long periods of time from the NIR as may happen during inflation or disinflation episodes.

The difference between the observed interest rate and the NIR is called the real interest rate gap; this variable is used (see Laubach and Williams, 2001, Mésonnier and Renne, 2007, Castillo et al., 2006) as a measure for the stance of monetary policy. In this paper however, the interest rate gap is not exactly a variable that represents this definition given that we use a market interest rate instead of a policy interest rate. We do not include the latter because it may not represent the relevant interest rate for the agents in the economy, as the households and firms do not face it directly.

The model consists of an IS curve that represents aggregate demand, a Phillips curve that represents aggregate supply and some other equations that explain the dynamics of the real exchange rate. The remaining equations represent the determinants of the NIR. The openness of the economy is described by the real exchange rate gap and the terms of trade in the IS curve, the price of imports in the Phillips curve and by considering the uncovered interest rate parity as a determinant of the NIR. The system of equations can be represented in a state space form (see Appendix D.), the unobserved variables are obtained by means of the Kalman filter and the hyperparameters calibrated or estimated by bayesian techniques.

The system equations are given by

IS curve

$$\tilde{y}_t = \alpha_1 \tilde{y}_{t-1} + \alpha_2 \tilde{r}_{t-1} + \alpha_3 \tilde{q}_{t-1} + \alpha_4 \tilde{T}_t + \eta_t^{\tilde{y}},$$

where $\tilde{y}_t$ is the output gap, $\tilde{r}_t$ is the real interest rate gap, $\tilde{q}_t$ is the real exchange rate gap and $\tilde{T}_t$ is the gap of the terms of trade.

Phillips curve

$$\pi_t^c = \beta_1 \pi_{t-1}^c + \beta_2 \pi_t^{imp} + \beta_3 \tilde{y}_{t-1} + (1-\beta_1-\beta_2) E_t \pi_{t+1} + \eta_t^{\pi},$$

where π_t^c is a measure of the core inflation, π_t^{imp} is the inflation of imported goods and services, $\tilde{y}_t$ is the output gap and

$E_t\pi_{t+1}$ representes the inflation expectations for the period $t+1$ using information up to t.

Inflation expectations

$$E_t\pi_{t+1} = \bar{\pi}_{t+1} + \lambda\zeta_{t-1} + \eta_t^E,$$

where $\bar{\pi}_t$ is the inflation target and $\zeta_t = (\pi_t - \bar{\pi}_t)$.

Real exchange rate gap

$$\tilde{q}_t = \rho_q \tilde{q}_{t-1} + \eta_t^{\tilde{q}}.$$

Potential real exchange growth rate dynamics

$$\Delta\bar{q}_t = \varphi_0 + \varphi_1\Delta\bar{y}_t + \varphi_2\Delta\overline{B_t} + \varphi_3\Delta\overline{g_t} + \varphi_4\Delta\bar{T}_t + \eta_t^{\bar{q}}$$

where $\bar{q}_t$ is the potential real exchange rate, $\bar{y}_t$ potential output, $\bar{B}_t$ potential foreign net assets, $\bar{g}_t$ potential public expenditure and $\bar{T}_t$ is the potential of terms of trade.

Ciclycal component of foreign net assets

$$\tilde{B}_t = \rho_b \tilde{y}_t + \rho_{ab}\tilde{B}_{t-1} + \eta_t^{\tilde{b}}$$

Potential foreign net assets dynamics

$$\Delta\bar{B}_t = (1-\rho_{\bar{b}})b_0 + \rho_{\bar{b}}\Delta\bar{B}_{t-1} + \eta_t^{\bar{b}}$$

Real interest rate gap

$$\tilde{r}_t = \rho_{\tilde{r}}\widetilde{r_{t-1}} + \eta_t^{\tilde{r}}$$

Uncovered interest parity

$$\bar{r}_t = \lambda_1\bar{r}_t^* + \Delta\bar{q}_t + \tau_t$$

$$\tau_t = \gamma_\tau + \rho_\tau\tau_{t-1} + \eta_t^\tau$$

where $\bar{r}_t$ is the NIR, $\bar{r}_t^*$ is the foreign NIR and τ_t is an unobserved risk premium which is assumed to follow an AR(1) model.

Potencial GDP

$$\Delta\bar{y}_t = \phi\Delta\bar{y}_{t-1} + (1-\phi)\overline{\Delta y} + \eta_t^{\Delta y}$$

where $\overline{\Delta y}$ is the long run productivity growth.

Finally, the observed variables are decomposed as follows

1. GDP percentage change (Δy_t)

$$\Delta y_t = \tilde{y}_t - \tilde{y}_{t-1} + \Delta \bar{y}_t$$

2. Total inflation (π_t)

$$\pi_t = \pi_t^c + \varepsilon_t$$

3. Percentage change of real exchange rate (Δq_t)

$$\Delta q_t = \tilde{q}_t - \tilde{q}_{t-1} + \Delta \bar{q}_t$$

4. Percentage change in foreign net assets (ΔB_t)

$$\Delta B_t = \tilde{B}_t - \tilde{B}_{t-1} + \Delta \tilde{B}_t$$

5. Nominal interest rate (i_t)

$$i_t = \tilde{r}_t + \bar{r}_t + E_t \pi_{t+1}$$

The model consists of 34 parameters, including the variances of the shocks, 17 of which were estimated with bayesian techniques using the multiple-try MCMC described in Liu et al. (2000) with the FORTRAN95 procedures developed by Bonaldi et al. (2010). The parameters estimated are those included in the equations of the real exchange rate gap, the potential real exchange rate dynamics and the variances of the model. The others parameters were calibrated from the parameters values of the internal semi-structural model used in the central bank of Colombia (named MMT), see Gómez et al. (2002) for details of the model. They also had to match the long run equilibrium of ΔB which is calibrated at 10%, its historical average. The priors for the estimation of the variances were obtained by the calibration of the relative variability between the trend and cycle component of the variables considered in the model.

The state space representation is included in Appendix 8.

3. DATA

This section describes the data used to estimate the NIR for the methodologies presented in section 2. In all the exercises the 90-day deposit real interest rate is used to estimate the NIR. The sample period employed for the estimations is different for each methodology and depends on the availability of the required variables.

3.1. Unobserved components models

Two exercises are considered for the UCM. In both exercises the natural rate is defined as the trend component of the real interest rate. The first exercise is a univariate model. The second exercise is a multivariate model for the real interest rate, the logarithm of GDP and the CPI. The latter model simultaneously estimates the trend component of each variable assuming that the three series have a common level component. The series are seasonally adjusted using TRAMO-SEATS procedure (Gómez and Maravall, 1996).

The models are estimated for quarterly data using the sample period from 1982:1 to 2009:1. The inflation is measured as the annual variation of core CPI, which excludes food and administrated goods. The real interest rate is measured as the 90-day deposit nominal rate deflated by inflation expectations.

For the univariate model two measures of real interest rates are considered, RIR1 and RIR2. The first one uses caused inflation, π_{t+s}, as deflator of the nominal rate. The second one uses imperfectly rational inflation expectations (forward and backward looking), defined as $E_t\pi_{t+s} = \lambda\pi_{t+s} + (1-\lambda)\pi_{t-1}$, with $\lambda = 0.56$. The value of λ was selected according to an updated version of Gómez et al. (2002). The measure of the real interest rate for the multivariate model is RIR1.

3.2. Hodrick - Presscott multivariate filter

Two filtering exercises are performed to estimate the NIR using monthly data. Both filters are augmented by the economic relationships described in section 2.2, an IS curve and a policy rule. The IS curve exercise includes the GDP gap,[3] the RIR2 real interest rate, the Real exchange rate gap defined as the deviation of the Real exchange rate index from the trend component estimated with a Hodrick-Prescott filter. The sample period is from 1980:05 to 2009:06.

On the other hand, for the policy rule, the following variables are used, 90-day deposit and the overnight nominal

[3] The monthly GDP series is estimated applying the time series disaggregation algorithm suggested by Santos Silva and Cardoso (2001), using the quarterly GDP series and the monthly Industrial Production Index.

interest rates, total CPI inflation, GDP gap and the inflation target. Given that the inflation target is set on an annual basis, a monthly target series was estimated, assuming that the inflation target follows the same dynamic as the total CPI inflation monthly series.[4] The sample period considered for the policy rule exercise is from 1995:04 to 2009:06.

3.3. Semi-structural model

For this exercise, quarterly data from 2000:01 to 2009:04 is used. The data includes the observed domestic GDP growth, total CPI inflation, real exchange rate growth, percentage change in foreign net assets and nominal 90-day deposit interest rate.

The following exogenous variables are also included in the model: percentage change of terms of trade, the terms of trade gap measured as the cyclical component obtained with the Hodrick-Prescott filter, the growth of public expenditure, inflation target, inflation of imports, the USA NIR as a proxy of foreign NIR. The latter is measured as the trend component of the 3-month certificate of deposit rate deflated by non-seasonally adjusted core inflation, where the trend component is estimated with the Hodrick-Prescott filter.

[4] An ARIMA model for total CPI inflation is estimated with information up to the end of each year (from 1994 to 2008) and forecasts for the following twelve months are restricted such that the target at the end of each year is achieved. Then, those restricted forecasts correspond to the estimated monthly inflation target series.

4. RESULTS

4.1. Univariate UCM

The results of NIR estimation based on a univariate unobserved components model are presented in this section. This model is estimated using two definitions of the real interest rate, RIR1 and RIR2, as defined in 3.1.

The specification of the UCM for both definitions of the real interest rate is the local level plus cycle model:

$$y_t = \mu_t + \varphi_t + \in_t \tag{35}$$

$$\mu_{t+1} = \mu_t + \eta_{t+1} \tag{36}$$

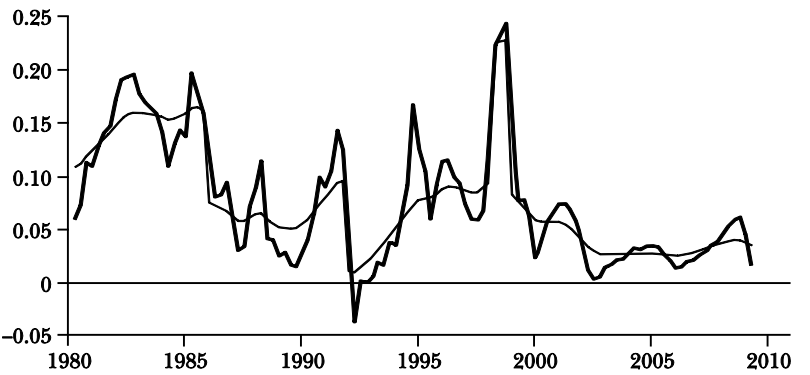
$$\begin{pmatrix} \varphi_{t+1} \\ \varphi^*_{t+1} \end{pmatrix} = \rho \begin{pmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{pmatrix} \begin{pmatrix} \varphi_t \\ \varphi^*_t \end{pmatrix} \begin{pmatrix} \kappa_{t+1} \\ \kappa^*_{t+1} \end{pmatrix} \tag{37}$$

where $\in_t \sim NID(0, \sigma^2_{\in})$, $\eta_t \sim NID(0, \sigma^2_{\eta})$, $0 < \rho < 1$ and $t = 1, .., N$. This model also includes some dummy variables for interventions in the level and the irregular components.

The estimation results and diagnostics are presented in tables A.1, A.2, A.3 and A.4 in Appendix A. These estimations consider a high persistence of the cyclical component ($\rho = 0.9$) and a cycle period of five years, which correspond to a plausible business cycle for the Colombian economy. For both exercises, the residuals show no misspecification problems.

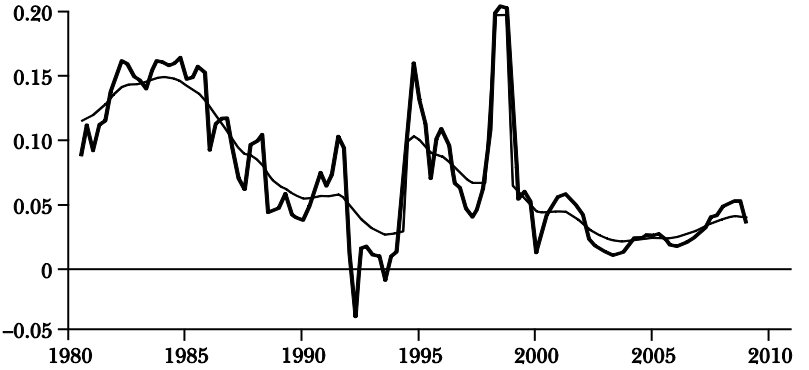
Figures 1 and 2 show the estimated natural rate of interest

FIGURE 1. NIR ESTIMATION BY UCM USING RIR1, 1980-2010



NOTE: The real interest rate is the wide line, the NIR estimation corresponds to the thin line.

FIGURE 2. NIR ESTIMATION BY UCM USING RIR2, 1980-2010



NOTE: The real interest rate is the wide line, the NIR estimation corresponds to the thin line.

using RIR1 and RIR2, respectively. Both NIR estimates reflect the trend of actual real rate; however, there are periods when they closely follow the observed series, such as the peak observed in 1998-1999, and sharp decline at the end of 1991.

In the first half of the eighties the NIR was 13% on average, then is reduced to an average rate of 9% between 1985 and 2000 and after 2001 the NIR has been 3% in average. At the end of the sample a small increase in the NIR is observed which is reverted in the last observed quarters.

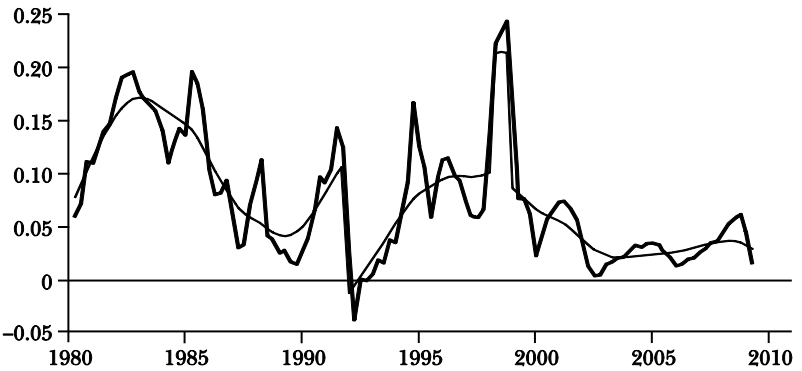
4.2. Multivariate UCM

The specification of multivariate UCM model that best fit the three-variable vector is the local trend plus cycle model, which is given in equations (23), (24), (25) and (16). The estimation results and diagnostics are presented in tables A.5 and A.6 in Appendix A.

The estimated NIR and real interest rate, RIR1, are presented in figure 3. The NIR dynamics is almost identical to the NIR estimation obtained in the univariate case except for the behavior around 1985, which is smoother for the univariate model.[5]

[5] An alternative exercise using RIR2 is not presented in the document since there was no specification that satisfies the residuals assumptions.

FIGURE 3. NIR ESTIMATION BY MULTIVARIATE UCM USING GDP, CPI AND RIR1, 1980-2010



NOTE: The real interest rate is the wide line, the NIR estimation corresponds to the thin line.

4.3. HPMV filter

This section shows the estimation results based on the methodology described in section 2.2. Those estimations include two economic relationships, an IS curve and a policy rule, presented in equations (27) and (28).

4.3.1. HPMV filter augmented by an IS curve

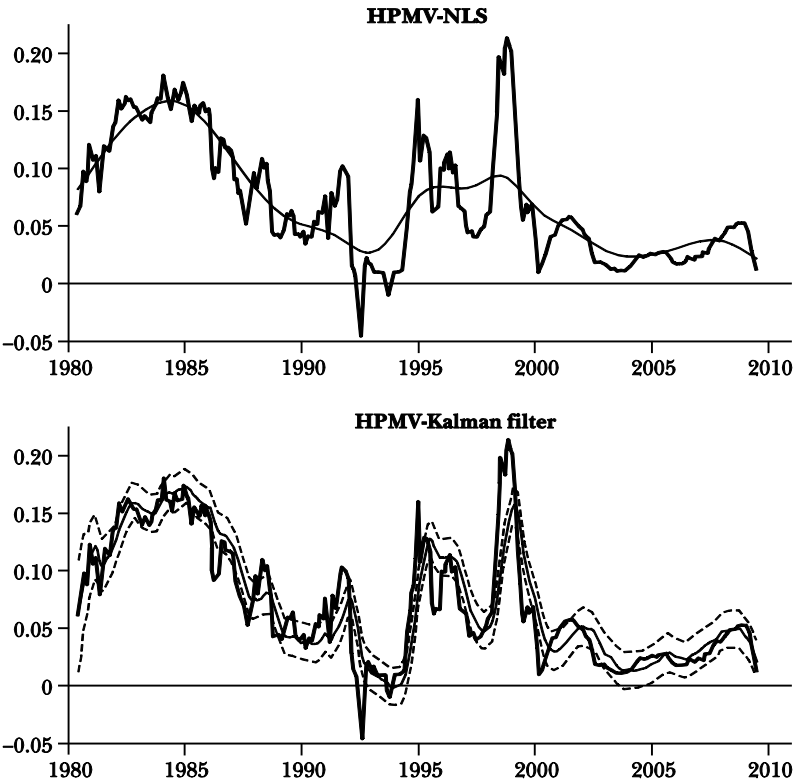
For this exercise the estimated parameters obtained from the two estimation methods, optimization and Kalman filter, are very similar (tables B.1, B.2 in Appendix B). However, the estimated NIR generated by the optimization methodology is smoother (figure 4). That might be due to the difference in weight assigned to the economic relationship (parameter λ_2 in (26)).

