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Roland Craigwell
Winston Moore
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Financial innovation and efficiency in the Barbadian banking industry

I. INTRODUCTION

Financial innovation can be defined as any new financial service or product which changes the way in which financial transactions are completed or delivered. Financial innovations in the Barbadian banking industry are not a recent phenomenon (Zephirin and Seerattan, 1997). The 1980s witnessed the inauguration of the Securities Exchange of Barbados, venture capital investments and mutual fund instruments, while during the 1990s, electronic technologies transformed how people transact business at commercial banks in Barbados. Most of the innovations that have occurred have been occasioned by new distributional channel systems such as automatic teller machines (ATMs) and debit card technologies,

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which have allowed banks to diversify the way in which customers transfer funds, pay bills and buy goods and services without using cash or cheques. In essence, technological innovation in the banking system has lowered costs per transaction and realised processing efficiencies by shortening the time taken for completing a transaction and reducing the possibility of human errors (see Parris, 2002 for more details). This proposition can be supported by observing that banks' total costs as a percent of total assets has declined from 8.8% in the 1979-1983 period to 6.8% in the 1994-1999 period.

Given the potential importance of financial innovation to bank behaviour, the recent focus of empirical work has been on its impact on productivity. Wilson (1995), in his survey, concludes that the majority of the studies are in agreement with what has come to be known as the "IT Paradox", where information technology (IT) investment has an insignificant impact on productivity.

One drawback of examining the effect of innovation on productivity in the banking industry is that there is no clearly identifiable output. For example, Haynes and Thompson (2000) use real earning assets as the output variable while Frei, Harker and Hunter (1997) utilise total loans plus total deposits. However, the output of the banking firm should not be linked to a single variable but to a multiplicity of variables that capture the many services offered by a commercial bank. In addition, linking innovations to productivity ignores an important factor firms consider when investing in product or process innovations, namely, efficiency. Productivity is concerned with the relationships between outputs and inputs while efficiency shows if a firm is using its inputs optimally to generate the greatest possible output.

This study therefore employs Data Envelopment Analysis (DEA) and stochastic cost frontier (SCF) techniques to compute the level of efficiency in the Barbadian banking system over the period 1979 to 1999, and then utilises these estimates to investigate the relationship between efficiency and financial innovation. DEA allows one to specify the banking firm as a producer of multiple outputs and a user of multiple inputs. In addition, it generates productivity-related statistics such as technical efficiency, which show the ability of a firm to obtain maximum outputs with a given set of inputs. One caveat that must be borne in mind is that Barbados has an underdeveloped capital market. As a result, banks have not faced any serious competition from other players in the financial arena in terms of their outputs. It is therefore possible that one could obtain the perverse situation that a bank's

operating cost, as a proportion of total assets is very high, but its revenue is even higher. This would suggest that an approach which focuses more on cost inefficiencies, might give different results. Consequently, a stochastic cost frontier model is also estimated to examine whether the efficiency scores differ significantly from those obtained from the DEA approach.

This research adds to the literature in developing countries, since most of the work on efficiency and productivity has been undertaken on developed economies. Certainly in Barbados, only two studies are available and both are rather narrow in scope. Langrin (1995) estimates a translog cost function for Barbadian commercial banks using data over the period 1984 to 1990, and concludes that banks seem to be more efficient in their role as a financial intermediary than a producer of financial funds. However, no efficiency scores are derived in the study. Howard and Haynes (2001) also examine the issue of bank efficiency in Barbados but their study is restricted to ratio analysis, for example, interest, labour and operating costs to total assets.

This paper is divided into five sections. Following the introduction, Section II outlines the methodology and describes the data. Section III presents the empirical estimates of commercial bank inefficiency while Section IV explores the relationship between efficiency and financial innovation. Section V concludes.

II. METHODOLOGY AND DATA

1. Estimating efficiency

DEA and an SCF model are utilised to derive estimates of efficiency in Barbados. The DEA approach assumes that each bank uses the same inputs, in differing combinations, to produce various outputs. Assuming that there exists data on K inputs, M outputs, N firms and constant returns to scale, the formal linear programming problem can be specified as:

$$\begin{aligned} &min_{\theta,\lambda}\ \theta \\ &st \quad -y_i + Y\lambda \geq 0, \\ &\quad\ \theta x_i - X\lambda \geq 0, \\ &\quad\ \lambda \geq 0 \end{aligned} \tag{1}$$

where θ is a scalar, y_i is a vector of output prices for the i^{th} firm, x_i is a vector of input prices for the i^{th} firm, Y is an $M \times N$ output

matrix, X is a $K \times N$ input matrix, λ is an $N \times 1$ vector of constants. The linear programming problem above constructs a piece-wise external production surface, which represents the revealed optimal production frontier. The value of θ obtained provides the efficiency score of the i^{th} firm, with a value of 1 indicating a point on the frontier and a technically efficient firm (TE). This index shows the ability of a bank to obtain the greatest possible output with a given set of inputs.

To obtain an estimate of minimum cost efficiency, Equation (1) and the following cost minimising problem must be solved simultaneously:

$$\begin{aligned} & min_{\lambda, x_i^*} \; w_i' x_i^* \\ & st \quad -y_i + Y\lambda \geq 0, \\ & \quad x_i^* - X\lambda \geq 0, \\ & \quad \lambda \geq 0 \end{aligned} \tag{2}$$

where w_i is a vector of input prices for the i^{th} firm and x_i^* is the cost minimising vector of input quantities. Total cost efficiency (CE) can then be computed from the ratio of minimum cost to observed cost:

$$w_i' x_i^* / w_i' x_i \; . \tag{3}$$

Allocative efficiency (AE), which reflects the ability of the firm to use inputs in optimal proportions given input prices, is then derived from the ratio of CE and TE. For a more technical introduction to the approach see Fried, Lovell and Schmidt (1993) and Coelli, Rao and Battese (2001).

In order to control for the impact of method choice on the inferences derived, results from the alternative SCF approach are calculated. This approach determines the level of efficiency of a bank by comparing it to an idealised cost frontier. The SCF function is specified as:

$$c_i = c(q_i, w_i) + \varepsilon_i \tag{4}$$

where c_i are the total expenses observed for the i^{th} bank, q_i is a vector of outputs, w_i is a $K \times 1$ vector of input prices and ε_i is an error term. As in Aigner, Lovell and Schmidt (1977) and Meeusen and van der Broeck (1977) the error term of the SCF is assumed to be of the following form:

$$\varepsilon_i = u_i + v_i \tag{5}$$

where u_i and v_i are independently distributed. The u_is denote the effects of inefficiency and are assumed to have a half-normal random distribution. On the other hand, the v_is are random variables postulated to have a two-sided normal distribution with mean zero and variance σ_v^2, which captures statistical noise.

Given the above model, estimates of technical inefficiency, u_i, can be derived as the ratio of the frontier minimum cost to observed cost, which is also equal to:

$$CE_i = exp(-u_i). \tag{6}$$

The score is bounded between zero and one, with a score of 0.7, for example, suggesting that the bank can produce the same level of outputs using 30% less overheads.

2. Specification of inputs, input prices and outputs

An important aspect of obtaining accurate efficiency estimates is the specification of outputs and inputs. Within the banking literature, there are three main approaches to the specification of what constitutes inputs and outputs. These are the production approach (see Fried, Lovell and Schmidt, 1993), the intermediation approach and the asset approach (see Favero and Papi, 1995). Following other studies on bank efficiency such as Berger and Mester (1997), DeYoung and Hasan (1998) and Isik and Hassan (2002), the intermediation method is chosen over other empirical specifications since it most closely captures what financial institutions do, that is, convert and transfer financial assets from surplus economic units to deficit units. Therefore, commercial banks are assumed to be multi-product firms that produce four outputs and employ three inputs.