With respect to the estimation of the IS curve, both the optimization and Kalman filter results show high persistence in the output gap and the exchange rate gap is not significant.

4.3.2. HPMV filter augmented by a policy rule

The estimation results for the policy rule exercise are shown in tables B.3, B.4 in Appendix B and figure 5. Although most parameter estimates are similar for both methods, optimization and Kalman Filter, there are important

FIGURE 4. NIR ESTIMATION BY HPMV-NLS AND HPMV-KALMAN FILTER USING A IS CURVE, 1980-2010



NOTE: The real interest rate (RIR2) is the wide line, the NIR estimation and its 90% condence intervals correspond to the thin and dotted lines, respectively.

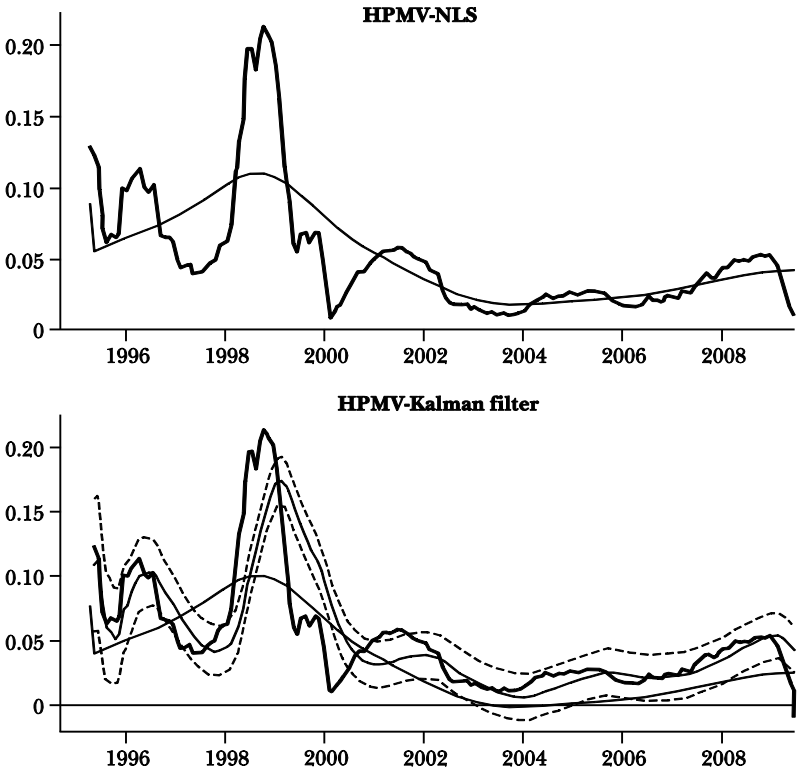
differences in some parameters. In the Kalman estimation the interest rate gap, the inflation gap and the overnight rate persistence are significant meanwhile in the NLS estimation (optimization method) only the overnight rate persistence is significant. As in the IS exercise, the NIR estimation by NLS is smoother than the one obtained by Kalman filter.

The dynamic of the NIR estimations with both economic relationships is similar. However, there are different trends at the end of sample, three of the four estimations show a decreasing trend, starting at different periods.

4.4. Semi-structural model

This section presents the results of the estimated model

FIGURE 5. NIR ESTIMATION BY HPMV-NLS AND HPMV-KALMAN FILTER USING A POLICE RULE, 1996-2008



NOTE: The real interest rate (RIR2) is the wide line, the NIR estimation and its 90% condence intervals correspond to the thin and dotted lines, respectively.

FIGURE 6. NIR ESTIMATION BY A SEMI-STRUCTURAL MODEL, 2000-2010

NOTE: The 90-day real interest rate is the wide line, the NIR smoothed estimation correspond to the thin line.

described in section 2.3. Here we focus our attention in the NIR estimated with the model, the details on parameters values and the estimation diagnostic is presented in Appendix D. Figure 6 plots the path of the real interest rate (constructed as the nominal interest rate minus the inflation expectations obtained within the model) and the natural interest rate estimated with the Kalman smoother.

For the horizon considered the NIR fluctuates between one percent and five percent. It presents a positive trend since 2003Q1 to the 2007Q2, a period of sustained growth of the Colombian economy. The maximum reached is 4.4 percent in the middle of 2007. Then since 2008, as the world economy started to slowed its GDP growth, the NIR starts a decreasing trend.

The difference between the real interest rate and the NIR (interest rate gap) is a measure of the effect of the interest rate over the GDP, the IS curve of the model presents explicitly this relationship. If the real interest rate is above the NIR the interest rate have a negative effect over GDP or can be defined as a contractive interest rate. In the other case the interest rate have a positive effect over GDP and is an expansionary interest rate. Our estimation of the NIR implies that the interest rate had contractive effects on the economy during the period 2000Q1-2005Q2, and between the second quarter of 2007 and the first quarter of 2009. In the rest of the sample the interest rate had expansionary effects.

The magnitude of the contractionary or expansionary effects of the interest rate depends proportionally of the magnitude of the interest rate gap. The parameter which measures this relationship is α_2, and implies that an increase of one percentage point in the interest rate gap induces a reduction of 0.14 percentage points in the output gap. Since the interest rate gap can change because of movements of the NIR and movements of the interest rate, the effect of a given level of the interest rate change over time depends on the determinants of the NIR. Consider for example the year 2008, figure 6 shows that the real interest rate stayed almost constant during that year, nevertheless as the NIR decrease the interest rate gap increase and the interest rate become more contractive at the end of the year.

Our results suggest there is significant variability of the NIR in Colombia, this is especially relevant for monetary policy because as the NIR is not observable this variability implies a

large degree of uncertainty about the stance of monetary policy.

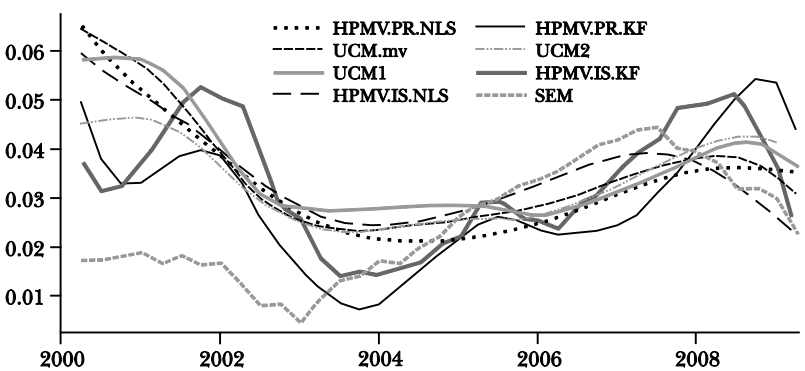
4.5. Comparisons of NIR estimations

Annual averages of the real interest rate and the NIR obtained by the different methodologies are presented in table 1 for the period 2002Q2-2009Q2. As described in previous sections, all the real interest rate definitions use the nominal 90-day deposit rate deflated by different measures of inflation expectations. RIR1 uses observed inflation, RIR2 imperfectly rational inflation expectations and RIR.SEM inflation expectations estimated by a semi-structural model.

On the other hand, UCM1 and UCM2 denote the univariate unobserved component model estimations using RIR1 and RIR2, respectively. UCM.mv refers to NIR estimated by a multivariate UCM. The estimations obtained by the multivariate Hodrick-Prescott filter are denoted by HPMV.$\boldsymbol{a.b}$ where $\boldsymbol{a} = IS, PR$ indicates the economic relationship (IS stands for the IS curve and PR for the policy rule), $\boldsymbol{b} = NLS, KF$ refers to the estimation methodology (NLS for the non-linear optimization and KF for the Kalman Filter). Finally, SEM is related to NIR estimated by the semi-structural model.

The NIR differences are due not only to the estimation methodology but also to the Real interest rate definition.[6] Both UCM and HPMV methods estimate the long-run trend component of the real interest rate. However, the latter includes an economic relationship. On the other hand the NIR estimated by

FIGURE 7. NIR ESTIMATIONS, 2000-2008



[6] The real interest rates are plotted in figure E.1 in Appendix E.

TABLE 1. ANNUAL AVERAGES OF REAL AND NATURAL INTEREST RATES. THE NAME IN PARENTHESIS INDICATES THE REAL INTEREST RATE USED IN THE MODEL, 2000-2009

	Variable	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Real Interest Rates	RIR1	5.6	7.0	1.6	2.0	3.3	3.0	1.9	3.3	5.6	3.3
	RIR2	4.1	5.6	2.6	1.3	2.5	2.5	2.2	3.7	5.2	2.5
	RIR.SEM	5.1	5.7	3.5	2.7	3.2	2.8	2.6	4.6	6.0	2.6
Natural Interest Rates	UCM1 (RIR1)	5.9	5.4	3.4	2.8	2.9	2.8	2.8	3.4	4.1	3.8
	UCM2 (RIR2)	4.6	4.4	3.1	2.4	2.4	2.6	2.8	3.5	4.2	4.1
	UCM.mv (RIR1)	6.2	5.1	3.3	2.4	2.4	2.6	3.0	3.6	3.8	3.3
	HPMV.IS.NLS (RIR2)	5.6	4.7	3.5	2.6	2.5	2.9	3.5	3.9	3.4	2.4
	HPMV.IS.KF (RIR2)	3.4	4.6	4.2	1.9	1.7	2.7	2.7	4.2	4.9	2.9
	HPMV.PR.NLS (RIR2)	6.1	4.7	3.4	2.5	2.2	2.3	2.7	3.3	3.6	3.6
	HPMV.PR.KF (RIR2)	4.0	3.7	3.0	1.1	1.3	2.4	2.3	2.9	4.8	4.9
	SEM (RIR.SEM)	1.8	1.8	1.2	1.1	1.9	3.0	3.7	4.3	3.5	2.7

the SEM methodology is based on economic theory. This explain the smooth behavior of the NIR estimated by UCM (figure 7).

The dynamics of the NIR estimations share a common pattern that can be characterized in three periods. The first part of the sample (2000-2003) shows a downward trend, followed by a period of stabilization and upward trend (2004-2008) and at the end of the sample the NIR start decreasing again. It is important to note that the SEM and the HPMV.IS.NLS estimates anticipate the fall in the last part of the sample. The NIR in the last quarter of the sample is around 3.1 in average.

5. CONCLUDING REMARKS

This paper estimates the natural interest rate for the Colombian economy using three methodologies; unobserved component models (UCM), Hodrick-Prescott multivariate filter augmented by an economic relationship (HPMV) and a semi-structural model for a small open economy (SEM). Different definitions of inflation expectations were used in order to measure the real interest rate.

The UCM and HPMV are statistical filters and in both cases the NIR is defined as the trend component of the market real interest rate, what suggests that the NIR may be considered as a long-run real interest rate anchor for monetary policy. On the other hand, the NIR estimated by the SEM methodology is based on economic theory which considers the NIR as a medium term anchor for monetary policy.

For the common estimation sample, 2000-2009, three features are observed in the dynamics of the NIR estimates. The first part of the sample (2000-2003) shows a downward trend, followed by a period of stabilization and upward trend (2004-2008) and at the end of the sample the NIR start decreasing again. The NIR in the last quarter of the sample is around 3.1 in average.

Appendix A

Estimation results of observed components models

TABLE A.1. UNIVARIATE UCM ESTIMATION RESULTS FOR RIR1

Variable	*Coefficient*	*RMSE*	*t-value*	*P-value*
Level	*3.6632*	*1.3805*	*2.6536*	*0.0091*
Estimated coefficients of final state vector				
$Cycle_1$	0.10049	1.0682		
$Cycle_2$	–0.59771	1.1487		
Lvl 1986. 1	–8.7539	1.9842	–4.4117	0.0000
Lvl 1992. 1	–8.3930	1.9850	–4.2281	0.0000
Irr 1994. 4	8.2582	2.3452	3.5213	0.0006
Lvl 1998. 2	13.342	2.0960	6.3652	0.0000
Lvl 1999. 1	–14.474	2.0955	–6.9073	0.0000
Estimated parameters of the cycle				
The cycle variance is 1.52261				
The rho coefficient is 0.9				
The cycle period is 20 (five years)				
The frequency is 0.314159				
The amplitude of the cycle is 0.606094				

TABLE A.2. DIAGNOSTIC REPORT FOR THE UNIVARIATE UCM USING RIR1

	Statistic	*P-value*
Skewness [χ^2 (1)]	0.12115	0.7278
Kurtosis [χ^2 (1)]	0.010216	0.9195
Normal-BS [χ^2 (1)]	0.13136	0.9364
Normal-DH [χ^2 (1)]	0.25975	0.8782
Std.Error	2.5370	
Normality	0.25975	
H(38)	0.37189	
r(1)	0.46513	
r(10)	0.11387	
DW	1.0220	
Q(10,6)	36.094	
R_d^2	0.81247	
Information criterion of Akaike		2.032894
Information criterion of Schwartz		2.268977

TABLE A.3. UNIVARIATE UCM ESTIMATION RESULTS FOR RIR2

Variable	*Coefficient*	*RMSE*	*t-value*	*P-value*
Estimated coefficients of final state vector				
Level	0.041445	0.011046	3.7521	0.0003
$Cycle_1$	0.0028286	0.0085470		
$Cycle_2$	–0.0034745	0.0091907		
Irr 1986. 1	–0.038727	0.018750	–2.0654	0.0412
Irr 1992. 1	–0.045769	0.019196	–2.3843	0.0188
Irr 1992. 2	–0.082524	0.019194	–4.2995	0.0000
Lvl 1994. 3	0.070250	0.015905	4.417	0.0000
Lvl 1998. 1	0.043588	0.020771	2.0985	0.0381
Lvl 1998. 2	0.086819	0.021153	4.1043	0.0001
Lvl 1999. 1	–0.13229	0.016821	–7.8646	0.0000
Estimated parameters of the cycle				
The cycle variance is 9.74781e-005				
The rho coefficient is 0.9				
The cycle period is 20 (five years)				
The frequency is 0.314159				
The amplitude of the cycle is 0.00448031				

TABLE A.4. DIAGNOSTIC REPORT FOR THE UNIVARIATE UCM USING RIR2

	Statistic	*P-value*
Skewness [χ^2 (1)]	0.40872	0.5226
Kurtosis [χ^2 (1)]	3.5748	0.0587
Normal-BS [χ^2 (1)]	3.9835	0.1365
Normal-DH [χ^2 (1)]	5.6721	0.0587
Std.Error	0.020103	
Normality	5.6721	
H(38)	0.34702	
r(1)	0.42188	
r(10)	0.062146	
DW	1.0997	
Q(10,6)	34.762	
R_d^2	0.85560	
Information criterion of Akaike		–7.605117
Information criterion of Schwartz		–7.318690

TABLE A.5. MULTIVARIATE UCM ESTIMATION RESULTS USING GDP, TOTAL CPI AND RIR1

	Parameters[a]		
Variable	*GDP*	*CPI*	*RIR1*
Level	18.080	102.19	3.0890
	(0.000)	(0.000)	(0.1732)
Slope	0.0060225	1.2795	–0.34281
	(0.1008)	(0.000)	(0.6403)
$Cycle_1$	–0.011542	0.35084	0.0093325
$Cycle_2$	–0.0073581	–0.29772	–1.2810

TABLE A.5 *(continuum)*

Variable	*GDP*	*CPI*	*RIR1*
Estimated parameters of the cycle			
The amplitude of the cycle is	0.0136876	0.460139	1.28098
The rho coefficient is 0.9			
The cycle period is 20 (five years)			
The frequency is 0.314159			

[a] P-values in parenthesis.

TABLE A.6. DIAGNOSTIC REPORT FOR THE MULTIVARIATE UCM USING GDP, TOTAL CPI AND RIR1

	GDP	*CPI*	*RIR1*
Skewness [χ^2 (1)]	0.85808	2.5006	5.2361
	(0.3543)	(0.1138)	(0.0221)
Kurtosis [χ^2 (1)]	2.5413	1.0137	8.8576
	(0.1109)	(0.3140)	(0.0029)
Normal-BS [χ^2 (2)]	3.3994	3.5143	14.094
	(0.1827)	(0.1725)	(0.0009)
Normal-DH [χ^2 (2)]	4.4787	3.3169	8.9075
	(0.1065)	(0.1904)	(0.0116)
Std.Error	0.012647	0.66210	2.5472
Normality	4.4787	3.3169	8.9075
H(38)	1.4065	37.487	0.26608
r(1)	0.057129	0.086898	0.23237
r(11)	–0.040052	–0.0023817	0.20108
DW	1.8819	1.7852	1.5078
Q(11, 6)	10.428	210.64	30.203
R_d^2	0.021200	0.35273	0.18757
Multivariate Normal DH test		15.99271	(0.0137931)

[a] P-values in parenthesis.

Appendix B

Estimation results of HPMV filters

TABLE B.1. OPTIMIZATION OF THE HPMV FILTER - IS CURVE

Parameter	*Estimate*	*Std. Error*[a]	*z-value*	*Pr(> |z|)*
α_0	–0.000	0.000	–0.277	0.782
α_1	0.999	0.016	61.881	< 0.001
α_2	–0.026	0.010	–2.542	0.011
α_3	–0.000	0.006	–0.031	0.976
σ_0	0.028			
λ_1	14,400.0			
λ_2	322.591			

[a] VAR-COV correction matrix using Newey West - Quadratic Spectral Kernel.