Starting with inputs, LABOUR, is given by the number of persons employed; CAPITAL, is measured as the book value of premises and fixed assets, and; FUNDS represent total resources available to the bank and is defined as the sum of deposit and non-deposit funds (non-deposit funds includes monies due to other banks, the head office, the Central Bank and other branches). These three inputs are the main resources needed to operate a bank. The output variables, which primarily reflect desired outcomes, include: TLOANS, measured by total loans outstanding; other earning assets, OASSETS, which incorporates investments and securities (treasury bills, government bonds and other securities); interest income, INTINCOME, given by total

interest income from loans and other investments, and; FEEINCOME, which includes incomes obtained from fees and other services provided by the bank.

3. Sample statistics

Table 1 presents the variable definitions while Table 2 gives the means and standard deviations for the inputs, input prices and outputs for four periods on the seven commercial banks operating in Barbados. Employment at commercial banks fluctuated significantly over the period. During the mid-1980s banks reduced their complement of workers, from 224 between 1979-1983 to 194 during 1984-1988. This fall might be related to the almost doubling in the price of labour registered over the period of analysis. However, with the expansion in bank business during the 1990s, mainly due to the booming economy, banks raised employment levels above those reported in the 1979-1983 period. Another trend observed from Table 2 is that banks have significantly increased their stock of fixed capital during the latter half of the 1990s. While in the 1979-1983 period the average bank held $4.5 million in capital assets, by 1989-1993 the stock had risen to $10.5 million and exploded to just under $18 million in 1994-1999. Banks have also benefited from a significant expansion in loanable funds since the 1984-1988 period. The growth in

TABLE 1. DEFINITION OF VARIABLES

Variables	*Definition*
Inputs	
LABOUR	Total number of employees
CAPITAL	Book value of premises and fixed assets
FUNDS	Sum of deposit and non-deposit funds
Input Prices	
P_l	Total expenditure on employees divided by the total number of employees
P_c	Total expenditure on premises and fixed assets divided by the book value of premises and fixed assets
P_f	Total interest expenses on deposit and non-deposit funds divided by the sum of deposit and non-deposit funds
Outputs	
TLOANS	Total loans
OASSETS	Other earning assets (such as investments, etc.)
INTINCOME	Total interest income
FEEINCOME	Total fee and other income

loanable funds registered in 1989-1993 over the 1979-1983 era almost doubled that recorded in the previous period while loanable funds in 1994-1999 was more than 50% greater than in the preceding period. This increase in resources was obtained in spite of a decline in the rate of return offered to customers from 4.9% in the 1979-1983 period to 3.6% by 1994-1999.

TABLE 2. SAMPLE STATISTICS OF INPUTS AND OUTPUTS (BDS$ '000), 1979-1999[a]

	1979-1983		*1984-1988*		*1989-1993*		*1994-1999*	
Variables	*Mean*	*S.E.*	*Mean*	*S.E.*	*Mean*	*S.E.*	*Mean*	*S.E.*
Inputs								
LABOUR	224	161	194	161	248	176	283	155
CAPITAL	4,525	5,243	6,213	5,535	10,466	8,956	17,935	11,611
FUNDS	138,458	63,665	198,443	94,295	278,094	135,384	471,073	246,185
Input Prices								
P_l	16.402	5.083	28.256	8.960	28.669	5.918	38.154	5.453
P_c	0.025	0.021	0.052	0.076	0.037	0.026	0.048	0.037
P_f	0.049	0.016	0.041	0.017	0.049	0.013	0.036	0.010
Outputs								
TLOANS	92,799	40,565	130,931	63,107	175,340	80,030	272,542	135,453
OASSETS	25,292	14,241	43,882	22,878	67,084	34,726	114,647	74,618
INTINCOME	13,135	5,702	15,767	7,259	26,124	11,403	38,706	16,921
FEEINCOME	3,377	2,151	4,947	3,356	7,077	5,105	12,372	7,393
Memo								
Total Expense	13,317	6,036	17,311	8,719	26,695	12,949	36,638	16,543
Total Assets	151,362	68,314	221,721	101,725	311,301	142,496	535,657	258,423

[a] Two Barbados Dollars = One US Dollar (Fixed).

Turning attention now to the outputs, two key trends are evident. First, over the period under investigation, banks have reduced their reliance on retail banking in favour of investments and other interest earning assets. For example, in the 1979-1983 period the average bank held 61% of its assets in loans compared to 51% in the 1994-1999 period. This decline could imply that commercial banks are obtaining greater returns from their investment portfolios relative to that obtained on loans. The second key trend obtained from the sample statistics is the growing importance of FEEINCOME as a source of bank income. In the 1979-1983 the average bank obtained 20% of its total income from fees and other income, however by the 1994-1999 period

the contribution had risen to approximately 24% of bank's revenues.

4. Econometric model

To examine the relationship between financial innovation and bank efficiency, the following random effects panel data regression is estimated:

$$u_{it} = u(FINOV_{it}, x_{it}^{1}, ..., x_{it}^{n}) \tag{7}$$

where *FINOV* is an indicator of financial innovation and $(x_{it}^{1}, ..., x_{it}^{n})$ is a vector of variables used to account for other factors that might influence bank efficiency (see Table 3 for the definitions and sample statistics of the control variables employed).

Two indicators of financial innovation are used. The first of these, *INOV*, is an index which seeks to measure the number and

TABLE 3. SUMMARY STATISTICS FOR EXPLANATORY VARIABLES

Variables	*Definition*	*Mean*	*St. Dev*
SIZE	Total assets of the i^{th} bank divided by total industry assets	0.147	0.064
LOANTA	Total loans divided by total assets	0.568	0.113
FUNDTA	Total loanable funds divided by total assets	0.880	0.078
RREQ	Total reserve requirements	27.699	0.136
INCGROWTH	Percentage change in real gross domestic product at factor cost	1.491	3.667
$\sigma(ROA)$	Standard deviation of return on assets	0.010	0.005
FRBANK	Dummy variable indicating that the bank's head office is located overseas	0.692	0.463
STBANK	Dummy variable indicating that the bank is owned by the state	0.147	0.355
INOV	Index of financial innovation	0.566	0.145
ATM	Dummy variable which takes the value 1 if ATM technologies are being used by the bank and 0 otherwise	0.364	0.483

availability of financial products in a given year (Bynoe-Mayers and Craigwell, 2002). It is based on Gelbard and Leite's (1999) index of financial development and begins by asking several questions about the development of commercial banks financial products; for example, do banks issue debt or credit cards? Then it converts the answers to the questions into an index, by assigning a value of 0 or 100, to 'yes or no' answers, and also by using the following equation:

$$d_j = \frac{k_j - min}{max - min} \times 100 \tag{8}$$

where j is the p^{th} attribute, d_j is an index between 0 and 100 of the p^{th} attribute, k_j is the value of attribute j, min is the minimum value of the p^{th} attribute and max is the maximum value of the p^{th} attribute. Therefore the index accounts for the existence of a wide range of new financial products and practices overtime. It is expected that this variable will positively impact on efficiency since innovations offer customers a greater level of products to purchase and therefore opportunities to increase the output of the given bank.