TABLE B.2. KALMAN ESTIMATION OF THE HPMV FILTER-IS CURVE

Parameter	*Estimate*	*Std. Error*	*z-value*	*Pr(> |z|)*
α_0	0.000	0.000	–0.884	0.094
α_1	0.999	0.005	207.980	0.000
α_2	–0.025	0.004	–6.799	0.000
α_3	0.000	0.002	–0.125	0.225
σ_0	0.030	0.001	25.607	0.000
λ_1	14,399.993	3,240.313	4.444	0.000
λ_2	346.408	42.459	8.159	0.000

TABLE B.3. OPTIMIZATION OF THE HPMV FILTER-POLICY RULE

Parameter	*Estimate*	*Std. Error*[a]	*z-value*	*Pr(> |z|)*
α_0	–0.017	0.032	–0.528	0.597
α_1	2.010	5.002	0.402	0.688
α_2	0.224	1.573	0.142	0.887
ρ	0.869	0.166	5.240	<0.001
σ_0	0.03			
λ_1	14,400.0			
λ_2	1.2			

[a] VAR-COV correction matrix using Newey West - Quadratic Spectral Kernel.

TABLE B.4. KALMAN ESTIMATION OF THE HPMV FILTER - POLICY RULE

Parameter	*Estimate*	*Std. Error*	*z-value*	*Pr(> |z|)*
α_0	–0.013	0.028	–0.461	0.161
α_1	2.479	1.925	1.287	0.049
α_2	0.712	1.157	0.616	0.135
ρ	0.911	0.028	31.972	0.000
σ_0	0.031	0.001	53.036	0.000
λ_1	14,399.8	5,323.6	2.705	0.002
λ_2	1.036	0.027	38.812	0.000

Appendix C

State space representation of unobserved component models

The state space (SS) form for an unobserved component model is given by the following measurement and state equations

$$\mathbf{y}_t = Z\boldsymbol{\alpha}_t + \boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim NID(\mathbf{0}, G) \tag{C.1}$$

$$\boldsymbol{\alpha}_{t+1} = T\boldsymbol{\alpha}_t + \boldsymbol{\epsilon}_{t+1}, \qquad \boldsymbol{\epsilon}_t \sim NID(\mathbf{0}, Q) \tag{C.2}$$

where $\boldsymbol{\alpha}_1$ is the initial state vector such that $\boldsymbol{\alpha}_1 \sim N(\boldsymbol{a}, P)$.

The measurement equation in (C.1) describes a linear relationship between the observed variables vector, $\mathbf{y}_t$, and the state vector, $\boldsymbol{\alpha}_t$. The state equation, (C.2), describes the unobserved components dynamics.

For the UCM the state vector contains the trend, seasonal and other unobserved components. The noise processes of (C.1) and (C.2), $\in_t$ and $\in_t$, are assumed to be orthogonal to each other and serially uncorrelated Gaussian errors. They also are independent from the initial state vector $\boldsymbol{\alpha}_t$.

The SS form for the model that includes local linear trend and cycle is given by equations (C.1) and (C.2) with the following vectors and matrices

$$\boldsymbol{\alpha}_t = (\mu_t, \beta_t, \varphi_t, \varphi_t^*)', \quad \boldsymbol{\varepsilon}_t = (\eta_t, \zeta_t, \kappa_t, \kappa_t^*)'$$

(C.3)
$$T = \begin{bmatrix} \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix} & \mathbf{0} \\ \mathbf{0} & \rho \begin{bmatrix} \cos\lambda & \sin\lambda \\ -\sin\lambda & \cos\lambda \end{bmatrix} \end{bmatrix}, \quad Z = [1,\ 0,\ 1,\ 0]$$

$$Q = \begin{bmatrix} \begin{bmatrix} \sigma_\eta^2 & 0 \\ 0 & \sigma_\zeta^2 \end{bmatrix} & \mathbf{0} \\ \mathbf{0} & \begin{bmatrix} \sigma_\kappa^2 & 0 \\ 0 & \sigma_\kappa^2 \end{bmatrix} \end{bmatrix}, \quad G = \sigma_l^2$$

where $\mathbf{0}$ represents a zero matrix of appropriate size.

The SS representation for the multivariate trend –cycle model written in SUTSE form is given by

(C.4)
$$\mathbf{y}_t = Z\boldsymbol{\alpha}_t + \in_t, \qquad \in_t \sim NID(\mathbf{0}, G)$$

(C.5)
$$\boldsymbol{\alpha}_{t+1} = T\boldsymbol{\alpha}_t + \boldsymbol{\varepsilon}_t, \qquad \boldsymbol{\varepsilon}_t \sim NID(\mathbf{0}, G)$$

where

$$\mathbf{y}_t = [y_{1t},\ y_{2t},\ \ldots,\ y_{kt}]'$$

(C.6)
$$\boldsymbol{\alpha}_{t+1} = [\mu_t,\ \beta_t,\ \varphi_t,\ \varphi_t^*]'$$

$$\boldsymbol{\varepsilon}_t = [\eta_t,\ \zeta_t,\ \kappa_t,\ \kappa_t^*]'$$

$$T = \begin{bmatrix} \begin{bmatrix} I & I \\ 0 & I \end{bmatrix} & \mathbf{0} \\ \mathbf{0} & \rho \begin{bmatrix} \cos\lambda I & \sin\lambda I \\ -\sin\lambda I & \cos\lambda I \end{bmatrix} \end{bmatrix}, \quad Z = [I,\ 0,\ I,\ 0] \tag{C.7}$$

$$Q = \begin{bmatrix} \begin{bmatrix} \sum_{\eta}^{2} & 0 \\ 0 & \sum_{\zeta}^{2} \end{bmatrix} & \mathbf{0} \\ \mathbf{0} & \begin{bmatrix} \sum_{\kappa}^{2} & 0 \\ 0 & \sum_{\kappa}^{2} \end{bmatrix} \end{bmatrix}, \quad G = \sum_{\in}^{2} \tag{C.8}$$

Appendix D

Semi-structural model

D.1. State-space representation

Measurement equation

$$\mathbf{y}_t = z\boldsymbol{A}_t + \boldsymbol{\eta}_t$$

where

$$\mathbf{y}_t = \begin{pmatrix} \Delta y_t \\ \pi_t \\ \Delta q_t \\ \Delta B_t \\ i_t \end{pmatrix}$$

and

$$z = \begin{pmatrix} 4 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & -4 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 4 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & -4 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$\mathrm{V}(\boldsymbol{\eta}_t) = GG' = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & \sigma^{m} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

Transition equation

$$w\boldsymbol{A}_{t+1} = B_t\boldsymbol{A}_t + c\boldsymbol{X}_{t+1} + H\boldsymbol{\nu}_{t+1}$$

It can be rewritten as:

$$\boldsymbol{A}_{t+1} = T_t\boldsymbol{A}_t + C\boldsymbol{X}_{t+1} + R\boldsymbol{\nu}_{t+1}$$

were $T_t = w^{-1}B_t,\ C = w^{-1}c,\ R = w^{-1}H$ and

$$\boldsymbol{A}_t = \begin{pmatrix} \tilde{y}_t \\ \tilde{r}_t \\ \tilde{q}_t \\ \pi_t^c \\ E_t(\pi_{t+1}^c) \\ \lambda \\ \tilde{B}_t \\ \overline{r}_t \\ \Delta\overline{q}_t \\ \tau_t \\ \Delta\overline{y}_t \\ \Delta\overline{B}_t \\ \tilde{y}_{t-1} \\ \tilde{q}_{t-1} \\ \tilde{B}_{t-1} \\ \Delta\overline{B}_{t-1} \\ \Delta\overline{B}_{t-2} \\ \tilde{B}_{t-2} \\ \tilde{B}_{t-3} \end{pmatrix},\ \boldsymbol{X}_t = \begin{pmatrix} T_t \\ \pi_t^{imfp} \\ \overline{\pi}_{t+1} \\ \overline{r}_t^* \\ 1 \\ \dfrac{\Delta\overline{g}_t}{\Delta Y} \end{pmatrix},\ \boldsymbol{\nu}_t = \begin{pmatrix} \eta_t^{\tilde{y}} \\ \eta_t^{\pi} \\ \eta^{E(\pi)} \\ \eta_t^{\tilde{q}} \\ \eta_t^{\tilde{b}} \\ \eta_t^{\tau} \\ \eta_t^{\overline{q}} \\ \eta_t^{\overline{y}} \\ \eta_t^{\overline{b}} \\ \eta_t^{\overline{r}} \end{pmatrix}$$

$$w = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & -(1-\beta_1-\beta_2) & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
-\rho_b & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & -1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & \varphi_1 & \varphi_2 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{pmatrix}$$

$$B_t = \begin{pmatrix}
\alpha_1 & \alpha_2 & \alpha_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & \rho_{\tilde{r}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \rho_q & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\beta_3 & 0 & 0 & \beta_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \zeta_{t-1} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \rho_{ab} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \rho_\tau & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \phi & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \rho_{\tilde{b}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0
\end{pmatrix}$$

$$c = \begin{pmatrix}
\alpha_4 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & \beta_2 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & \gamma_1 & 0 & 0 & 0 \\
\varphi_4 & 0 & 0 & 0 & \varphi_0 & \varphi_3 & 0 \\
0 & 0 & 0 & 0 & \gamma_\tau & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & (1-\phi) \\
0 & 0 & 0 & 0 & b_0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix}$$

and

$$H = \begin{pmatrix}
\sigma^{\tilde{y}} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \sigma^{\tilde{r}} \\
0 & 0 & 0 & \sigma^{\tilde{q}} & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & \sigma^{\pi} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & \sigma^{E(\pi)} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & \sigma^{\tilde{b}} & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \sigma^{\overline{q}} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & \sigma^{\tau} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \sigma^{\Delta\overline{y}} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \sigma^{\overline{b}} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{pmatrix}$$

The variance-covariance matrix of ν_t is an identity matrix Q of size 10 x 10.

D.2. Estimation results

Table D.1 presents a list of all the parameters and their values. For those that were estimated, the reported value is the posterior mode. The estimation were carried out using the multiple-try MCMC described in Liu et al. (2000) with the FORTRAN95 procedures developed by Bonaldi et al. (2010).

TABLE D.1. PARAMETER ESTIMATIONS

Item	*Parameter*	*Feasible range*	*Value in Castillo et al.(2006)*	*Calibrated value/ Posterior mode*
1	β_1	(0, 1)	0.7	0.77
2	β_2	(0, 1 − β_1)	0.15	0.02
3	ρ_b	(0, 1)	0.2	0.1
4[a]	φ_1	(−0.5, 0.5)	0	0.15
5[a]	φ_2	(0, 1)	0.62	0.21
6	α_1	(0, 1)	0.65	0.91
7	α_2	(−0.5, 0)	−0.17	−0.14
8	α_3	(0, 0.5)	0.04	0.012
9	ρ_{r^*}	(0, 1)	n.a.	0.43
10[a]	ρ_q	(0, 1)	0.6	0.86
11	β_3	(0, 0.5)	0.2	0.15
12	ρ_τ	(0, 1)	0	0.1

TABLE D.1 *(continuum)*

Item	*Parameter*	*Feasible range*	*Value in Castillo et al.(2006)*	*Calibrated value/ Posterior mode*
13	φ	(0, 1)	0.95	0.95
14	$\rho_{\bar{r}}$	(0, 1)	n.a.	0.94
15	α_4	(0, 0.5)	0.2	0.003
16[a]	γ_1	(0.4, 1)	0.65	0.66
17[a]	φ_4	(−1, 0)	−0.6	−0.039
18[a]	φ_0	(−5, 0)	0.45	−2.49
19[a]	φ_3	(−0.1, 0.1)	0	0.007
20	γ_τ	(0, 3)	1.25	2.34
21	b_0	(0.05, 15)	n.a.	10.18
22[a]	$\sigma^{\tilde{y}}$	(0, ∞)	n.a.	1.88
23[a]	$\sigma^{\tilde{r}}$	(0, ∞)	n.a.	6.69
24[a]	$\sigma^{\tilde{q}}$	(0, ∞)	n.a.	26.8
25[a]	σ^{π}	(0, ∞)	n.a.	2.66
26[a]	$\sigma^{E(\pi)}$	(0, ∞)[b]	n.a.	0.87
27[a]	$\sigma^{\tilde{b}}$	(0, ∞)	n.a.	1.79
28[a]	$\sigma^{\bar{q}}$	(0, ∞)[b]	n.a.	0.05
29[a]	σ^{r}	(0, ∞)[b]	n.a.	2.69
30[a]	$\sigma^{\Delta\bar{y}}$	(0, ∞)[b]	n.a.	0.019
31[a]	$\sigma^{\bar{b}}$	(0, ∞)[b]	n.a.	0.24
32	σ^{m}	(0, ∞)	n.a.	0.001
33	λ	(0, 1)	n.a.	0.35
34	ρ_{ab}	(0, 1)	n.a.	0.59

[a] Estimated parameters. [b] Small variances (permanent shocks).

The posterior and priors distributions of those parameters for which the likelihood function of the model was informative are reported in figure D.1

D.2.1. MCMC diagnostic

Two statistics are presented in order to check convergence in the Markov chains. Figure D.2 plots the within variance of the Markov chains and a variance estimator obtained by a weighted average of the within and the between variance. They are expected to converge both to the same level. Table D.2 presents the potential scale reductor described in Gelman and Shirley (2020) for each of the estimated parameters. Those authors argue that in practice this statistic should be less than 1.1 for each parameter (perfect mixing of the chains implies that the statistic converges to 1). Both statistics support the fact that the MCMC converged.

FIGURE D.1. PRIORS AND POSTERIOR DISTRIBUTIONS

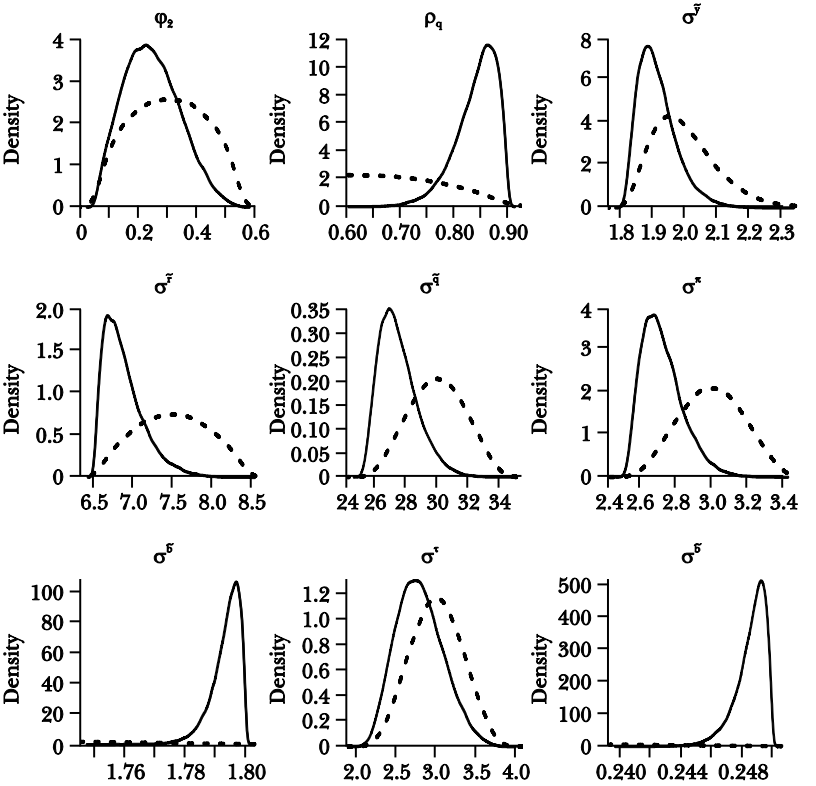


FIGURE D.2. MULTIVARIATE MCMC DIAGNOSTIC

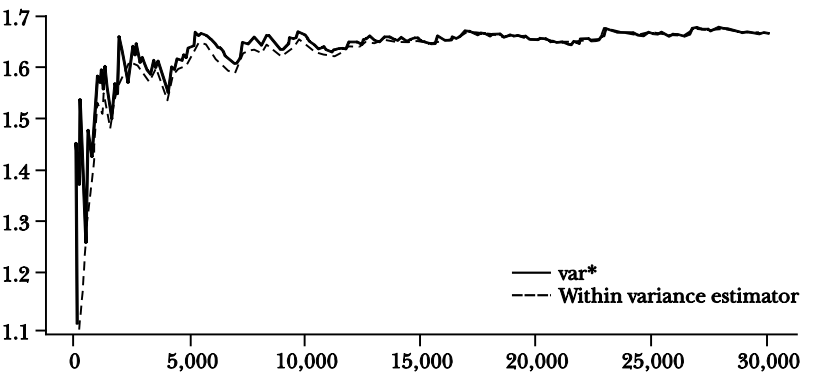
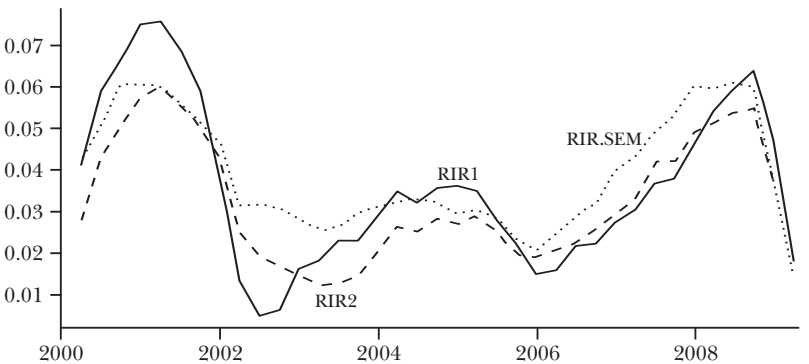


TABLE D.2. POTENTIAL SCALE REDUCTOR

Parameter	*Statistic*
φ_1	1.00118
φ_2	1.00015
ρ_q	1.00036
γ_1	1.00338
φ_4	1.00097
φ_0	1.00277
φ_3	1.00169
$\sigma^{\tilde{y}}$	1.00211
$\sigma^{\tilde{r}}$	1.00210
$\sigma^{\tilde{q}}$	1.00099
σ^{π}	1.00109
$\sigma^{E(\pi)}$	1.00465
$\sigma^{\tilde{b}}$	1.00003
$\sigma^{\tilde{q}}$	1.00160
$\sigma^{\Delta\tilde{y}}$	1.00422
$\sigma^{\tilde{b}}$	1.00003

Appendix E

FIGURE E.1. REAL INTEREST RATES, 2000-08



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A dynamic factor model of quarterly real gross domestic product growth in the Caribbean: the case of Cuba and the Bahamas

1. INTRODUCTION

Real output growth is a central economic indicator for all policymakers. It defines the business cycle, establishes the timing of recessions, and largely drives discretionary fiscal and monetary policy decisions. The lack of timely reporting of quarterly GDP in some countries presents difficulties in the assessment of current economic conditions, and has fomented a growing literature that *nowcasts* GDP at higher (monthly) frequencies and anticipates quarterly data releases.[1] While increasingly rare among emerging market

[1] See, for example, Liu, Matheson and Romeu (2010) on nowcasting

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economies, many countries do not report quarterly GDP growth at all. A number of these cases are in the Caribbean, where the availability of timely indicators of economic activity is even more important given the volatility stemming from natural disasters, the high dependency on commodity imports, and other vulnerabilities. This study proposes a framework that combines nowcasting econometric techniques with data that takes advantage of the geographic characteristics of Caribbean economies to estimate quarterly GDP growth rates.