The second indicator of financial innovation, *ATM*, is a dummy variable that represents the introduction of automatic teller machines (ATMs) in the banking system. This variable is also expected to be positively related to efficiency, since ATMs reduce the need for a large complement of bank tellers and a number of branches.

Several control variables are employed. SIZE, is used to test whether banks of various scales of operations have differing levels of efficiencies. If the coefficient on this variable is negative it would support the hypothesis put forward by authors such as Nakamura (1993) and Mester, Nakamura and Renault (1998) that small firms have greater access to credit information and less agency problems since management might be closer to both the customer and the loans officer. On the other hand, if the sign of the coefficient is positive it would be in agreement with the expense preference hypothesis postulated by Rhoades and Rutz (1982) and Clark (1986). This approach contends that managers at small banks may invest in less risky loans and investments so as to enjoy a 'quiet life' and in the process reject loans that could have generated additional profits for the bank. LOANTA captures the risk averseness of the bank and is expected to be positively related to efficiency as banks in Barbados have a greater degree of market power over their loan portfolio relative to other

components of their asset holdings. The inclusion of the variable FUNDTA tests whether banks with greater deposit bases have differing levels of efficiency. The coefficient on this variable is expected to be positive since, banks with larger stocks of loanable funds should produce relatively more outputs relative to their peers, holding all other factors constant, due to financial economies of scale. In Barbados, banks are subject to both cash and securities requirements (RREQ), which acts as a cost to the commercial bank, as these funds could have been used to provide loans or make other interest earning investments to generate income. Therefore it is likely that RREQ will impact negatively on bank efficiency. The variable $\sigma(ROA)$ is included to capture an aspect of profit risk. Riskier banks may have higher levels of efficiency since they are trading low levels of risk for possibly greater returns. However, if the expected returns from taking on additional risk do not materialise then bank efficiency could decline. The coefficient on the variable $\sigma(ROA)$ is therefore ambiguous. Income growth (INCGROWTH) proxies for the growth in demand for financial services and is expected to be positively related to efficiency since an increase in income would likely lead to greater demand for bank services and by extension more opportunities to make profits. Two dummy variables are also included in the model to test whether efficiency varies between foreign and domestic banks (FRBANK) and public and private commercial banks (STBANK).

III. EMPIRICAL ESTIMATES OF EFFICIENCY

Table 4 shows the efficiency estimates derived from the DEA and the SCF models for four periods. The average standard deviations of the difference in efficiency between banks for a given year are also reported in the table. The estimates produced by the DEA suggest that the average bank in Barbados has an efficiency score of 0.952 for the period 1979-1999. In economic terms this means that the average bank could have produced the same level of outputs using 4.8% less inputs. In addition, there appears to be an upward trend in cost efficiency with the average score rising from 0.940 in the 1979-1983 period to 0.968 in the 1994-1999 period. Apparently banks in Barbados have been streamlining their management techniques over time and possibly benefiting from technological innovations within the industry.

The resource wastage found in this study is relatively low when

compared to the level of inefficiency of banks of both developing and developed countries. Isik and Hassan (2002) estimates inefficiency of Turkish banks at 40%, Altumbus, Evans and Molyneux (1994) 24% for German universal banks, for the US banking industry the estimate is 13.2% (Berger and Mester, 1997) and 5-10% for English banks (Altunbas, Maude and Molyneux, 1995). These efficiency scores certainly explain the higher rates of profitability experienced by Barbadian commercial banks (approximately 2.1% compared to 0.4% for industrial countries (Demirguc-Kunt and Hizinga, 1998)). One of the main explanations for this finding is the relatively high interest margins (4.3%) the average bank in Barbados was able to maintain during the period under investigation. This situation is amplified even further when fee and other income is added to the analysis. Given the concentration of the market amongst seven commercial banks, this result is not surprising.

TABLE 4. ESTIMATES OF COMMERCIAL BANK EFFICIENCY, 1979-99

	1979-1983		*1984-1988*		*1989-1993*		*1994-1999*	
Variables	*Mean*	*S.E.*	*Mean*	*S.E.*	*Mean*	*S.E.*	*Mean*	*S.E.*
DEA Estimates								
TE[a]	0.993	0.014	0.985	0.029	0.975	0.036	0.997	0.020
AE[a]	0.946	0.094	0.955	0.068	0.980	0.035	0.971	0.049
CE[a]	0.940	0.102	0.941	0.085	0.960	0.055	0.968	0.059
Stochastic Frontier Estimates								
SFCE[a]	0.894	0.007	0.895	0.006	0.895	0.006	0.895	0.006

[a] TE: Technical efficiency, AE: Allocative efficiency, CE: Cost efficiency, SFCE: Cost efficiency from the stochastic frontier model.

The results presented in Table 4 also show the technical and allocative efficiencies for four periods. These scores reveal that average technical inefficiency is 1.3% where as the average allocative inefficiency is 3.7%. This suggests that allocative inefficiency is the dominant source of bank inefficiencies. Therefore, Barbadian banks appear to utilise inputs in the improper mixes but are relatively good at getting the most output from their given resources. This inability to choose the correct input mix seems to be declining over time, evidenced by the rising efficiency score. One possible explanation is the delegation of input management to branch managers who may not be using inputs in the correct proportions.

Regarding the relatively low level of technical inefficiency, one possible explanation is that commercial banks may be getting high returns on their computerisation and other innovative product investments undertaken during the late 1980s and early 1990s. As mentioned earlier, the 1990s saw the growth of debit card utilisation, ATM technologies, credit cards and the establishment of the a system known as CARIFS, which allowed users to access cash from any bank ATM even if they are not a customer of that bank.

The authors also estimated a stochastic cost frontier model to examine whether the efficiency estimate differs significantly from those obtained from the DEA and these results are reported in the final row of Table 4. The efficiency estimates are in broad agreement with those from the DEA. The SCF results show that the average bank in Barbados has costs 11% higher than those obtained on the efficient frontier.

Table 5 reports the correlation ratios among the different efficiency measures and three common accounting ratios that may be considered alternative measures of efficiency. The first of these is return on assets (ROA), which attempts to capture the productivity of the asset base, while total expenses divided by total assets (COSTTA) proxies cost inefficiency. The final performance variable is total assets divided by total labour employed (TALABOUR) and attempts to measure employee productivity. There is a positive relationship between ROA and TALABOUR and all the efficiency scores. These results suggest that more profitable and productive banks are usually more efficient than their peers. Similarly, COSTTA, a proxy for inefficiency is negatively correlated with all of the efficiency scores and the other performance

TABLE 5. CORRELATES WITH COMMERCIAL BANK EFFICIENCY

	TE	*AE*	*CE*	*SFCE*	*ROA*	*COSTTA*	*TALABOUR*
TE	1.000						
AE	0.176	1.000					
CE	0.517	0.920	1.000				
SFCE	-0.013	0.415	0.346	1.000			
ROA	-0.007	0.115	0.101	0.175	1.000		
COSTTA	-0.052	0.006	-0.007	-0.174	-0.385	1.000	
TALABOUR	0.109	0.209	0.218	0.391	-0.017	-0.381	1.000

NOTES: TE: Technical efficiency, AE: Allocative efficiency, CE: Cost efficiency, SFCE: Cost Efficiency from the stochastic frontier model, ROA: Return on assets, COSTTA: Total expenses divided by total assets, TALABOUR: Total assets divided by total number of employees.

indicators. These results show that all the efficiency scores generated are associated with more simple estimates of financial performance. This finding illustrates the usefulness of the calculated efficiency scores and also acts as a check on the consistency of the efficiency scores obtained.

V. FINANCIAL INNOVATION AND EFFICIENCY

Table 6 presents the results of estimating the model given in Equation 7. The coefficients on the control variables are considered first. SIZE is negatively and significantly related to bank efficiency. This finding suggest that efficiency at larger banks is lower than their peers and agrees with the results of Akhigbe and McNulty (2003) and supports the information advantage hypothesis of Nakamura (1993) and Mester, Nakamura and Renault (1998), which proposes that there would be less agency problems between the bank and the loan officer since senior management is closer. Banks with higher loan-to-asset ratios (LOANTA) tend to have higher efficiency scores. Thus, bank loans seem to be more highly valued than alternative bank outputs, say for example, securities. However, the variable is only significant in the allocative and cost efficiency models, but not the technical efficiency models. Another factor, which explains the growth in efficiency, is the relatively high rates of national income growth recorded during the period under analysis. During the period, the Barbadian economy grew at an average rate of 2.9% per year, which was reflected by an increase in GDP per capita from US$2697 in 1979 to US$9222 by 1999. This economic expansion allowed banks to benefit from higher demand for their financial services and thus greater output. The remaining control variables $\sigma(ROA)$, RREQ, FRBANK and STBANK are insignificant in all three-regression equations.

Focussing now on the financial innovation variable (*INOV*), the results presented in Table 6 show that this variable is positively related to all the efficiency measures. However, it only manifests as a significant factor in the *AE* and *CE* models. The finding that innovation is an insignificant variable in the *TE* and *SFCE* models is not surprising since these measures of efficiency are more related to managerial ability and experience than the new products and services available to the bank. The results do reveal, however, that banks have used new financial services and products to maximise their ability to use inputs in optimal proportions (reflected

TABLE 6. COMMERCIAL BANK EFFICIENCY AND FINANCIAL INNOVATION

	TE	*AE*	*CE*	*SFCE*
SIZE	-0.112	-0.581	-0.722	-0.011
	(0.068)	(0.133)[c]	(0.137)[c]	(0.003)[c]
LOANTA	0.020	0.116	0.114	0.000
	(0.029)	(0.053)[b]	(0.058)[b]	(0.001)
FUNDTA	-0.021	-0.012	0.004	-0.001
	(0.057)	(0.098)	(0.116)	(0.001)
RREQ	-0.002	0.002	0.001	-0.000
	(0.001)	(0.002)	(0.003)	(0.000)
INCGROWTH	0.003	0.001	0.003	0.000
	(0.001)[b]	(0.002)	(0.002)	(0.000)
σ (ROA)	0.463	-1.112	-1.801	0.004
	(0.922)	(1.671)	(1.864)	(0.020)
FRBANK	0.005	0.029	0.027	-0.000
	(0.014)	(0.025)	(0.029)	(0.000)
STBANK	0.004	0.047	0.048	0.003
	(0.015)	(0.029)	(0.030)	(0.001)[a]
INOV	0.011	0.113	0.127	0.001
	(0.027)	(0.047)[b]	(0.055)[b]	(0.001)
Intercept	1.038	0.869	0.877	0.897
	(0.060)[c]	(0.105)[c]	(0.122)[c]	(0.001)[c]
R-squared	0.151	0.251	0.258	0.971
$\chi^2(9)$	21.730[c]	32.330[c]	46.230[c]	22.920[c]
Obs	143	143	143	143

NOTES: White robust standard errors are reported in parentheses below the coefficients. [a] Denotes significance at the 10 percent level. [b] Denotes significance at the 5 percent level, [c] Denotes significance at the 1 percent level.

by the significance of *INOV* in the *AE* and *CE* models). Calculating the elasticity of financial innovation with respect to cost efficiency shows that for every 1% increase in the innovation indicator, bank efficiency rises by approximately 0.076%. This estimate is consistent with the productivity gains reported by Haynes and Thompson (2000) for the introduction of ATM technologies among UK building societies. This finding is especially important, since Table 4 reveals that allocative inefficiencies have been the main area in which there have been shortcomings. It therefore suggests that innovations should continue if banks are to reduce their levels of allocative inefficiencies overtime. This can be achieved if banks diversify their activities from basic retail banking activities into other areas of financial services.

The financial innovation index accumulates a number of inno-

vations introduced by banks. However, by examining a particular innovation one can directly measure its impact on efficiency. As noted earlier, the innovation chosen is the introduction of the ATM technology. The same efficiency model is estimated but a dummy variable, taking on the value 1 for all periods after the ATM is introduced and 0 otherwise, is included in the model and the results are presented in Table 7. Most of the coefficients on the control variables maintain similar signs to those observed in Table 6, although their magnitudes are somewhat different. These outcomes also show that the introduction of ATMs increases firm efficiency by approximately 3.5% for the average bank, while allocative efficiencies rise by 2.8%. These results imply that the introduction of ATM technologies is usually accompanied

TABLE 7. COMMERCIAL BANK EFFICIENCY AND THE INTRODUCTION OF ATM TECHNOLOGIES

	TE	*AE*	*CE*	*SFCE*
SIZE	-0.117	-0.579	-0.742	-0.010
	(0.069)[a]	(0.137)[c]	(0.139)[c]	(0.003)[c]
LOANTA	0.025	0.126	0.128	0.000
	(0.029)	(0.056)[b]	(0.059)[b]	(0.001)
FUNDTA	-0.017	-0.006	0.035	-0.000
	(0.058)	(0.100)	(0.117)	(0.001)
RREQ	-0.001	0.004	0.004	-0.000
	(0.001)	(0.002)[a]	(0.003)	(0.000)
INCGROWTH	0.003	0.001	0.003	0.000
	(0.001)[b]	(0.002)	(0.002)	(0.000)
σ (ROA)	0.418	-0.929	-1.881	0.005
	(0.918)	(1.685)	(1.862)	(0.019)
FRBANK	0.005	0.022	0.019	-0.000
	(0.014)	(0.025)	(0.029)	(0.000)
STBANK	0.004	0.042	0.044	0.003
	(0.014)	(0.029)	(0.029)	(0.001)[a]
ATM	0.005	0.028	0.035	0.000
	(0.007)	(0.012)[b]	(0.014)[b]	(0.000)
Intercept	1.031	0.835	0.827	0.896
	(0.062)[c]	(0.108)[c]	(0.125)[c]	(0.001)[c]
R-squared	0.147	0.244	0.261	0.971
$\chi^2(9)$	22.300[c]	29.940[c]	47.090[c]	22.78[c]
Obs	143	143	143	143

NOTES: White robust standard errors are reported in parentheses below the coefficients. [a] Denotes significance at the 10 percent level. [b] Denotes significance at the 5 percent level, [c] Denotes significance at the 1 percent level.

by efficiency gains, such that adopters enjoy a significant advantage over non-adopters.

V. CONCLUSIONS

This study employs DEA and stochastic frontier analysis to estimate the level of efficiency amongst commercial banks in Barbados over the period 1979 to 1999. The results show that Barbadian banks have relatively low levels of inefficiencies, wasting only 4.8% of inputs, when compared to their international counterparts. The study then estimates an econometric model to derive estimates of the relationship between efficiency and financial innovation and other control variables. These results show that bank size, loan-to-asset ratio, national income growth and financial innovation are the most significant determinants of efficiency in Barbados. Moreover, the coefficient estimate obtained for the innovation variable indicates that for every 1% increase in the index of financial innovation, efficiency rises by 0.076%. To provide an analysis of the impact of a recent innovation, an ATM dummy is included in the model. The econometric results show that this development increased bank efficiency by approximately 3.5%.