Caribbean economies exhibit a number of characteristics that aid the statistical inference of their quarterly output growth. First, as islands, commercial shipping dominates the transport of their external trade in goods, hence providing more accurate and timely measures of trade than overland routes for other countries. Second, external trade tends to reflect a large proportion of internal consumption and investment, as these economies are relatively small and less diversified, and hence they import a large part of their consumption basket and capital goods. Thus trade generally mirrors economic activity in the wider economy. Third, their geographic proximity to the United States (US) and various trade treaties implies that most of their trade is with the US, and to a lesser extent the European Union (EU) and China, all of which publish accurate and timely bilateral trade data. Fourth, one of their dominant industries is tourism, for which at least summary statistics are accurately measured and published on a timely basis.[2] Moreover, this sector closely links an important part of Caribbean economic activity to labor conditions in advanced economies, for which there is broad data availability. Finally, idiosyncratic regional exposure to factors such as hurricanes and extreme weather events, advanced economy financial sectors, or remittances, among others, also lends itself to timely measurement and reporting.

Among the larger Caribbean economies, many already produce and publish quarterly gross domestic output, such as Jamaica or the Dominican Republic. Others, such as Guadeloupe, Turks and Caicos Islands, or Puerto Rico are not

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monthly GDP in Latin America and the Caribbean.

[2] See Romeu (2008) on the influence of trade treaties, natural disasters, and tourism for Caribbean economies.

separate political entities, and hence, their economic activity is largely reported by other (OECD) economies to varying degrees. As a result, this study focuses on Cuba and the Bahamas, two larger Caribbean economies that do not publish quarterly GDP and for whom the aforementioned conditions, such as geographic proximity to the US or dependence on tourism are likely to aid in quarterly GDP estimation.

Annual GDP data published by national authorities in both countries can be delayed as much as six months after the end of the period, hence, in the early part of any given year; the latest official information on national economic activity can be as much as eighteen months old. Nonetheless, a large number of aforementioned indicators are released more frequently and are available with a shorter lag. Arguably, policymakers likely already use these indicators in their continuous assessment of the economy. Nevertheless, no systemic analysis of the impact on policy of changes in short-term has been made public, with only ad hoc references and in some cases, official announcements being available. Consequently, guidance to the private sector or trading partners on policy reactions to evolving conditions is limited, introducing further uncertainty.

To address these problems, this study creates a quarterly model of GDP growth for Cuba and the Bahamas using higher frequency indicators. The framework adopts the parametric dynamic factor model (DFM) to summarize a large number of indicators to produce a quarterly GDP series. This model can be used to assess recent economic developments and provide short-term quarterly forecasts of GDP. The proposed analytical framework provides a more timely assessment of GDP, and can be updated on an ongoing basis as new data are released and indicators are updated.

The model results help shed light on the impact of the crisis that began in 2007 on these economies. Official data released by the Cuban authorities reported aggregate 2009 GDP growth of 1.3%, compared to 5% in 2008.[3] The nowcast

[3] Official GDP in Cuba is heavily weighted towards services (over 80%), which is higher than in the rest of Latin American and the Caribbean. To address the potential overweighting, Romeu (2011) compares nowcasts of official GDP and an unofficial (reweighted) Cuban GDP based on the

shows, however, that the annual figure masks a very strong output decline in the last quarter of 2008 and the first quarter of 2009, followed by a moderate recovery. The quarterly path for the Bahamas similarly displays a very sharp decline in output in the first quarter of 2009 (a contraction exceeding 5% on an annualized basis), with a moderate recovery appearing only in the last quarter of 2009. For 2010, the model predicts a moderate improvement in short-term GDP growth for both countries. Cuba is projected to increase growth from approximately 2% in 2010 to approximately 2.5% in 2010, and the Bahamas is projected to rise from –4.7% in 2009 to approximately zero growth in 2010, and moderate growth for 2011. Sustained high US unemployment appears to be weighing down on the forecasts for both countries through 2010, and a prolonged period of very low growth is forecasted for the next two years on the basis of existing data.

The next section outlines the modeling methodology. The following section gives an overview of the data, which is detailed in the Appendices, and tests the model, including forecast comparisons of the proposed dynamic factor model with comparator forecasting models, and summarizes results. The last section concludes.

2. METHODOLOGY

This section presents the dynamic factor model employed for nowcasting and forecasting quarterly GDP growth. Generally, the estimation procedure can be separated into the following four steps. First, the Dynamic Factor Model (DFM) is estimated based on the unbalanced dataset. Second, the Kalman filter recursion is used to help predict the missing observations to produce a balanced panel. Third, the factors are re-estimated based on the new balanced panel.[4] Finally, the quarterly GDP series are computed based on Chow and Lin's (1971) interpolation procedure.

The second and third steps are critical for filling in missing

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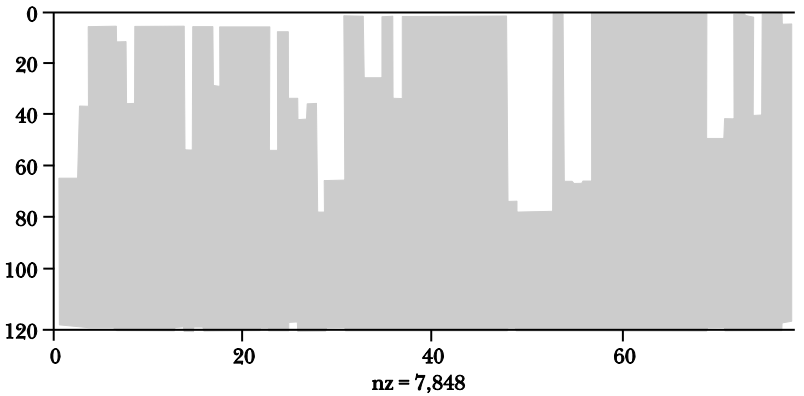
services weight for the Dominican Republic.

[4] In practice, steps two and three are repeated until there is little change to the estimated factor.

observations for both past and current (as yet unreported) series. This is illustrated in figure 1, which shows missing data for Cuba in a quarterly sample of 77 series from 1980 to 2010. A naturally occurring *rugged edge* appears in the dataset as a result of the asynchronous timing of new data releases and differences in historical data availability. The Dynamic Factor Model addresses these by *filling* in the missing observations recursively using the estimated factors, which are shown in the figure as white area. The Kalman smoother is then used to fill backwards missing values based on information in the entire dataset, and thereby produce a balance panel.

FIGURE 1. CUBA: DATA AVAILABILITY OF QUARTERLY INDICATORS OF ECONOMIC ACTIVITY



SOURCE: Authors' estimates.

NOTE: The figure shows missing data for Cuba in a quarterly sample of 77 (across the horizontal axis) series from 1980.1 to 2010.3 (along the undated vertical axis). The gray area shows observed data. The Dynamic Factor Model addresses the naturally occurring *jagged* edge of the dataset resulting from the asynchronous timing of new data releases by filling in the missing observations recursively.

2.1. The dynamic factor model

Assume that the $n \times 1$ vector of weakly stationary time series X_t has the following factor representation:

$$X_t = \Lambda F_t + e_t, \quad e_t \sim N(0, \Sigma), \tag{1}$$

where F_t is a $k \times 1$ vector of common factors that drive the joint evolution of all variables and e_t is the idiosyncratic component associated with each observed time series, which is assumed to be normally distributed with zero mean and variance covariance Σ. Forni et al. (2000) and Stock and

Watson (2002) show that the common factors in equation (1) can be consistently estimated by principal components. To complete the specification of the DFM, the common factors are assumed to follow a VAR(p) process such that:

$$F_t = A(L)F_{t-1} + Bu_t \text{ and } u_t \sim N(0, I_q) , \tag{2}$$

where $A(L)$ is an p^{th} order matrix polynomial, B is a $k \times q$ matrix of full rank q, and u_t is a vector of uncorrelated white noise shocks.[5] In the model, we assume three common factors (k), two pervasive common shocks (q), and two lags for the VAR.

The DFM described in equations (1) and (2) is estimated using the two-step procedure described in Giannone et al. (2008). First, based on the shorter balanced data panel, the common factors are estimated using the principal component method and the VAR coefficients are estimated using ordinary least square (OLS). Next, given the initial parameter estimates, apply the Kalman filter to the entire data set (including missing observations), and re-estimate the factors. For missing observations, the implicit signal extraction process of the filter will place no weight on that variable in the computation of the factors in time t. Finally, the missing observations are filled in using the estimated factors [via equation (1)]. These steps are repeated until there is no further change to the estimated factors.

The interpolation method developed by Chow and Lin (1971) is then used to map the annual GDP into quarterly series. The method assumes that it is possible to write the unobserved quarterly GDP series (y_t) as a linear stochastic function of some observed quarterly indicators. In this case, the estimated common factors (F_t) from the DFM are employed such that:

$$y_t = \beta' F_t + v_t , \tag{3}$$

where β' is a $k \times 1$ vector of parameters and v_t is a vector of stochastic disturbances with covariance matrix Π. Let y_t^* be the observed T annual values of GDP, and ζ be an $T \times 4T$ aggregation matrix that converts quarterly series into its annual

[5] The uncorrelated white noise restriction is shown to help improve the forecasting performance of the DFM.

values. The annual and quarterly series can be expressed as $y_t^* = \zeta y_t$ or

$$y_t^* = \zeta\beta F_t + \zeta v_t \tag{4}$$

Although equation (3) cannot be directly estimated, estimates of its parameters can be obtained from equation (4) using generalized least square (GLS). Define $F_t^* = \zeta F_t$, the GLS estimator is given by $\hat{\beta} = [y_t^{*\prime}(\zeta\Pi\zeta')^{-1}y_t^*]^{-1}y_t^{*\prime}(\zeta\Pi\zeta')^{-1}F_t$. Using the $\hat{\beta}$ from the GLS regression, one can obtain the estimates of quarterly GDP series such that:

$$\hat{y}_t = \hat{\beta}F_t + \Pi\zeta'(\zeta\Pi\zeta')^{-1}(y_t^* - \hat{\beta}F). \tag{5}$$

$\hat{y}_t$ can be decomposed into two components: *i)* the conditional expectation of quarterly GDP (y_t) given the common factors (F_t); and *ii)* the redistribution of the annual prediction error into quarterly prediction errors. The second component ensures the aggregated quarterly series coincide with the observed annual series. Lastly, we substitute the forecast of the common factors into equation (5) to obtain the forecast of quarterly GDP.

3. DATA

The quarterly dataset used to project quarterly GDP consists of trade and financial variables for Cuba and the Bahamas, which are detailed in the Appendices. For the Bahamas, the Dynamic Factor Model summarizes approximately 130 monthly and quarterly indicators, of which roughly one-half are direct indicators of domestic activity in the Bahamas, such as electricity generation or manufacturing. The rest of the variables are indicators of the US economy, which carry a particularly important weight for the Bahamas given its close proximity and its heavy dependence on tourism from US residents. The influence of the US on the Cuban economy is less direct, particularly because of limited direct trade. Nonetheless, the impact of shocks to the US is felt in the Cuban economy indirectly through world financial variables, commodity prices, tourism indicators, and hence, these are included for Cuba. In addition, weather and natural disasters are included,

as are income measures for residents abroad which are intended to reflect remittances in both countries.

The median of the change in the underlying indicator variables, shown in the Appendix for Cuba, summarizes the overall change that the dynamic factor model captures. The median indicator changes suggest a slowing down of activity in 2008-09, with a recovery in late 2009, but a return to slow growth in 2010. The strong variation within some of the available series is eliminated by the factor modeling, which produces the common component of the available series.

4. MODEL TESTING AND RESULTS

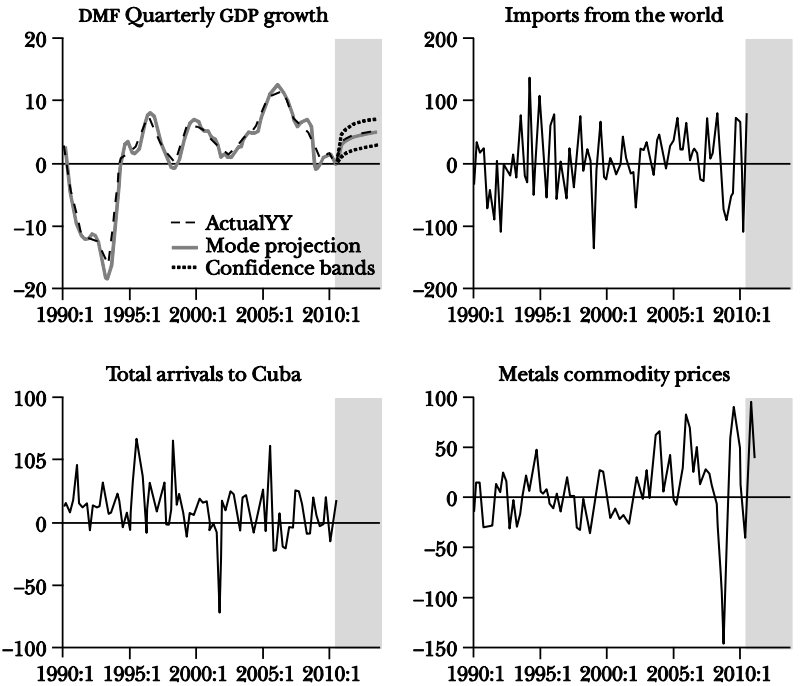
To get a feel for the modeling results presented below, figure 2 shows the derivation of quarterly GDP growth for Cuba.[6] The upper left panel compares actual GDP growth to the quarterly estimate. This estimate, based on the DFM, results from extracting the common component of the series presented in the Appendix. Three key series are shown, which drive the quarterly estimates. The upper right shows total imports by Cuba from the world. The lower left shows total overnight tourist arrivals. The lower right shows the evolution of the nickel commodity price index, a key commodity export for Cuba. The DFM brings all the underlying series to the present (including by filling in the missing variables) and estimates quarterly GDP based on the common components of all the underlying series, of which three are shown.

The initial empirical test of the model is presented in figure 3, which compares out-of-sample forecast for the DFM with two bivariate vector auto-regression (BiVAR) models. The first BiVAR model consists of annual GDP growth for the Bahamas and the US unemployment rate, while the second consists of annual GDP growth for the Bahamas and the US.[7] The figure shows the one-year-ahead forecast of GDP growth for the

[6] Without loss of generality, the section presents general results pertaining to the DFM quarterly GDP nowcasting model alternatively for Cuba or the Bahamas, but not both.

[7] See Romeu and Wolfe (2011) for the links on tourism to OECD employment conditions driving this choice for the BiVAR for the Bahamas.