Although overall bank inefficiencies are rather low, one area that could be improved is the allocative inefficiencies of banks. This variable shows the ability of firms to use inputs in optimal proportions. From the results presented in the study, it seems that financial innovations could be one area in which allocative inefficiencies can be reduced. However, the introduction of new technologies must be accompanied with greater training for employees in how best to use these technologies.

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Monetary policy rules and the transmission mechanism in Jamaica

1. INTRODUCTION

The conceptual framework that has underpinned the conduct of monetary policy since the latter half of the 1990s is based on a robust link between money supply and inflation. Thus, by regulating the supply of money and credit, through its control over the monetary base, the central bank influences agents' portfolio decisions, aggregate demand and consequently inflation. This approach has led to a significant reduction in inflation, with the period being characterized by moderate monetary expansion and six consecutive years of single digit inflation.

However, it is likely that the nature of the process through

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which monetary policy affects the economy- the monetary transmission mechanism, has evolved[1] over the years. This is in a context where the 1990s was characterized by a significant transformation of the financial sector and a progressive opening of the economy to international trade and capital flows, which accelerated in the latter half of the decade. This evolution poses significant implications for the design and implementation of monetary policy.

Against this background, this paper uses a simple aggregated model, similar to Allen, Hall and Robinson (2002), to study the monetary transmission process in Jamaica. The analysis is conducted over the post liberalization period.[2] The effect of a monetary shock on the economy is simulated under different policy rules.

The next section outlines the model and the estimation results, which is followed by an analysis of the transmission process, using stochastic simulations, in section 3. Section 4 evaluates the efficacy of alternative policy frameworks, while the final section presents some conclusions and possible extensions.

2. THE MODEL

Given the data limitations, the model is highly aggregated, consisting of IS and LM curves, Phillips curve, exchange rate equation and a monetary policy rule. Economic agents are forward-looking and form expectations rationally, using information up to time t and are aware of the policy rule.

The model differs from Allen, Hall and Robinson (2002) in its treatment of potential output. As is frequently done, potential output was estimated using the Hodrick-Prescott filter. This is a purely statistical treatment of a real dis-equilibrium, the major shortcomings of which are documented in Harvey and Jaeger (1993). These shortcomings include the possibility of spurious cyclicality, excessive smoothing and the large end sample bias. Against this background, following Apel, Hansen and Lindberg (1996), potential output is estimated using an unobserved components method, which utilizes the information contained in observed variables. That is, it exploits the relation between potential

[1] See Robinson & Robinson (1997) for an earlier analysis of the transmission process in the Jamaica.

[2] Limited sample size precludes an analysis of the post 1995 period specifically.

output and observable variables such as unemployment or wages and inflation.

The model presented also extends the treatment of the Phillips curve in Allen, Hall and Robinson (2002) to account for forward-looking expectations. This forward-looking model provides richer dynamics compared to the backward looking ISLM type model of Allen, Hall and Robinson (2002) and is more consistent with models based on intertemporal optimization.

The equations are estimated as a system using the seemingly unrelated regression estimator (SUR).[3] Each equation is first estimated using general to specific modeling to obtain a parsimonious error correction form, which is then used in the system. The model is estimated using quarterly seasonally adjusted data for the period 1990 to 2002 and all variables are expressed in logs, except for interest rates.

2.1 Consumer prices

The relatively high consumer price inflation[4] in Jamaica in the early 1990s was to a large extent influenced by monetary conditions. Further, the openness of the economy has given more prominence, certainly in the short run, to exchange rate fluctuations (Robinson 2000). However, although the exchange rate pass through is still significant, with macroeconomic stabilization and increased competition, supply shocks have recently emerged as a major determinant of inflation. Against this background consumer price inflation is modeled along the lines of a forward-looking[5] open economy Phillips curve. i.e.

[3] While the right hand side variables, particularly in the money demand equation, are generally weakly exogenous (see Allen, Hall and Robinson (2002)), it may be unrealistic to expect that the equation errors are truly uncorrelated (contemporaneously). The likelihood ratio for contemporaneous correlation was 67.23 and with ten degrees of freedom we cannot reject the null hypothesis. The superior FIML estimation was also done, but the performance of the SUR estimates, both within sample and out of sample was better.

[4] Although core inflation is more relevant to policy, the model uses headline inflation measured by the consumer price index as this is what the public uses to gauge inflation. In this context, for credibility, the headline inflation is the ultimate target for the central bank, which is communicated to the public.

[5] This is consistent with the New Keynesian Phillips curve which assumes wage setting behaviour according to the rational expectations staggered contract models of Taylor (1980), and Calvo (1983). See also Roberts (1995), Gali and Gertler (1999), Fuhrer (1997), and Rudd and Whelan (2001).

$$\pi_t = \alpha_0 \mathrm{E}_t \pi_{t+1} + (1 - a_0)\pi_{t-1} + \alpha_1(L)(y_t - y_t^*) + \alpha_2(L)(\Delta s_t + \Delta p_t^*) \qquad (1)$$

where n_t is the inflation rate, $E_t n_{t+1}$ represents expected inflation, y_t denotes output, y^* potential output, s_t is the exchange rate, p^* represents foreign inflation and L the lag operator. Equation (1) conveys that inflation dynamics are influenced by inflation expectations, some measure of excess demand and imported inflation. Excess demand is proxied by an output gap[6] measured by the deviation of output from a measure of potential output. The inclusion of a backward looking component in this 'hybrid' model captures the importance of lagged inflation to expected future inflation under rational expectations.[7]

We estimated equation (1) by a two-step procedure similar to Galí (2000). In the first stage estimates for α_0 were obtained using GMM, with π_{t+1} serving as a proxy for $E_t n_{t+1}$ and current and lagged values of the output gap and first differences of the exchange rate as the instruments.[8] This estimate is then imposed in the SUR system to obtain the coefficients of the output gap and imported inflation.[9] The results are shown in Table 1. The first row of Table 1 contains the result of the GMM estimate of α_0 and the other coefficients correspond to the SUR estimates with the restriction α_0=0.368334.[10] The size of α_0, however, suggests that past inflation is of greater importance to current inflation than future inflation. Imported inflation, with a lag of up to two periods, was the most important factor in explaining current inflation.

The structure and characteristics of the economy explain this finding given its small size and openness and the heavy reliance on imported items for production and consumption. Further, any excess domestic demand in the economy tends to be quickly satisfied by imports. The results show that it is the output gap in the previous period that is important for current inflation. This could be due to a staggered price setting mechanism possibly reflecting

[6] In the New Keynesian approach, the Phillips curve embodies a relation between price and marginal cost (see Galí and Gertler (1999). The use of an output gap as a measure of real activity therefore assumes that there is a proportional relation between the gap and marginal cost.

[7] See Galí and Gertler (1999).

[8] Galí (2000) posits that this technique avoid biased results.

[9] The inclusion of an error correction term was not significant and did not yield sensible results.

[10] Wald test for the null that the coefficients of π_{t-1} and π_{t+1} sum to one could not be rejected.

the impact of competition. Alternatively, a narrowing of the output gap in time t-1 generates wage and demand pressures, which translate into price pressures in time t.

TABLE 1: INFLATION

Variables	*Coefficients*	*S. Error*	*t-stat*	*P-value*
α_0	*0.368334*	*0.082533*	*4.462843*	*0.0001*
$y_{t-1} - \overline{y}_{t-1}$	0.276600	0.132935	2.080713	0.0388
$\Delta s_t + \Delta p_t^*$	0.353274	0.042397	8.332472	0.0000
$\Delta s_{t-1} + \Delta p_{t-1}^*$	-0.144828	0.053462	-2.70896	0.0074
$\Delta s_{t-2} + \Delta p_{t-2}^*$	0.274808	0.043340	6.340694	0.0000

S.E. of regression: 0.022265 Sum squared resid: 0.017845
B-G: Prob $\chi^2(1)$=0.065 B-G: Prob $\chi^2(4)$=0.049
White: Prob $\chi^2(1)$=0.065 Jarque-Bera: Prob. = 0.609

2.2 Aggregate demand

Consistent with the traditional open economy IS curve, aggregate demand was specified as a function of interest rates and the real exchange rate. As in Allen, Hall and Robinson (2002) a credit channel is also incorporated in the model through the inclusion of banking system reserves, similar to Bernanke and Blinder (1988). The availability of credit facilitates consumption smoothing and investment, thereby influencing aggregate demand. Robinson and Robinson (1998) found that the credit channel was one of the monetary policy transmission channels in Jamaica. The credit channel amplifies the effect of monetary policy through the response of the corporate external finance premium and the availability of bank reserves (see Dale and Haldane (1993), and Bernanke and Gertler (1995)).

Aggregate demand was estimated using the following error correction form:

$$\Delta y_t = -\beta_0 [\, y_{t-1} - 0.17 res_{t-1} + 0.16 r_{t-1} - 0.07 rer_{t-1} - 6.65] + \beta_1(L)\Delta r_t + \beta_2(L)\Delta y_t \quad (2)$$

where r_t is the real interest rate, rer_t is the real exchange rate and res_t is average real bank reserves. The results are given in Table 2. The changes in the real exchange rate did not emerge as being important in the parsimonious dynamic specification. The error correction term was significant, however, the size suggests relatively slow quarterly adjustment of output to deviations from equilibrium. The short-run dynamics are driven mainly by lagged changes in output or the momentum in the economy.

TABLE 2: AGGREGATE DEMAND

Variables	*Coefficients*	*S. Error*	*t-stat*	*P-value*
c	0.002987	0.002247	1.329196	0.1854
ec_{t-1}	-0.285010	0.076694	3.716179	0.0003
Δr_{t-3}	0.062859	0.029601	2.123560	0.0350
Δy_{t-1}	0.213221	0.104232	2.045633	0.0422
Δy_{t-2}	-0.569449	0.097980	5.811883	0.0000
S.E. of regression: 0.01556			Sum squared resid: 0.008444	
B-G: Prob $\chi^2(1)$=0.065			B-G: Prob $\chi^2(4)$=0.577	
White: Prob $\chi^2(1)$=0.097			Jarque-Bera: Prob. = 0.934	

2.3 Money demand

The demand for real money balances[11] (M2) was estimated within an error correction framework which included the rate of depreciation, income and an opportunity cost measure, *h*, defined as (M^o/M2)*r. This captures the fact that all the components of money, except for high-powered money earn interest at the outside interest rate.[12] The change in the exchange rate was included to account for currency substitution.

$$\Delta m_t = -\gamma_0[m_{t-1} - 1.11y_{t-1} + 2.21h_{t-1} + 3.19\Delta s_{t-1} - 4.89] + \gamma_1(L)y_t + \gamma_2(L)r_t + \gamma_3(L)\Delta\Delta s_t \quad (3)$$

The long run coefficients indicate that the elasticity with respect to exchange rate depreciation is greater than that for interest rate, indicating the significance of the public's perception of devaluation on their portfolio choice. Similar to the results in Craig-

TABLE 3: MONEY DEMAND

Variables	*Coefficients*	*S. Error*	*t-stat*	*P-value*
ec_{t-1}	-0.161042	0.018942	8.501718	0.0000
$\Delta\Delta s_t$	-0.542844	0.065022	8.348619	0.0000
Δh_t	-0.391987	0.123082	3.184769	0.0017
S.E. of regression: 0.037013			Sum squared resid: 0.052057	
B-G: Prob $\chi^2(1)$=0.065			B-G: Prob $\chi^2(4)$=0.356	
White: Prob $\chi^2(1)$=0.277			Jarque-Bera: Prob. = 0.434	

[11] The central bank's policy is currently framed around M3. However, a stable and theoretically consistent demand function using this measure was not obtained over the sample period. The appeal of M3 has been questioned in light of the developments in the banking system and the structure of the banks' demand liabilities.

[12] See Ericsson et al. (1997).

well (1991), the income elasticity was marginally larger than one, although not statistically different from unity. The results for the short run dynamics are shown in table 3.

The error correction term was negative and significant, which indicates that there is a countervailing adjustment in the demand for real money balances in the subsequent quarter in response to a dis-equilibrium. The speed of adjustment, however, is low, especially when compared to Craigwell (1991) and Henry and Kent (1996). Cuthbertson and Taylor (1990) argue that a slow speed of adjustment is likely if the current portfolio choice of agents is significantly influenced by expected future income and return. Allen, Hall and Robinson (2002) attribute this result to the increasing financial sophistication of the Jamaican investor, particularly since liberalization. Similar to Allen, Hall and Robinson (2002), although important in the long run, changes in real GDP do not affect the short run demand. The interest rate and the rate of exchange rate depreciation are significant, with the rate at which the exchange rate depreciates having the most significant and immediate effect. While the largest component of M2, savings deposits, are relatively interest insensitive, there has been a growing tendency of agents to shift into other instruments including foreign currency when the trajectory of the exchange rate changes.

2.4 Banking system reserves

Reserves are determined by the real interest rate and the liquid asset ratio.[13] A rise in interest rates is expected to positively influence the stock of reserves through an increase in interest bearing deposits, as well as increased holdings of short-term (risk free) interest bearing securities that are usually held as liquid assets or excess reserves by banks. The latter would serve to increase the pool of funds available for credit. The estimated equation is:

$$\Delta res_t = -\delta_0[res_{t-1} - 10.02 - 1.47 * r_{t-1} - 1.58 * LAR_t] + \delta_1(L)\Delta r_t + \delta_2(L)\Delta LAR_t + \delta_3(L)\Delta res_{t-1} \quad (4)$$

The short-run dynamics depend on the previous positions (see Table 4). The size of the error correction term suggests a quick response to deviations from the desired or equilibrium position. Changes in the LAR were not important to the short run dynamics.

[13] This is comprised of a statutory cash reserve ratio and (non-cash) liquid asset ratio.

TABLE 4: RESERVES

Variables	*Coefficients*	*S. Error*	*t-stat*	*P-value*
ec_{t-1}	-0.740464	0.203506	3.638537	0.0004
Δres_{t-1}	0.743800	0.167760	4.433717	0.0000
Δres_{t-3}	-0.430545	0.110400	3.899861	0.0001
S.E. of regression: 0.084652			Sum squared resid: 0.25798	
B-G: Prob $\chi^2(1)$=0.139			B-G: Prob $\chi^2(4)$=0.139	
White: Prob $\chi^2(1)$=0.1			Jarque-Bera: Prob. = 0.369	

This is not surprising, since banks generally hold reserves in excess of the requirement and as such the LAR is not a binding constraint. Further, the impact of changes in the LAR depends on the component that is adjusted. Changes in the cash reserve component only may not affect overall reserves as the banks may convert excess liquid assets into cash and vice versa.