FIGURE 2. CUBA: AN EXAMPLE OF DFM ESTIMATES, 1990-2010



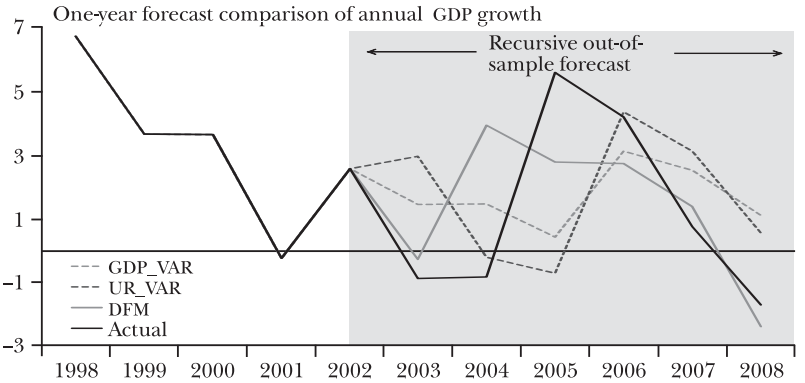
SOURCE: GTA, Haver, Country authorities, Authors' estimates.

NOTE: The figure shows the derivation of quarterly GDP growth for Cuba. The upper left panel compares actual GDP growth to the quarterly estimate. This estimate, based on the Dynamic Factor Model (DFM), results from extracting the common component of the series presented in Appendix 1 for Cuba (and analogously for The Bahamas). Three key series are shown, which drive the quarterly estimates. The upper right shows total imports by Cuba from the world. The lower left shows total overnight tourist arrivals. The lower right shows the evolution of the nickel commodity price index, a key commodity export for Cuba. All figures expressed in annualized, seasonally adjusted, one-quarter growth rates.

Bahamas from 2003 to 2008 for all three models, with the DFM forecast based on information at the end of each year over the corresponding period. The results show that the DFM outperforms the two BiVAR models in every year except for 2004. The root mean squared forecast errors of the DFM is 23 and 32% smaller than the BiVAR model based on US unemployment rate and GDP growth.

Figure 4 compares the estimates of quarterly GDP for the Bahamas and Cuba with the official annual data. Both countries show large and persistent recession in the early to mid 1990s, however, Cuba's post-Soviet decline was more than double that of the Bahamas. This deep recession in the early

FIGURE 3. THE BAHAMAS: COMPARING NOWCASTING MODELS, 1998-2008



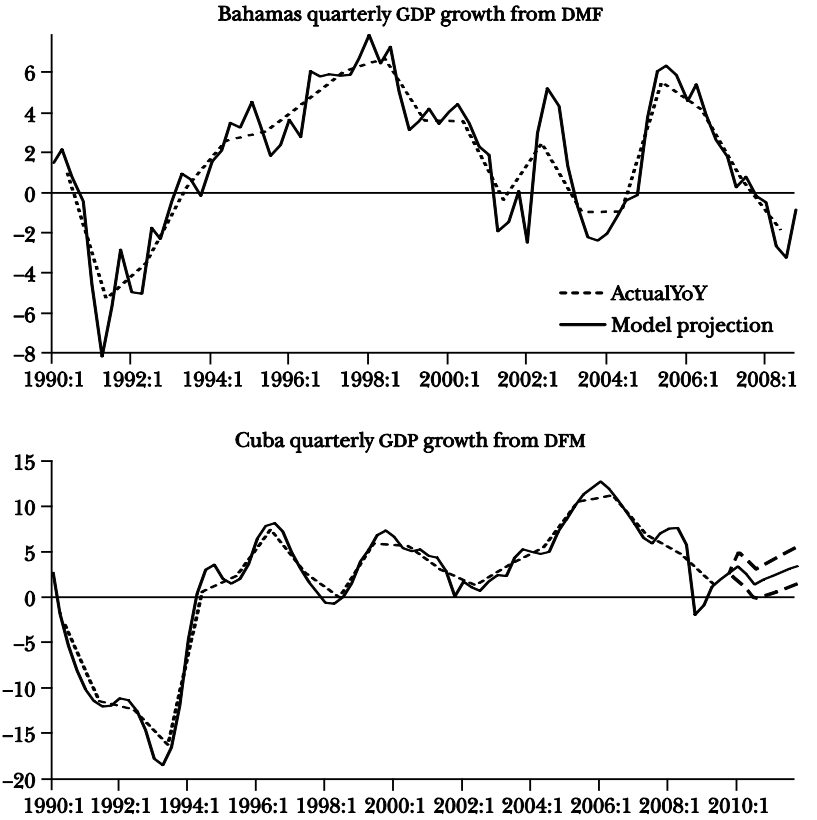
SOURCE: Country authorities. Authors' estimates.

NOTE: The figure compares actual GDP growth with out of sample forecast for the Dynamic Factor Model (DFM, solid red) with two bivariate VAR (BiVAR) models of GDP growth based on US unemployment rate and GDP growth. The shaded area shows the one-year-ahead recursive GDP growth rate forecast for the Bahamas from 2003 to 2008. The one-year-ahead DFM forecast is based on information at the end of each year over the corresponding period. The DFM outperforms the two BiVAR models in every year except for 2004, with a root mean squared forecast errors of 23% and 32% smaller than the two BiVAR model, respectively.

1990s illustrates the large quarterly declines that occurred within the year but are masked by the averaging that occurs in the official annual growth. For both countries, the trough of the recession in the early 1990s was significantly deeper than the reported annual decline (–8% for the Bahamas and –18% for Cuba). In addition, the figure shows the similarity in the sharp and rapid downturn experienced by both countries in the wake of the 2007/08 global financial crisis.

Figure 5 shows the DFM forecast for the Bahamas, including 95% bands against the annual data. The shaded area represents forecasting of quarterly GDP in 2009-11. The bottom panel shows the log of tourist arrivals to the Bahamas (by air) which dropped off considerably in 2009, and is an important driver of the quarterly nowcast of GDP. The model suggests that at the trough, quarterly GDP declines exceeded 5% in early 2009, and at present, output has recovered mildly, to approximately one percent annualized growth. Similarly, figure 6 shows the DFM forecast for Cuba, with 95% bands also shown and graphed against the annual data. For Cuba, the bottom panel shows imports from the world, which is traditionally a key indicator of activity due in part to hard currency financing constraints, and which dropped off considerably in

FIGURE 4. DFM FORECASTS FOR THE BAHAMAS AND CUBA, 1990-2010



SOURCE: Country authorities. Authors' estimates.

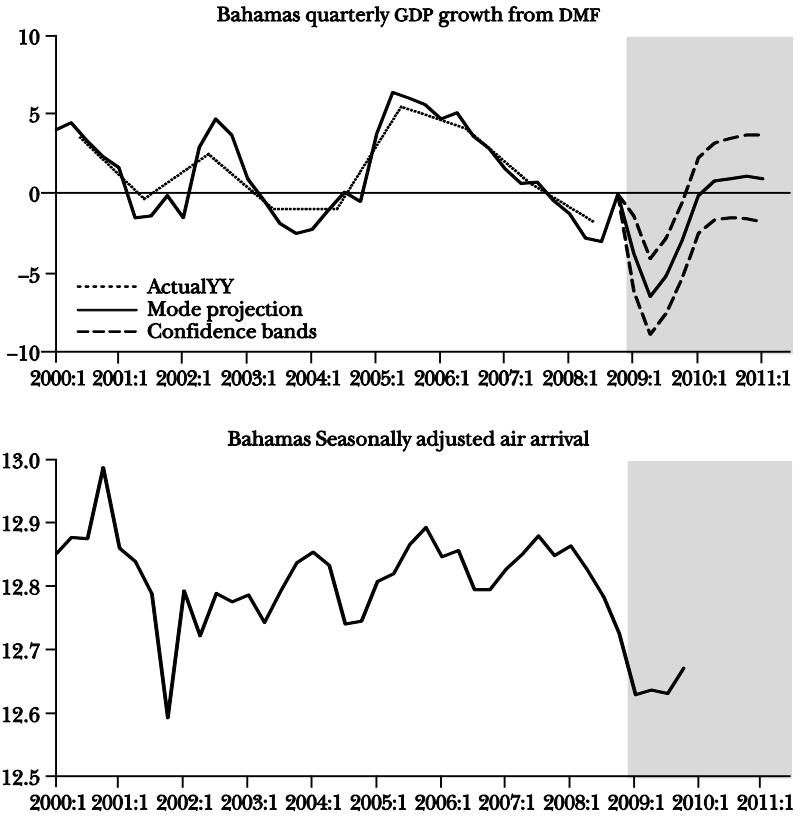
NOTE: Quarterly (DFM estimates, SAAR) and annual (official) GDP growth is presented for the Bahamas, and Cuba. The solid line shows the annual growth rate, the dotted shows the quarterly DFM forecast. Both countries show large and persistent recession in the early to mid 1990s, however, Cuba's post-Soviet decline was more than double that of the Bahamas. The recession of 2008 was of similar magnitude across both economies.

2009. The model suggests that at the trough, quarterly GDP declined by approximately 2% at the end of 2008 and into 2009 in Cuba. In addition, estimates of output in 2010 suggest a mild recovered and a return to recessionary conditions, with seasonally adjusted annualized GDP growth estimated at approximately one percent.

5. CONCLUSION

This paper proposes a framework for nowcasting and forecasting

FIGURE 5. THE BAHAMAS: THE CRISIS IMPACT AND CURRENT GDP, 2000-2011

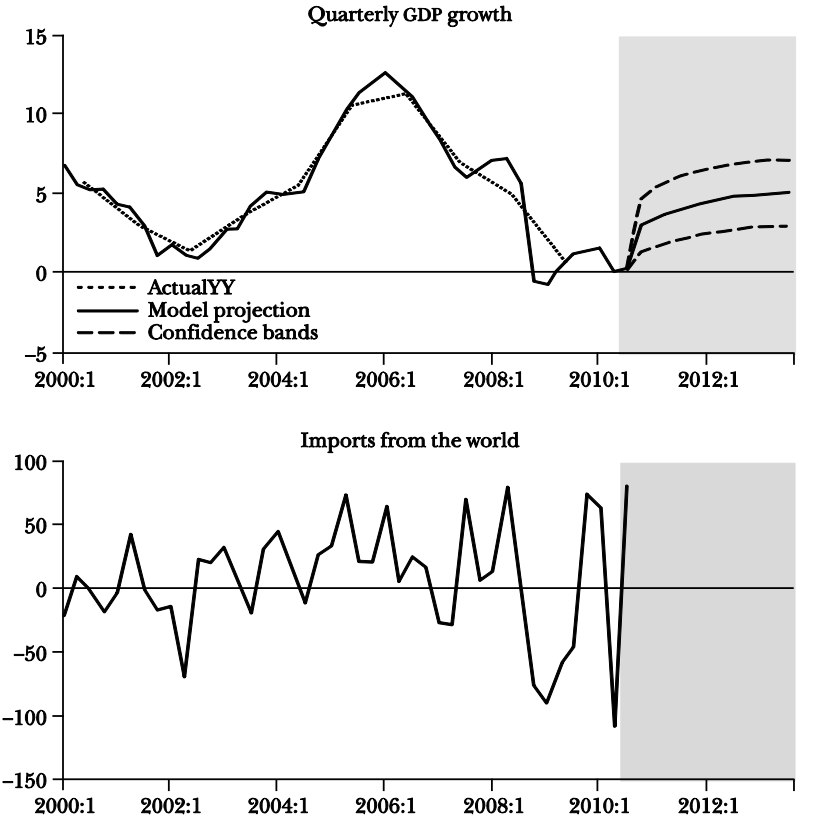


SOURCE: Country authorities. Authors' estimates.

NOTE: The upper panel shows the Dynamic Factor Model forecasts for the Bahamas including 95% bands against the annual data (dotted line). The shaded area represents forecasting of quarterly GDP in 2009-2011. The bottom panel shows tourist arrivals to the Bahamas (by air) which dropped off considerably in 2009, and is an important driver of the quarterly nowcast of GDP. The model suggests that at the trough, quarterly GDP declines exceed 5% in early 2009, and at present, output has recovered mildly, to approximately 1% annualized growth.

quarterly real GDP growth using a Dynamic Factor Model for Cuba and the Bahamas, countries which at present do not report quarterly output growth. The study employs several characteristics idiosyncratic to Caribbean countries that are particularly useful in estimating quarterly growth using the Dynamic Factor Model, including proximity to the US, the fact that they are islands, and trade treaties, among others. Estimates of the proposed model are evaluated against two simple bivariate vector autoregressions, and the latter are found to underperform relative to the DFM.

FIGURE 6. CUBA: THE CRISIS IMPACT AND CURRENT GDP, 2000-2012



SOURCE: Country authorities. Authors' estimates.

NOTE: The upper panel shows the Dynamic Factor Model forecasts for the Cuba including 95% bands against the annual data (dotted line). The shaded area represents forecasting of quarterly GDP in 2009-2011. The bottom panel shows Cuba's imports from the world.

The model estimations also shed light on both the depth and breadth of past recessions in both countries and the more recent impact of the global financial crisis. Both countries suffered historically large and prolonged recessions in the early part of the 1990s. During these, the reported annual declines in output did not exceeded 6% for The Bahamas, fluctuated between 10% and 15% for Cuba. The DFM estimates, however, show growth declines approaching 8% during this period for the Bahamas and nearly 20% in some quarters for Cuba. Hence, unsurprisingly, the annual growth tends to understate the depth of the contractions during some quarters of this period. For the global financial crisis

that began in 2007/08, the DFM model estimates show a very rapid decline in GDP in both countries, with a particularly pronounced drop coinciding with the turmoil in the last quarter of 2008 and the first quarter of 2009. Moreover, both countries are currently facing very slow recoveries with projected growth rates under 3% for 2010.

Appendix

TABLE A. 1. CUBA: DATA DESCRIPTION AND SEASONALLY ADJUSTED CHANGES, 2000-2010

	2000-2007	*2008*	*2009*	*2009Q4*	*2010Q1*
Seas. adj. external loans and deposits of reporting banks vis–à–vis all sectors	...	...	...	...	...
Seas. adj. external loans and deposits of reporting banks vis–à–vis all sectors	...	...	...	...	...
Seas. adj. consolidated claims of reporting banks–inmediate borrower banks	...	...	...	...	...
Seas. adj. Venezuela, imports from Cuba	–4.8	3.6	0.3	3.9	–0.5
Seas. adj. Venezuela, exports to Cuba	–2.9	3.5	0.9	5.7	10.9
Seas. adj. WORLD, imports from Cuba	4.4	–9.0	5.0	12.7	13.7
Seas. adj. ARG, imports from Cuba	–0.3	–7.5	14.6	206.1	75.3
Seas. adj. BRA, imports from Cuba	–4.2	33.1	–18.2	–24.7	84.8
Seas. adj. CAN, imports from Cuba	3.5	–21.8	9.0	30.2	5.5
Seas. adj. CHN, imports from Cuba	9.4	–3.1	12.2	25.9	16.2
Seas. adj. EU, imports from Cuba	–0.7	–3.5	6.6	–23.0	–4.1
Seas. adj. JPN, imports from Cuba	–7.9	–18.8	24.6	88.7	–42.2
Seas. adj. MEX, imports from Cuba	3.7	57.4	–57.1	–104.1	–4,229.5
Seas. adj. RUS, imports from Cuba	–17.1	–6.9	–6.3	–8.9	–5.4
Seas. adj. WORLD, exports to Cuba	4.2	2.8	–11.7	20.7	17.5
Seas. adj. ARG, exports to Cuba	0.9	4.8	–20.6	–39.5	258.6
Seas. adj. BRA, exports to Cuba	6.3	6.1	–28.8	–40.4	31.5
Seas. adj. CAN, exports to Cuba	5.2	–0.3	–24.6	–17.5	100.5
Seas. adj. CHN, exports to Cuba	5.8	5.2	–16.8	–9.8	137.6
Seas. adj. EU, exports to Cuba	2.0	5.9	–12.1	10.3	0.7
Seas. adj. JPN, exports to Cuba	5.3	–22.2	–14.0	–25.4	6.2
Seas. adj. MEX, exports to Cuba	1.1	14.0	4.4	16.9	3.1
Seas. adj. RUS, exports to Cuba	3.3	–17.5	53.6	585.7	–69.7
Seas. adj. USA, exports to Cuba	6.6	6.6	–7.3	4.5	–14.0
Seas. adj. arrivals, total	2.4	1.3	2.5	5.9	–1.1
Seas. adj. price coffee Colombian	–1.0	0.2	5.4	5.9	4.6
Seas. adj. price sugar raw cane world FOB (Cents/Lb)	1.6	3.2	20.8	18.8	2.1
Seas. adj. Dominican Republic tourist arrivals rest of the world	–2.9	1.5	–12.7	57.2	15.0
Seas. adj. US tourism: US citizen air traffic to Mexico (NSA, units)	1.8	–0.1	0.6	0.8	2.6