2.5 Exchange rate

The exchange rate is modeled along the lines of the standard monetary model with rational expectations, where the reduced form changes in the rate are driven by expected fundamentals. Consistent with the model presented, the forcing variables are the interest differential with the US, the inflation differential and the demand for domestic money balances. To account for the market microstructure we include a measure of exchange rate volatility, the change in the rate of depreciation. In thin markets, like Jamaica's, accelerations in the rate of depreciation tend to get amplified. A general dynamic form in first differences was used.[14] The results, shown in table 5 meet a priori expectations.

$$\Delta s_t = \varphi(L)_0 * (i_t - i_t^*) + \varphi(L)_1 * (\pi_t - \pi_t^*) + \varphi(L)_2 * \Delta m_t + \varphi(L)_3 * \Delta\Delta s_t \qquad (5)$$

TABLE 5: EXCHANGE RATE

Variables	*Coefficients*	*S. Error*	*t-stat*	*P-value*
i_{t-1}-i_{t-1}*	-0.046537	0.023277	-1.99929	0.0470
n_t-n_t*	1.660261	0.091113	18.22196	0.0000
Δm_t	-0.465547	0.065703	7.085652	0.0000
$\Delta\Delta s_{t-1}$	0.258833	0.055399	4.672174	0.0000
S.E. of regression: 0.0370			Sum squared resid: 0.05206	
B-G: Prob $\chi^2(1)$=0.065			B-G: Prob $\chi^2(4)$=0.833	
White: Prob $\chi^2(1)$=0.13			Jarque-Bera: Prob. = 0.511	

[14] Test for a long run relation based on PPP did not yield satisfactory results.

2.6 Model prediction

The in sample[15] predictive power of the model is assessed using the standard mean square error (MSE), root mean square error (RMSE) and the Theil U statistics, over the sample period. A Theil U greater than one is undesirable and the closer the statistic is to zero the more robust the predictive accuracy. Table 6 gives the results for the main macroeconomic variables. The performance of the model can also be seen in the actual and fitted values shown in Appendix A.1.

The statistics indicate that the model replicates the behaviour of the Jamaican economy fairly well. The predications for reserves are relatively weaker, although the accuracy is reasonably acceptable. The graphs indicate that the model picks up the major turning points in the series reasonably well.

TABLE 6: MODEL PREDICTION, 1990:1–2000:4

	MSE	*RMSE*	*Theil U*
GDP	0.00039	0.01981	0.00281
Inflation	0.00018	0.01335	0.02381
Reserves	0.01435	0.11978	0.55929
M2	0.00310	0.05572	0.01151
Ex. Rate change	0.00128	0.03578	0.07441

3. MONETARY POLICY SIMULATION

In this section we attempt to define the monetary transmission mechanism in Jamaica. The transmission of monetary policy occurs through different channels, which are identified by simulating the dynamic response of the economy to an *unanticipated* monetary policy shock. In this exercise, we consider the response of the system to a 100 basis point increase in interest rates, which lasts for one quarter. Bank of Jamaica's open market rates have a pervasive and strong influence on a wide spectrum of market rates. Hence, purely for convenience, we assume that changes in the policy rate translate one-for-one into changes in market rates. Given that the model includes forward-looking variables, the Fair-Taylor solution algorithm is used.

Following on Allen, Hall and Robinson (2002), the simulations

[15] These small-scale models are designed for monetary policy simulations and not necessarily for forecasting.

use a baseline policy rule, which accounts for the fact that changes in the exchange rate have featured more prominently in monetary policy operations in Jamaica relative to the movements in the monetary base. This is against the background that the exchange rate is an important nominal anchor, particularly for expectations in the Jamaican economy given its openness. Hence this price has emerged over the years, under various policy regimes, as the key intermediate target.

The importance of the exchange rate to monetary policy operations even within the rubric of base money targeting is also derived from the fact that movements in the monetary base in itself may not convey sufficient information about current monetary conditions given the lagged information on (and endogeneity of) the money multiplier.[16] Fluctuations in the exchange rate therefore give a better indication of current conditions. Monetary policy in Jamaica therefore can in effect be described as a form of inflation-targeting *Lite*.[17]

It must be noted, however, that the focus of monetary policy in Jamaica is not on the level of the exchange rate, but the rate of adjustment in the market. We attempt to capture this idea in the following policy rule

$$i_t = \theta i_{t-1} + (1-\theta) r^* + \lambda_0 (E_t \Delta s_{t+h} - \Delta \bar{s}) + \lambda_1 (E_t y_{t+j} - \bar{y}) \qquad (6)$$

The policy choice is therefore encapsulated by the quintuplet $\{\theta, \lambda_0, \lambda_1, h, j\}$, where θ is the smoothing parameter and λ_0 and λ_1 are the feedback policy parameters. In the simulations r*, which is the equilibrium real interest rate, is suppressed, as the central bank, though cognizant, does not consider the equilibrium real rate as an operational target. We set θ=0.4, λ_0=0.6, λ_1=0.4, h = 0 and j = 0. These feedback parameters were found to best replicate monetary policy actions (Allen, Hall and Robinson (2002)) and as such monetary policy can be said to conform to an *outcome-based*[18] rule. The value of θ captures the secondary role that interest rate smoothing plays, as although the Bank is concerned about financial stability, it puts more weight on current market conditions. The parameters h and j indicate that the monetary

[16] There was also the issue of the stability of money demand.

[17] There is a broad inflation objective, however, this is pursued with a stable foreign exchange (financial) market being the *foremost* policy objective (see Stone (2003)). The issues of low credibility and lack of transparency raised by Stone (2003), however, are not necessarily applicable to Jamaica.

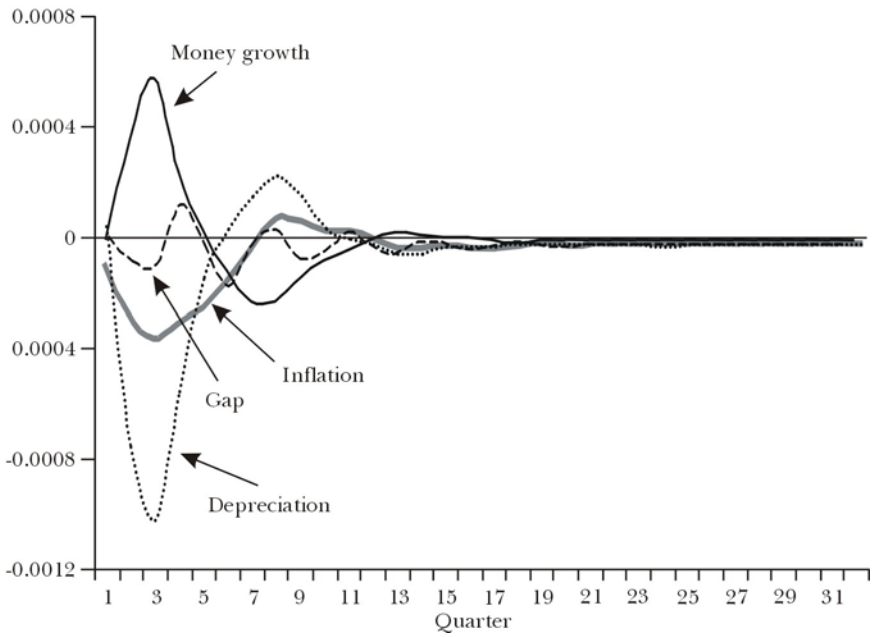
[18] A rule that is based on a small set of current and lagged variables.

authority does not employ a forecast based rule, as is the case in a number of countries with inflation targeting.