TABLE A. 1 *(continuum)*

	2000-2007	*2008*	*2009*	*2009Q4*	*2010Q1*
Seas. adj. US tourism: US citizen air traffic to Caribbean (NSA, units)	0.1	–3.7	1.7	0.8	–1.3
Seas. Adj. CPI–U: Miami–Fort Lauderdale, FL (NSA, 1982–84=100)	0.8	1.1	0.0	1.1	0.0
Seas. adj. CPI–W: Miami–Fort Lauderdale, FL (NSA, 1982–84=100)	0.9	1.2	0.0	1.3	0.3
Seas. adj. cushing OK West Texas intermediate spot price FOB ($/Barrel)	4.8	–0.3	13.1	31.3	10.2
Seas. adj. copper, high grade: COMEX spot price ($/Lb)	3.9	–8.8	19.7	33.2	10.3
Seas. adj. cash price: soybeans, number 1 yellow, central Illinois ($/bush)	1.8	0.9	1.1	2.1	–11.5
Seas. adj. gold, Handy & Hanran Base Price ($/Troy Oz)	2.5	–0.3	9.9	11.3	–2.5
Seas. adj KR–CRB spot commodity price index metals (1967=100)	2.5	–8.4	16.2	18.0	10.0
Seas. adj. KR–CRB spot commodity price index raw industrials (1967=100)	1.3	–4.0	9.3	11.0	7.2
Seas. adj. KR–CRB spot commodity price index foodstuffs (1967=100)	1.5	1.9	–0.3	16.1	4.5
Seas. adj. KR–CRB spot commodity price index fats and oils (1967=100)	3.1	0.3	4.1	13.7	7.6
Seas. adj. KR–CRB spot commodity price index livestock and products (1967=100)	2.2	1.9	3.3	12.2	14.0
Seas. adj. prices received by farmers: all crops (1990–92=100)	1.3	3.5	–2.8	8.0	–2.1
Seas. adj. Spain: foreign trade prices: exports (NSA, 2000=100)	0.7	0.0	–2.4	0.9	1.9
Seas. adj. Spain: foreign trade prices: imports (NSA, 2000=100)	0.8	1.1	–2.7	0.3	4.3
Seas. adj. PPI: Finished consumer goods excluding foods (NSA, 1982=100)	1.0	2.4	0.4	3.7	2.8
Seas. adj. PPI: Finished consumer foods (NSA, 1982=100)	0.7	1.9	–0.4	2.1	2.5
Seas. adj. synthetic euro calculated using 1997 GDP weights (US$/Euro)	1.3	–0.6	3.1	3.9	–5.0
Seas. adj. Dominican Republic: workers remittances (NSA, Mil. US$)	1.4	–0.1	–1.0	–5.0	0.0
Seas. adj. Dominican Republic: tourist arrivals: non–residents (NSA, persons)	0.8	–2.5	2.7	4.2	–0.9
Seas. adj. Dominican Republic: tourist arrivals: Canada (NSA, persons)	4.1	0.3	0.2	0.0	1.4
Seas. adj. Dominican Republic: tourist arrivals: South America (NSA, persons)	0.9	–0.3	11.1	32.9	–7.6
Seas. adj. Dominican Republic: tourist arrivals: Europe (NSA, persons)	–0.1	–2.5	0.3	4.0	–0.8
Seas. adj. Mean temperatureF	...	...	...	...	...
Seas. adj. Max wind speedMPH	0.9	1.8	–1.8	–4.4	2.7
Seas. adj. Max gust speedMPH	–4.0	–2.0	–2.4	–4.2	5.5

TABLE A. 1 *(continuum)*

	2000-2007	*2008*	*2009*	*2009Q4*	*2010Q1*
Seas. adj. Fog = 1 Fog–Rain=2 Rain=3 Rain–Thunderstorm=4 Thunderstorm	3.5	–1.5	7.3	21.2	27.8
Seas. adj. Precipitation In	4.9	8.9	9.7	8.7	12.3
Median of all indicators	*1.4*	*0.3*	*0.6*	*4.5*	*2.8*

SOURCE: GTA, Haver, ONE, Country authorities, NOAA, BIS, DX Data.

NOTE: The table shows the data employed in estimating the Dynamic Factor Model for Cuba, including the median one–quarter seasonally adjusted change in the variable is shown for the period in the header.

TABLE A. 2. BAHAMAS: DATA DESCRIPTION AND SAMPLE PERIOD

	Series name	*Sample*
Balance of payments	Goods exports	89Q1–09Q2
	Goods imports	89Q1–09Q2
	Trade balance	89Q1–09Q2
	Services receipts	89Q1–09Q2
	Services payments	89Q1–09Q2
	Income receipts	89Q1–09Q2
	Income payment	89Q1–09Q2
	Current account	89Q1–09Q2
	Direct foreign investment	89Q1–09Q2
	Overall balance	89Q1–09Q2
Government	Total revenue and grants	89Q1–09Q4
	Tax revenue	89Q1–09Q4
	Nontax revenue	89Q1–09Q4
	Total expenditure	89Q1–09Q4
	Current expenditure	89Q1–09Q4
	Capital expenditure	89Q1–09Q4
Electricity generation	Generated	89Q1–08Q4
	Domestic	89Q1–08Q4
	Commercial	89Q1–08Q4
	Street	89Q1–08Q4
	Total	89Q1–08Q4
Construction	Permit issued value	94Q1–08Q4
	Starts value	94Q1–08Q4
	Completion values	94Q1–08Q4
Monetary statistics	Net foreign assets	90Q1–09Q4
	Credit govt	90Q1–09Q4
	Credit private	90Q1–09Q4
	Total credit	90Q1–09Q4
	Commercial deposit	90Q1–09Q4
	CB deposit	90Q1–09Q4
	Total M1	90Q1–09Q4
	Savings deposit	90Q1–09Q4

Monetary statistics	Fixed deposits	90Q1–09Q4
	Foreign deposits	90Q1–09Q4
	Total quasi money	90Q1–09Q4
	Notes and coins	90Q1–09Q4
	Weighted deposit rate	90Q1–09Q4
	Central bank rate	90Q1–09Q4
	Prime rate	90Q1–09Q4
	Total reserves	90Q1–09Q4
Commercial banks	Interest income	93Q1–09Q3
	Interest expense	93Q1–09Q3
	Interest margin	93Q1–09Q3
	Commission & forex income	93Q1–09Q3
	Gross earnings margin	93Q1–09Q3
	Staff costs	93Q1–09Q3
	Operating costs	93Q1–09Q3
	Provisions for bad debt	93Q1–09Q3
	Net income	93Q1–09Q3
	Effective interest rate spread	93Q1–09Q3
	Average monthly assets	93Q1–09Q3
Prices and exchange rate	Real effective ER	89Q1–09Q4
	REER based on CP	89Q1–09Q4
	Nominal CPI	89Q1–09Q4
	CPI, seasonally adjusted	89Q1–09Q4
Tourism activities	Expediture day Nassau	89Q1–09Q4
	Expediture day Grand B	89Q1–09Q4
	Expediture day Islands	89Q1–09Q4
	Expediture day all	89Q1–09Q4
	Expediture cruisse Nassau	89Q1–09Q4
	Expediture cruisse Grand B	89Q1–09Q4
	Expediture cruisse Islands	89Q1–09Q4
	Expediture cruisse all	89Q1–09Q4
	Expediture stop Nassau	89Q1–09Q4
	Expediture stop Grand B	89Q1–09Q4
	Expediture stop Islands	89Q1–09Q4
	Expediture stop all	89Q1–09Q4
	Expediture all Nassau	89Q1–09Q4
	Expediture all Grand B	89Q1–09Q4
	Expediture all Islands	89Q1–09Q4
	Total expenditure	89Q1–09Q4
	Stop over arrivals	89Q1–09Q4
	Cruise arrivals	89Q1–09Q4
US economy indicators	Stock price averages	89Q1–09Q4
	Standard & Poor's 500	89Q1–09Q4
	Wilshire 5000 price	89Q1–09Q4
	West Texas intermediate cushing	89Q1–09Q4
	Brent crude oil	89Q1–09Q4
	Federal funds rate	89Q1–09Q4
	1–Year treasury bill yield	89Q1–09Q4
	5–Year treasury note yield	89Q1–09Q4
	10–Year treasury note yield	89Q1–09Q4

	Treasure bond long–term composite	89Q1–09Q4
	Phila FRB bus outlook	89Q1–09Q4
	FRB Sr officers survey: large firms	89Q1–09Q4
	FRB Sr officers survey: small firms	89Q1–09Q4
	FRB loan survey: commercial real estate	89Q1–09Q4
	FRB Sr loan survey: res mortgages	89Q1–09Q4
	Industrial production index	89Q1–09Q4
	Industrial production: manufacturing	89Q1–09Q4
	All employees: total nonfarm	89Q1–09Q4
	All employees: total private industries	89Q1–09Q4
	All employees: construction	89Q1–09Q4
	All employees: manufacturing	89Q1–09Q4
	Average weekly hours: total private	89Q1–09Q4
	Average weekly hours: manufacturing	89Q1–09Q4
	Civilian employment	89Q1–09Q4
	Civilians employed: men 20 years	89Q1–09Q4
	Civilian unemployment rate	89Q1–09Q4
	Civilian unemployment: rate: men	89Q1–09Q4
	Unemployed for 15 weeks and over	89Q1–09Q4
	Not in the labor force	89Q1–09Q4
	Index of help–wanted advertising	89Q1–09Q4
	Initial claims for unemployment	89Q1–09Q4
	Insured unemployment	89Q1–09Q4
	Unemployment insurance	89Q1–09Q4
US economy indicators	Unemployment insurance: duration	89Q1–09Q4
	Unemployment covered employment	89Q1–09Q4
	Retail sales & food services	89Q1–09Q4
	Retail sales: total	89Q1–09Q4
	Retail sales: total excl motor vehicle	89Q1–09Q4
	Personal income	89Q1–09Q4
	Real disposable personal income	89Q1–09Q4
	Real personal consumption expenditures	89Q1–09Q4
	ISM Mfg: PMI composite index	89Q1–09Q4
	ISM Mfg: new orders index	89Q1–09Q4
	ISM Mfg: production index	89Q1–09Q4
	ISM Chicago: business barometer index	89Q1–09Q4
	ISM Chicago: production index	89Q1–09Q4
	Conference Board: consumer confidence	89Q1–09Q4
	Conference Board: consumer expectations	89Q1–09Q4
	University of Michigan: sentiment	89Q1–09Q4
	University of Michigan: expectations	89Q1–09Q4
	KR–CRB spot commodity price index	89Q1–09Q4
	Light sweet crude oil futures 1st expiring	89Q1–09Q4
	Light sweet crude oil futures 6–months	89Q1–09Q4
	Average hourly earnings	89Q1–09Q4
	ISM: Mfg: price index	89Q1–09Q4
	Imports CIF: Goods	89Q1–09Q4
	Nominal trade–weighted USD	89Q1–09Q4
	Nominal USD vs major currencies	89Q1–09Q4
	Real broad trade–weighted USD	89Q1–09Q4
	Real USD vs major currencies	89Q1–09Q4
	Real gross domestic product	89Q1–09Q4

SOURCE: Country Authorities, Haver, Authors' estimates.

NOTE: The table shows the data employed in estimating the Dynamic Factor Model for the Bahamas.

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Sharon Miller-Betty

Monetary policy *alternatives* in the face of a dysfunctional transmission mechanism

1. INTRODUCTION

The global financial crisis, which had its genesis in 2007, had a debilitating impact on the global economy. Central banks across the world, faced with a near collapse of their financial systems and a sharp decline in output, were forced to adopt unconventional monetary policies to ensure the proper functioning of markets. In some countries, interest rates were also brought down to unprecedented levels or near the zero bound but output and prices did not respond as anticipated. Consequently, discussions have emerged on the effectiveness of the policy rate as the only instrument as well as the cost and benefits of non-traditional tools of monetary policy. In general, the crisis has forced central banks globally to question whether or not the consensus on monetary policy that obtained

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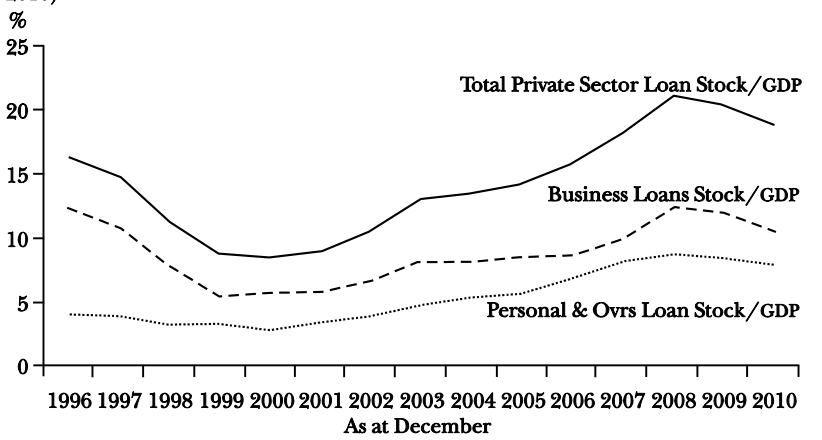
prior to the crisis holds and has led individual central banks to examine alternatives that could be used to supplement the policy rate.

Following the crisis, the Bank of Jamaica (BOJ) also adopted a suite of policy measures, most of which were unconventional. However, in contrast to most central banks which injected liquidity in the domestic system, the BOJ's policy responses had a net impact of withdrawing liquidity from the system. The measures undertaken by the BOJ were primarily aimed at restoring stability to the foreign exchange market and ensuring the smooth functioning of the financial markets. After increasing rates for a short period, interest rates were brought down to rates not seen in 30 years, partly due to the implementation of a debt exchange programme, the Jamaica Debt Exchange (JDX), in 2010 and the favorable outlook for inflation.[1]

FIGURE 1. COMMERCIAL BANK PRIVATE SECTOR CREDIT/GDP (Dec. 1996-Dec. 2010)



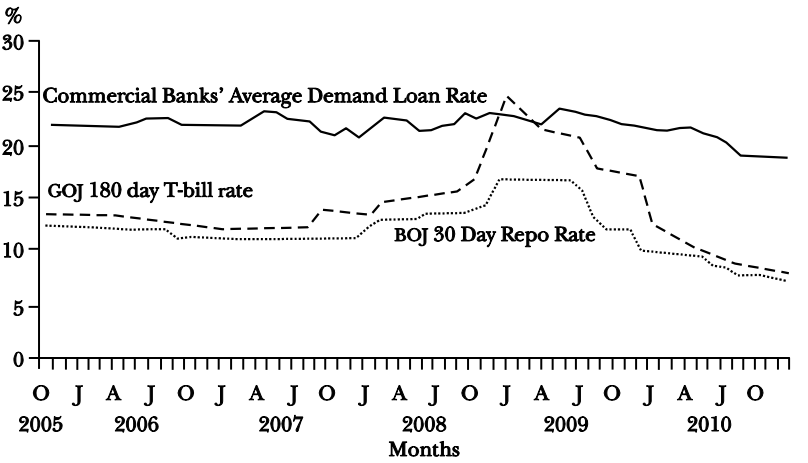
The major institutions supervised by the BOJ, the commercial banks, were relatively unscathed by the crisis. This was mainly due to measures put in place subsequent to Jamaica's financial crisis of the mid-1990s which reduced their vulnerability to risks. In fact, some of the prudential requirements

[1] The JDX was implemented in February 2010 and entailed a programme where holders of Jamaica government domestic denominated securities voluntarily agreed to exchange them for securities with lower interest rates and longer tenors.

implemented in the mid-1990s were much more stringent than international norms and have not been loosened since.

Notwithstanding the significant reduction in the policy rate, commercial banks have been reluctant in lowering interest rates, leading to an increase in spreads from pre-crisis levels. At end-December 2010, for example, commercial bank lending rates were in excess of 11 percentage points above the BOJ policy rate of 7.5% in comparison to a spread of 9.8 percentage points at end-2006 (see figure 2). The maintenance of high and sticky interest rates in the banks, has led the BOJ to question the effectiveness of its policy rate.

FIGURE 2. BOJ POLICY RATE, 180-DAY T-BILLS AND DEMAND LOAN RATES, 2005-2010



In this regard, the aim of the paper is to examine the conduct of monetary policy in Jamaica juxtaposed against the current debates in the literature. Given the appearance of a dysfunctional transmission mechanism, the paper examines *alternatives* to supplement the traditional interest rate tool, with a view to enhancing the transmission of lower interest rates to the private sector.

The paper finds that there is some merit in using macro-prudential policy tools and quantitative easing, areas that have gained considerable attention since the global recession of the late 2000s. Included in the macro-prudential policy tool kit are some fiscal policy measures that could be implemented, without jeopardizing the fiscal targets outlined in

the International Monetary Fund Stand-By Arrangement (IMF-SBA).[2]

Risks likely to materialize from these initiatives include reputational risks from a worsening of the central bank's profitability position and an expansion in its balance sheet. The latter could be misread to mean that the BOJ has lost its commitment to low and stable inflation. These risks, however, can be appropriately managed through effective communication strategies, aimed at anchoring long-term inflation.

The remainder of the paper will begin with a brief review of the literature on monetary policy, focusing on the discussions that have evolved in the post global recession period of the late 2000s. This will be followed by a discourse on the conduct of monetary policy in Jamaica which will precede the conclusions and policy recommendations.

2. LITERATURE REVIEW

Most of the major central banks within the past decade, have generally conducted monetary policy by targeting or setting nominal short-term interest rates. These short-term rates, for the most part, have been the overnight rate. Other central banks, while having an overnight rate, concentrate on a rate of a longer tenor as its main policy instrument. The European Central Bank and the Bank of Jamaica are examples. The general consensus is that changes in the policy rates influence other interest rates in the system such as money market rates and subsequently loan rates to the private sector. These rates in turn influence aggregate demand which is eventually transmitted to prices.

Prior to the global financial crises of 2007-08, the general view on monetary policy was that the central bank would always be able to influence aggregate demand and prices by adjusting interest rates.[3] The consensus was that this could be

[2] Jamaica signed a 27-month IMF-SBA in February 2010.

[3] Consequently, traditional tools such as reserve requirements were deemphasized by a number of central banks in both developed and developing countrie. In more extreme cases, a number of countries including Canada, United Kingdom, New Zealand, Japan and Australia had fully eliminated reserve requirements as a tool to reduce inflation. See Buzeneca

achieved through inflation targeting, which provided a sound framework to systematically analyze and discuss monetary policy.[4] This framework is characterized by an explicit commitment that low and stable inflation should be monetary policy's primary goal. In this regard, short-term interest rates (in most cases an overnight rate) were manipulated in order to meet the inflation target (level or range). Under the regime, inflation was targeted at a short and fixed horizon.[5]

The inflation targeting framework does not entail an intermediate target such as money, but uses the inflation forecast itself as the intermediate target. Economic models were therefore developed which paid little attention to the development of the money and credit aggregates but relied on a form of the Taylor rule. In fact, the impact of money and credit was totally disregarded in most models as the policy framework focused on the deviation of inflation from the target. A lot of weight was placed on the output gap in forecasting inflation. In a context where it was believed that central banks could always avoid deflation by lowering interest rates, there was not much concern about the policy rate being ineffective at relatively low interest rates.

There was also consensus that asset prices should affect monetary policy only to the extent that they helped to predict prices. In this regard, it was felt that there was no need to respond to asset price bubbles and monetary policy should only play a role after the burst of the bubbles (Blinder 2005). Issing (2008) suggests that the Jackson Hole Consensus was exactly this view.

It was also the consensus that fiscal and monetary policies should be separated. In this regard, the framework also stressed the importance of central bank independence and transparent communication in order to anchor long-term inflation.

Another important consensus that obtained prior to the

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and Maino (2007) for a survey of central banks.

[4] See Ortiz (2008) for a discussion on how this framework has influenced the development of monetary policy in emerging markets. See also Bernanke (2003) as well as Mishkin and Schmidt-Hebbel (2007) for useful discussions on inflation targeting.

[5] See Stark (2010) for an explanation on the consensus.

crisis was that the supervision of financial institutions should be undertaken from a micro-prudential perspective as it was the health of individual financial institutions that mattered. There was also a view that the supervisory aspects of a central bank should be separated from its macroeconomic aspect and it would be ideal if these functions were allocated to different policy authorities.

The global financial crises of the late 2000s provided a robust test for this framework. The devastating impact on output, prices and the stability of the system highlighted that there were shortcomings in the framework and hence some of the tenets of the framework were in need of revision. These include the systematic disregard for money, credit and financial assets in the determination of risks to price stability and the heavy weight placed on the output gap under a Taylor rule framework, in the determination of interest rates. In addition, the definition of price stability objectives as point targets over a short horizon and the use of interest rates as *the instrument* to achieve these objectives have been questioned, warranting central banks to look more keenly at how monetary policy is conducted. While the paper does not have room to discuss all aspects of the current debates, those particularly relevant to the paper are highlighted.

As it relates to the instruments used by central banks, consensus seems to be emerging that the use of interest rates is not the panacea to achieving the central bank objectives. Rather there appears to be a strong role for the use of *non-standard* policy alternatives. Some of the non-standard measures being debated had reemerged for discussion prior to the onset of the crises but did not gain traction as the occurrence of the zero bound was considered to be highly unlikely (for example, see Bernanke, Reinhart and Sack 2004). These non-standard measures were grouped into three classes: *i)* using communications policies to shape public expectations about the future course of interest rates; *ii)* increasing the size of the central bank's balance sheet; and *iii)* changing the composition of the central bank's balance sheet.

These non-standard measures have been a feature of a number of central banks since the onset of the crisis in 2007. Some of these measures were also used in the past. For example, the expansion of the central bank's balance sheet

(quantitative easing) was used by the Bank of Japan in the 1990s. One of the lessons learnt from that experience is that policy makers did not loosen policy enough to account for the downside risk of falling prices. This was in a context where it was felt that if the economy rebounded on its own accord, then a further loosening could have had adverse consequences (Ahearne et al., 2001). Consequently, if too little stimulus is provided, the future ability of monetary policy to pull the economy out of its slump can be substantially undermined. In this regard, they opined that both monetary and fiscal policy should go beyond the levels conventionally implied by baseline forecast of future inflation and economic activity.[6]

Another area of interest in the current debate, relates to the supervision of financial institutions. A number of conferences, speeches and papers have highlighted the issue and a consensus seems to be forming that the supervision of financial institutions should go beyond focusing on a micro approach, which takes account of the health of individual financial institutions, to focus on an approach such that changes in capital requirement and related supervisory tools are coordinated with monetary policy. In this regard, the supervisory role should take on a more macroeconomic approach through the use of macro-prudential policies.[7] Consequently, it is now the view that the central bank should play a key role in the supervision of financial institutions.

Macro-prudential policies seem to focus on financial stability or containing systemic risks, rather than risks to individual financial institutions (Moreno, 2011). In addition, macro-prudential policies also focus on the interaction between macroeconomic conditions and the financial system as well as the possibility of dampening procyclicality in the financial system.

The Governor of the Bank of Japan, Shirakawa (2009), has argued that the current regulatory and supervisory framework

[6] Ahearne noted that fiscal policy focused on public works, roads and bridges in home districts of legislators, rather than investments in more visibly productive projects, which would have raised productivity and increased confidence in the future growth of the economy.

[7] See Galati et al. (2011), Moreno (2011), Banca D'Italia Workshop and Conference (2009), BIS Conference.

does not have the effective mechanisms and instruments necessary to control the inherent procyclicality of the financial system. He further argued that measures against procyclicality need to address the build-up of financial imbalances in upturns and their subsequent unwinding in downturns from a system-wide perspective. This will ensure financial system stability through serving as a shock absorber, instead of a transmitter of risk to the broader economy, thus functioning as an automatic stabilizer of boom-and-bust cycles.

One of the areas in which macro-prudential policies can be used to address cyclicality is private sector credit. In explaining the cyclicality of credit, Hilbers et al. (2005), based on the accelerator principle, noted that credit expands more rapidly than GDP at the beginning of a cyclical upturn due to firms' investment and working capital needs. On the converse, if asset prices and collateral values are depressed or fall below expectation, the indebtedness of the borrowers will increase, decreasing both their capacity to service their loans and their access to new loans. He noted that these factors play a great role in extending a boom and increasing the severity and length of a downturn.

Jimenez (2006) noted that bank supervisors are convinced that bank lending mistakes are more prevalent during upturns than in downturns. He concluded that during upturns, both lenders and borrowers are overconfident about investment projects and their ability to repay and recoup their loans as well as the corresponding fees and interest charges. Increasing competition and strong balance sheets during upturns lead banks to take on projects, even with negative NPVs.[8] The opposite happens during a recession.

Further work by Jimenez et al. (2008) noted that following a monetary expansion, in addition to a higher appetite for liquidity risk, banks also take on more credit risks. He noted that this supported the work of Stiglitz and Greenwald (2003), Diamond and Rajan (2006), Dell'Aricca and Marquez (2006) and Borio and Zhu (2007). In his explanation, Jimenez found that lower interest rates reduce the credit risk of

[8] The literature points to herd behavior in helping to explain why projects with negative NPVs are taken on during booms. Credit mistakes are judged more leniently if they are common to the whole industry.

outstanding loans. This is possibly the case as refinancing costs are lower and borrowers' net worth is higher, therefore credit risk is lower.[9] Consequently, there is a completely different impact on lower interest rates on the credit risk of new vis-à-vis outstanding loans. Therefore in the short-run, lower interest rates reduce total credit risk of banks since the volume of outstanding loans is larger than the volume of new loans. Reducing interest rates lowers the credit risk of all outstanding loans, making banks more willing to again accept credit risk, thereby reducing the tensions in the credit markets.

Macro-prudential tools that have been applied to address the credit cycle, the area of interest to this paper, include:

i) Loan to value ceilings (used in Korea and Canada, recently).

ii) Debt to income or debt service to income rules, that would tend to ensure that credit flows to those with a greater ability to repay (used in China, Korea, Thailand and Malaysia in the 1990s).

iii) Direct measures to limit/expand credit.

iv) Reserve requirements.

v) Taxes on lending (lowered in Turkey in 2009 to boost consumption).

vi) Targeting certain sectors, e.g. use of rebates in reserve requirements to encourage purchases of bank assets and of foreign currency.

vii) Risk weights on banks' exposure to certain types of loans, e.g. consumer, real estate.

Debates have even surfaced as to whether or not central banks should increase direct lending to the real economy. It is argued that this is not a theoretical subject in a context where the Federal Reserve, for example, established a liquidity facility directed to non-banks including issuers of commercial paper (González-Páramo 2009).

[9] Bernanke, Gertler and Gilchrist (1996) also pointed to the possibility that lower interest rates, by improving borrowers net worth, may result in banks lending to borrowers that were deemed risky in the past.

3. THE CONDUCT OF MONETARY POLICY IN JAMAICA

Jamaica is a small open economy in which prices are subject to frequent exogenous shocks such as hurricanes and other adverse weather conditions. The country has experienced high annual point-to-point inflation which peaked at 107.9% in April 1992. This high level of inflation was mainly transmitted through the exchange rate subsequent to the liberalization of the foreign exchange market. Since then, annual inflation has declined to more moderate levels through the use of tight monetary policy and was 7.2% as at February 2011, following two consecutive months of deflation.

By law, the main objective of monetary policy in Jamaica is to influence the volume and conditions of the supply of credit so as to promote the fullest expansion in production, trade and employment, consistent with the maintenance of monetary stability in Jamaica.[10] The Bank has over the years interpreted this to mean that price stability should be its major objective as low and stable prices could provide the foundation necessary for growth and employment. The current aim is to bring inflation down to that of the country's main trading partners.

In order to achieve its inflation objective, the Bank of Jamaica, since 1996, has used base money targeting as its monetary policy framework. A lot of attention is also paid to the exchange rate given the openness of the economy and the impact of the exchange rate on prices. The policy regime is framed within a medium-term financial programme, which takes account of the monetary, external, fiscal and real sectors. In recent years, increased attention has also been paid to the financial stability of the overall system and its impact on the monetary policy objective.

The framework entails the daily interaction of monetary analysis with market intelligence and operations. Close attention is paid to the balance sheet of the Central Bank through daily monitoring of the developments in the accounts. Developments and prospects in the money and foreign exchange market as well as developments in the Government cash flow, feed into an assessment of the impulses to base money and

[10] See ⟨http://www.boj.org.jm/supervised_legislation.php⟩.

inflation. Decisions are taken on a daily basis as to the level of open market operations required and whether or not the Bank needs to intervene in the foreign exchange market.

Open market operations (OMOs) are the major tools used and mainly entail the use of the Bank's own certificates of deposit (CDs). Effective January 2010, the 30-day CD became the only tool as all other tenors were withdrawn to allow a yield curve for Government instruments to develop following the implementation of the JDX. Prior to that, policy was conducted with OMO securities which had maturities of up to one year. In addition to its CDs, the Bank occasionally sells securities from its holdings of Government instruments.

In addition to the use of OMOs, deposit taking institutions (DTIs) are required to maintain a specified level of cash reserves with the Central Bank. However, the requirement did not vary much in the years preceding the global financial crisis. The requirement is imposed as a specified rate applied to the prescribed liabilities of DTIs. Although the rate is standard across all DTIs, building societies are given an exception in that a lower rate is applied as an incentive for those that meet a qualifying ratio of mortgage loans to savings funds. For all DTIs, the cash reserves form a part of an overall liquid assets requirement.

The Bank operates on the premise that changes in interest rates affect the level of OMOs and the monetary base.[11] This in turn has an impact on the money supply and the exchange rate, and interest rates in financial markets. These rates affect spending pattern and production through the cost of credit which then feeds through to the price level. The extent and timing of the response depends on the expectations of borrowers and lenders.

Care is taken to minimize large swings in the exchange rate given the estimated impact of the pass-through to prices. Research undertaken by the BOJ has shown that the main transmission channel of monetary policy in the Jamaican economy is the exchange rate (Allen et al., 2002). More recent research (Robinson and Allen, 2004) found that 78.0% of the impact

[11] In addition to the rate on the 30-day CD, the Bank also has an overnight deposit facility. The rate on this facility however does not vary much and has no relationship with its main policy rate.

of a 1.0% increase in the Bank's interest rate on inflation would be transmitted via the exchange rate channel. Most of the impact is felt within six months with full pass through felt within 18 – 24 months.

Although base money targeting remains the official framework of the Bank, the institution over the years has adopted several elements of an inflation targeting framework. At the reading of the fiscal budget, an inflation target is announced by the Minister of Finance. This target is arrived at in consultation with the Bank. The target is derived from the Bank's macroeconomic model which incorporates developments in the international and domestic economy that are likely to have an impact on inflation. After applying some judgment to the model, it sets out a path for the Bank's policy rate consistent with delivering the inflation target. Policy discussions, have in recent years, put a lot of weight on any potential deviation from the announced inflation target, while paying close attention to the developments in the monetary aggregates.

Over the years, a comprehensive assessment of developments in different sectors has been done at a weekly Economic Policy Committee Meeting (EPC). Prior to late-2010, assessments were done in an ad hoc manner based on available data and did not view all the sectors simultaneously. However, since late-2010, every month a specific meeting has been dedicated to discussing monetary policy action. At this meeting, developments in all the sectors are reviewed. A report is prepared with a recommendation which is then discussed at a high level policy committee.[12] The final decision is then taken at this meeting.

Further, in recent years, the Bank has attempted to increase the transparency of its monetary policy actions and shape public expectation of future policy actions by increasing its communication to the market. A press conference is held at least once per quarter in which the Bank releases its Quarterly Monetary Policy Report (QMPR) outlining the main

[12] The Bank does not have an official Monetary Policy Committee comprising of external members, hence all decisions are based on internal discussions. The high level committee meeting comprises five members, chaired by the Governor while the EPM Meeting is a much larger body, chaired by the Deputy Governor of the Research and Economic Programming Division.

factors that influenced inflation during the quarter. The QMPR also presents the Bank's perspective on future economic trends from which the market is able to discern monetary policy actions over the short-term. The inflation forecast for the quarter is also given in the report. In addition, the Governor participates in numerous events in which speeches are made on the Bank's commitment to low inflation.

With respect to the current monetary policy debates, the BOJ has never subscribed (publicly) to certain aspects of the consensus while there were other aspects that were endorsed and practiced. In particular, the very foundation on which the financial programme is based, dictated that there could have been no systematic disregard of money and credit indicators in the conduct of monetary policy. Developments in these aggregates in nominal terms were closely watched and used to make inferences about the state of the economy and likely pressures on inflation.[13] However, in the determination of the monetary policy action in recent years, more weight has been placed on the output gap and the projection of inflation itself relative to the target. Inflation is targeted at a short horizon, usually a year, and quarterly projections of inflation are also released to the public. In recent years, the Bank also adopted the use of a Taylor rule type framework to estimate short-term Treasury bill rates. This is used as a guide in setting the Bank's policy rate.

A significant amount of weight is also placed on the exchange rate movements given research which showed the large impact on inflation. In this regard, the foreign reserves have been used to smooth exchange rate changes, with care that the reserves do not fall beyond a certain level.

The Bank has never articulated a view on the treatment of asset price bubbles. However, the Bank monitors development in the stock market and reports on these developments in its QMPR. Little attention has been paid to other asset prices, partly due to data constraint. For example, housing prices from a wide cross section of the economy are garnered from anecdotal information.[14] These are sometimes discussed but

[13] Some of the findings were often disregarded by the proponents of an inflation targeting regime.

[14] The Bank is in the process of developing a housing price index.

not with a view of designing policy specifically to influence them.

3.1. Response to the crisis

The Bank of Jamaica responded to the various challenges from the global financial crisis with a suite of monetary policy actions, some of which were unorthodox. These temporary policy measures were all aimed at augmenting the supply of foreign currency and facilitating the flow of credit. The measures implemented included:

i) The establishment of a Special Loan Facility in foreign currency on October 15, 2008 for security dealers and other institutions with foreign currency needs to repay margin calls on GOJ global bonds.

ii) The establishment of a Deposit/Loan Intermediation Facility in foreign currency on November 12, 2008, to facilitate the flow of credit in the system. The facility entailed taking foreign currency deposits from institutions and on-lending these to other institutions. This was later extended to include deposits and loans in local currency.

iii) Increasing interest rates across the spectrum of open market instruments on October 17 and December 01, 2008.

iv) The offer of a special 15-day CD to primary dealers and commercial banks on November 18-19, 2008.

v) An increase in the statutory cash reserves requirement from 9% to 14%.

vi) Intervention sales in the foreign exchange market.

vii) More frequent and transparent communication to the market.

One of the noticeable features of the response (in contrast to various central banks) was the absence of a liquidity stimulus. The impact of the intermediation facility in (ii) on the system was neutral as liquidity was simply taken from supervised financial institution and on-lent to institutions not supervised by the BOJ as there was uncertainty about the riskiness

of these institutions. Hence, the net impact of the policy actions was to withdraw liquidity from the system and a general tightening of monetary policy. These policy actions assisted in restricting the pace of depreciation in the exchange rate to 12.24% for 2008. Inflation for that year was 16.8% and without the implementation of these measures, inflation would have been much worse.

Although the Bank did not articulate an exit strategy at the time of implementation of these measures, the facilities were easily wound up as the institutions emerged relatively unscathed from the crisis. Monetary policy has been subsequently loosened with interest rates falling to near record lows. The CRR, however, has not been returned to pre-crisis levels.

4. LESSONS LEARNT FROM THE CRISIS

In order to proceed with effective monetary policy following the crisis, it is essential to examine the lessons learnt from the crisis. My views are the following:

i) The role of frequent and effective communication is essential in soliciting cooperation from the market and in getting market players to understand the Central Bank's actions. It is believed that the depreciation in the Jamaica dollar and consequently inflation, would have been much worse, had it not been for frequent discussions with authorized dealers. In these meetings, the impact of any adverse behavior on their part on the overall stability of the system and the health of their own institution were explained. Consequently, a decision was taken by authorized dealers to enter into a foreign exchange rate pact, whereby bids in the foreign exchange market fell within a certain range, during a particular period.

ii) Consensus is important, especially in matters that affect major players. The success of the JDX is a case in point as market players understood the benefit to be derived from participating in such a programme.[15] The foreign exchange

[15] The debt became more unsustainable due to the impact of the crisis on the fiscal accounts.

market pact in (i) was also developed given the consensus that it was in the interest of all to minimize impulses to inflation.

iii) Fiscal and monetary policy coordination is essential. For example, the withdrawal of BOJ's longer term CDs from the market allowed for the development of a yield curve for GOJ instruments in line with JDX yields. The provision of liquidity to the Government during the period also allowed for the smooth functioning of financial markets and was not viewed as a deviation from the commitment of low inflation as this was transparent and properly explained to the market.

iv) The stress tests conducted by the BOJ were validated as, for the most part, the DTIs were able to withstand the shocks from the global economy. There was no request from any of the DTIs for liquidity support from the central bank during the period.[16] All DTIs remained well capitalized and, for the most part, capital and profitability ratios remained strong. Further stress tests continue to show that DTIs are able to withstand significant shocks.

v) In crisis periods, the central bank will take on the lender of last resort role, even to institutions not under its supervision. For example, the margin loans facility was extended to all financial institutions, including those not supervised by the BOJ. This move was necessary to ensure the stability of the foreign exchange market, given the potential impact of the exchange rate on inflation. Such policies, however, should not be a standard feature of the central bank due to moral hazard problems and hence should only be used in the event of emergencies.

vi) Given that the central bank will take on the lender of last resort role to all financial institutions, in extenuating circumstances, then balance sheet information about the financial conditions of all financial institutions in the system should be available to the central bank on a frequent basis.

vii) While not losing sight of the inflation objective,

[16] Excluding the margin loans, which were concentrated.

unemployment and GDP growth need to be taken into consideration in setting monetary policy.

viii) Traditional instruments, such as reserve requirements, that have been deemphasized, should not be abolished. Rather, they should take on a more cyclical role in supplementing the interest rate instrument, that is increase them during booms and reduce them during busts.

ix) Jamaica has undergone a paradigm shift. Excess liquidity will not necessarily fuel demand for foreign currency, even at relatively low interest rates. In addition, levels of interest rates that could be once considered loose may now be relatively tight given a similar set of challenges.

Jamaica is now under a 27-month IMF-SBA, signed in February 2010. All efforts have been made by the authorities to achieve the targets set out in the programme. Concerns however abound regarding the state of the real economy, especially in a context where the monetary policy transmission appears to be dysfunctional. Abstracting for the impact of increases in international grain and oil prices, impulses to inflation remain weak with reductions in the price of some commodities.

Notwithstanding the substantial reduction in the policy rates, spreads in commercial banks remain high as these institutions continue to enjoy relatively large profit ratios. The ROAs and ROEs, in most instances have also outperformed other banks globally (see tables 1 and 2).[17] These high interest spreads have generated net interest margins averaging 8.5% over a five year period ending 2010. The demand for loans at rates underlying these spreads has fallen significantly since the crisis (see figure 3). Spreads over the policy rates have also widened relative to the pre-crisis period, possibly reflecting the increased riskiness of borrowers and, for the most part, continue to reflect the impact of high operating costs (see figure 2). This increased risk is reflected in substantial deterioration of balance sheets of households and businesses and increases in non-performing loans (see figure 4). In this regard, outside of a few loans at much lower rates to 'good' borrowers,

[17] There was however some disparity among banks, as the performance of some banks was below international norms.

TABLE 1. AVERAGE RETURN ON ASSETS FOR COMMERCIAL BANKS IN SELECTED COUNTRIES, 2005-2010 (in percentage)

	2005	*2006*	*2007*	*2008*	*2009*	*2010*
Jamaica[a]	3.6	3.6	3.9	4.3	3.6	3.1
Barbados[b]	na	2.0	1.2	1.4	1.6	1.2
Guyana[b]	na	0.5	0.5	0.5	0.7	0.1
Trinidad & Tobago[b]	na	3.4	3.4	3.5	2.7	2.5
Australia	1.0	1.0	1.0	0.7	0.6	0.6
Canada	0.7	0.9	0.8	0.4	0.6	0.2
Japan	0.5	0.4	0.3	–0.2	0.2	–
United States	1.3	1.3	0.8	0	0.1	0.5
Brazil	2.9	2.7	2.9	1.5	1.9	2.2
Dominican Republic	1.9	2.5	2.6	2.7	2.3	2.8
Mexico	3.2	3.5	2.7	1.5	1.3	1.3

SOURCE: Global Financial Stability, October 2010.
[a] BOJ. [b] CCMF.

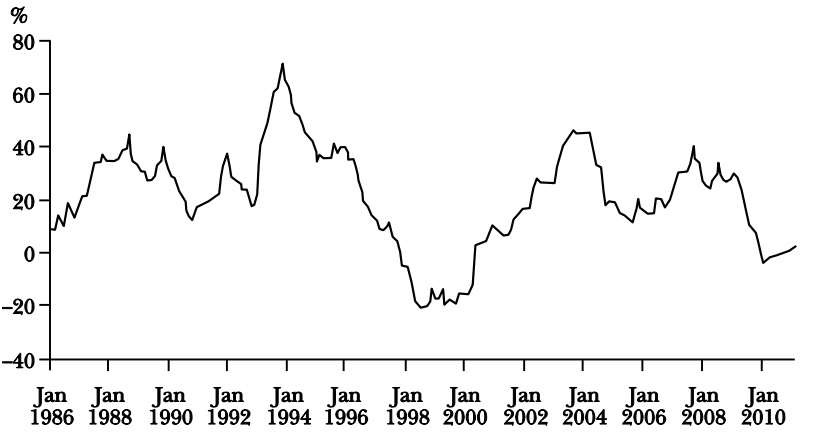
TABLE 2. COMPARATIVE ANALYSIS OF RETURN ON EQUITY FOR SPECIFIC BANKS COUNTRY, 2005-2009

Return on common equity	*2005*	*2006*	*2007*	*2008*	*2009*
Canadian banks					
Royal Bank of Canada	18.32	23.21	24.86	17.64	12.04
Bank of Montreal	18.64	19.00	14.62	12.59	9.87
Canadian Imperial Bank of Commerce	**–1.67**	27.49	29.93	**–19.49**	9.07
Toronto Dominican Bank	15.62	26.12	19.79	14.86	9.07
Bank of Nova Scotia	21.11	21.89	23.41	16.87	16.87
UK banks					
HSBC	16.93	15.64	16.1	5.00	5.08
Lloyds Banking Group	23.47	26.26	28.24	7.17	10.73
Royal Bank of Scotland Group	15.24	15.89	15.66	–43.44	–5.28
Standard Chartered	18.6	15.68	14.92	14.57	13.25
Barclays	20.71	24.56	20.5	14.63	22.39
Australia					
National Australia Bank	17.07	18.45	18.8	16.97	7.75
Commonwealth Bank of Australia	16.05	19.16	19.97	19.34	16.71
Westpac Banking Corp	20.77	22.14	22.93	23.06	13.21
Australia & New Zealand Banking Group	17.88	19.98	20.64	14.00	10.19
United States					
Bank of America Corp	16.35	18.07	10.77	**1.81**	**–1.32**
Citigroup Inc	22.33	18.66	3.08	**–31.9**	**–4.22**
Wells Fargo & Co	19.69	19.77	17.39	4.12	9.34
Jamaica					
BNS	27.63	28.61	35.94	31.14	26.90
NCB	20.82	23.43	25.44	36.58	30.03
RBTT	11.37	11.94	8.15	8.80	7.54
FCIB	19.91	14.29	13.92	13.61	12.32
CBNA	15.14	12.90	16.84	22.89	27.35
FGB	19.35	16.05	16.47	–28.69	–0.67
PCB	na	na	na	6.93	8.73

SOURCE: Bloomberg Global Financial Database, published annual financial statements of Commercial Banks in Jamaica.

there is reduced willingness of banks to take on additional risks while businesses and households have reduced their desire to take on more debt at these high interest rates.[18] These conditions (known as a balance sheet recession) are all likely to impair monetary policy.

CHART 3. PRIVATE SECTOR CREDIT, 1986-2011



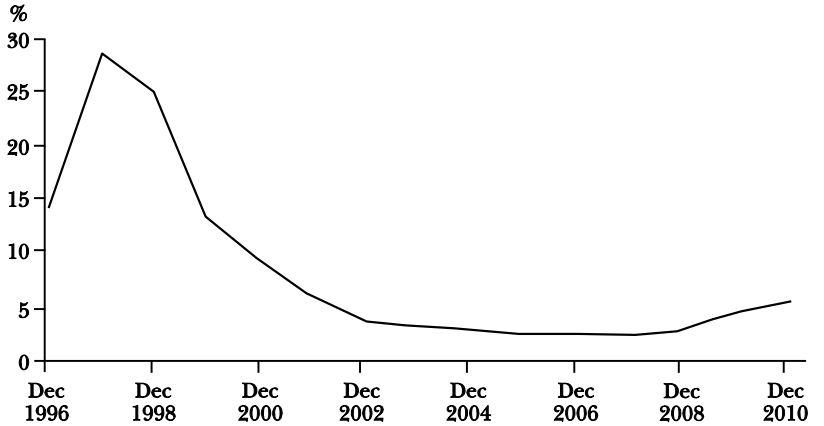
5. RECOMMENDATIONS/POLICY RESPONSE

The paper is not in support of some of the direct measures proposed in the literature or elsewhere to supplement the central bank rates. For example, consequent on the apparent failure of the pass-through of the policy rate to lending rates and the attendant weak demand for bank credit at these rates, some sectors of the society have argued that the BOJ should exercise its powers under section 33 (1) (a) of the BOJ Act. This section of the Act allows the BOJ to determine the maximum lending rates at which the banks are allowed to lend. The BOJ is, however, of the view that the use of these powers should be reserved for emergencies and catastrophic situations given the long-run reputational effects of government intervening in setting prices in a market economy.

In my view, policy responses that could be used to augment

[18] This situation contrast significantly with former years when businesses and households were willing to take on debt at even higher rates. For the five year period preceding the crisis, private sector credit growth averaged 27% while loan rates averaged over 24%.

CHART 4. RATIO OF NPLs, 1996-2010 (3 months and over)



the traditional interest rate tool include a mix of monetary, administrative and macro-prudential measures. There is also some room for fiscal policy but this is limited in a context where fiscal policy is constrained in Jamaica. In addition, there is much room for improving the Bank's communication in order to anchor long-term inflation.

Commenting on these in reverse order, the Bank of Jamaica over the years has greatly increased its credibility for reducing inflation. This is partly due to the improvement in the transparency of monetary policy. Inflation expectations are, however, not well anchored as the public changes its expectations of inflation when there are temporary deviations from the quarterly forecasts. For example, the market will increase its expectations for inflation following an agricultural or oil shock to prices and hence cast doubt on the projection from the Bank. The anchoring of inflation expectations is crucial as it makes the work of the central bank easier. If the public is of the view, that the Bank is committed to the target, this will more likely moderate price pressures from wages and other sources relative to a situation where the central bank is not seen as being committed. Such a view would contribute to a reduction of uncertainty and facilitate better planning in the economy.

In keeping with the literature, the Bank should also discontinue the short-term inflation forecast, especially the quarterly forecasts which are usually given to the public. Less emphasis should also be placed on the one-year forecast while

concentrating on the medium-term forecast. An appropriate communication strategy would need to be designed to explain the reason for such a change in order to avoid the perception that the central bank is being less transparent. This perception would likely be formed especially at a point when international commodity prices are rising. Temporary spikes that are expected can be highlighted without giving a short-term forecast. This would assist in focusing the public's attention away from the quarter and even the year to a longer term outlook for inflation. Responding too much to short-term deviations could overcorrect the policy required to achieve the long-term goal. Efforts should also be made to make the central bank's policy framework more explicit, with the objective of having a convergence of views towards that of the central bank.

5. 1. Fiscal measures

The use of expansionary fiscal policy in Jamaica is limited given high levels of debt as well as the targets outlined under the IMF-SBA Programme.[19] However, Government could substantially reduce the stamp duties associated with the transferring of loans and mortgages from one financial institution to another. The removal of these costs would make it more feasible for individuals to refinance loans at a lower rate thus reducing the overall riskiness of the loan portfolio. The argument is that with lower rates individuals would be in a better position to service existing loans. It is estimated that the income foregone by the Government would be minimal as loans are infrequently transferred due to the cost of doing so. The removal of such costs would make it cheaper to refinance loans and stimulate competition within the sector.

5. 2. Macro-prudential policy tools

Based on the literature, macro-prudential policy tools are considered to work effectively by making use of their nature as automatic stabilizers of boom-and-bust cycles. The reserve

[19] At end-December 2010, Jamaica's debt/GDP ratio was estimated at 123.9%.

requirement is one such tool mentioned in the literature. In recent years, the BOJ has only used the reserve requirement under extenuating circumstances. For example, early in the crisis, the cash reserve requirement was increased by five percentage points to address instability in the foreign exchange market. The reserve requirement has since been reduced but not to pre-crisis levels. In a context where the reserve requirements can be viewed as a tax on intermediation and contribute to the loan spread, then lower reserve requirements should translate to some reduction in loan rates, however marginal. The current situation requires a cash reserve level that is looser than the pre-2007 crisis given the relatively weak economy. Excluding the impact of international commodity prices on domestic inflation, prices in general appear to be depressed due to weak aggregate demand. In a context where balance sheets are weak and there is the possibility of further job reductions, inflation must be closely watched as deflation is possible, even in a country like Jamaica, which is susceptible to shocks.

The concept of a differentiated cash reserve requirement could also be explored. This is already practiced in Jamaica for the building societies where institutions with a qualifying ratio of 40% and over for mortgage loans to assets are required to hold 1% CRR relative to a requirement of 12% otherwise. A similar arrangement could be made for the commercial banks.[20] These measures could be reversed when the economy recovers and concerns for money growth inflation emerge. It is also suggested that, although banks are holding large excess reserves, the liquid asset requirement is reduced as this provides an incentive to acquire short-term instruments relative to granting loans.

Most of the other macro-prudential tools aimed at addressing private sector credit are not recommended given the culture in Jamaica. For example, there are no requirements as it relates to a loan to value ratio in Jamaica. The imposition of such a ratio at this time would not be viewed favorably by the market. A similar view obtains for the imposition of debt service to income ratios or some of the direct measures to influence credit.

[20] Banks currently hold 38% of its assets in private sector loans.

The variation in capital requirement is an area that is also highlighted as an alternative measure to address procyclicality. The capital requirement in Jamaica has, over a number of years, been two percentage points above the international benchmark and banks have also held capital above the requirement. While the paper is not advocating a reduction in the ratio, questions are being raised as to whether or not a one percentage point reduction in the requirement, for example, would encourage banks to take on more credit risks through lower interest rates.

5. 3. Monetary measures

Another non-standard measure of monetary policy that could possibly be implemented in Jamaica is the purchase of GOJ debt on the secondary market. Banks have claimed that they decide on a spread over the GOJ 5-year instrument in order to determine loan rates. In this regard, the BOJ could target the purchase of GOJ bonds in this range with the objective of stimulating demand for the bonds and hence lower yields, particularly on this tenor. The success of this, however, requires coordination with the fiscal authorities. The BOJ would need to signal to the market its intention to purchase the bonds on the secondary market with an exit strategy in mind.[21] Such a strategy could also reduce the general market demand for short-term bonds thus helping the Government to elongate its debt maturities and prevent bunching of maturities in the short-term. The timing of the purchases has to coincide with a period in which the Government is not strapped for financing such that this would not be regarded as indirectly monetizing government deficit. Such a policy could also assist in the restructuring of the Central Bank's balance sheet to allow for more flexibility in monetary policy and an improvement in profitability. The proposal is tantamount to quantitative easing, in which the central bank provides liquidity to the system beyond what is needed. In the context of weak demand pressures, the monetary expansion

[21] A volume limit could be set which bears some relationship to the expected interest receipts on the entire holdings of Government securities for the year.

is not likely to result in an overheating of the economy.

Currently, there is sufficient liquidity in the banking system to fund both the private sector and government without causing undue pressures on interest rates. However, in the current environment where balance sheets are in recession, the demand for loans at existing lending rates will remain weak. It is likely that banks will lower interest rates to attract new loans only to the extent that they can guarantee current profitability. Such a guarantee might be more easily achieved through the alternatives outlined to interest rate.

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