3.1 The monetary transmission process

The impulse responses to the monetary policy shock are shown in figure 1. The pattern of response is similar to that found in Allen, Hall and Robinson (2002), with the magnitude being relatively small. The more perceptible impact of the interest rate adjustment on inflation lasts for approximately three to four years,[19] after which the economy returns to equilibrium with inflation adjusting to the target. The influence of this policy change on inflation reflects the response of the exchange rate. On account of the policy action, the exchange rate appreciates over the ensuing four quarters with the greatest impact of 0.10% in the second quarter after the shock. In its transition back to equilibrium, however, the exchange rate exhibits some overshooting, which lasts for approximately five quarters.

FIGURE 1. RESPONSE TO INTEREST RATE IMPULSE



[19] Robinson and Robinson (1998) using monthly data for the first half of the 1990s found that the economy returned to equilibrium within two to three years.

The noticeable initial appreciation in the currency elicits a rise in the demand for real money balances, as it completely offsets the negative impact of the rise in real interest rates. The propensity for real money balances to rise persists for about four quarters after which the rising inflationary tendencies subsequently results in a decline, which lasts for the next five to six quarters. The rise in interest rate also leads to a decline in the output gap with a lag of one quarter.

The decline in the output gap also has a negative effect on inflation, albeit small. The response of the gap is not monotonic but is characterized by dampened oscillations around the equilibrium over time. This is due to the fluctuations in the real exchange rate. For example, the real appreciation in the first three quarters elicits a rise in aggregate demand in the subsequent two quarters through an increase in consumption[20] demand by the fourth quarter. The subsequent real depreciation exerts a dampening effect on aggregate demand.

In summary, the exchange rate responds most quickly, within the first quarter, to a monetary policy innovation. Monetary aggregates and output respond with a lag. An unanticipated tightening of monetary policy, by altering the relative returns on domestic assets vis-à-vis foreign assets, induces portfolio adjustments, which results in an appreciation in the exchange rate. This is reinforced by the subsequent rise in the demand for real domestic currency money balances. The adjustment in the exchange rate affects inflation directly, given the cost structure of domestic output and the ratio of tradeables to non-tradeables in domestic consumption. This is complemented by the dampening effect of the constraint on aggregate demand, arising from the higher interest rates. However, in the initial stages, this may be temporarily offset by a real appreciation, which encourages consumption.

Similar to previous studies, the two main channels of monetary policy that have been identified are the exchange rate channel and the credit channel. In this setting, changes in the short term interest rates affects current inflation via its impact on the exchange rate and future inflation through real interest rates, credit availability (credit channel) and hence aggregate demand. Figures 2 and 3 show the relative importance of both the exchange rate and credit channels in the transmission process.[21]

[20] The increase in consumption outweighs the decline in net external demand given its contribution to GDP.

[21] See Allen, Hall and Robinson (2002) for a description of the methodology.

FIGURE 2. TRANSMISSION CHANNELS OF MONETARY POLICY

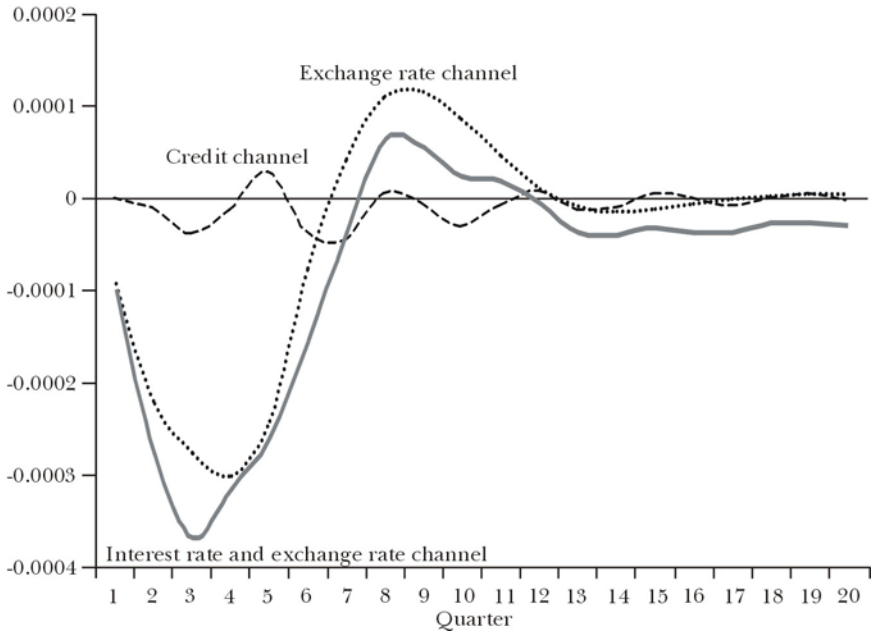
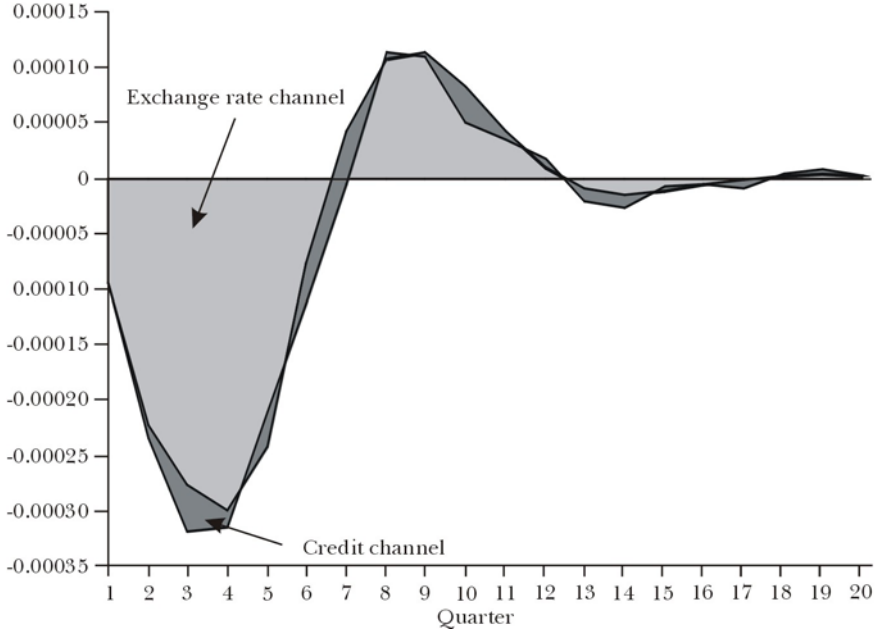


FIGURE 3. RELATIVE IMPORTANCE OF DIFFERENT CHANNELS OF MONETARY TRANSMISSION ON INFLATION



During the first two quarters after the shock the exchange rate channel constitutes the dominant conduit through which monetary policy influences inflation. Over longer horizons, beginning in the third quarter, the fall in the output gap, resulting from the credit channel, produces a subsequent slow down in inflation. The graphs demonstrate that the exchange rate channel dominates the credit channel. In the fourth quarter, for example, the fall in inflation amounting to 0.1% can be split into 0.078% reflecting the exchange rate channel and 0.022% reflecting the influence of the credit channel.

The results highlight the dominance of the exchange rate channel. Inflation, particularly since the 1990s, has been driven primarily by shocks to the exchange rate relative to demand-pull factors associated with the credit channel. The moderation in inflation over the past five years has coincided with a more stable foreign exchange market, although credit expansion, particularly during the rehabilitation period following the financial crisis, was not significant.

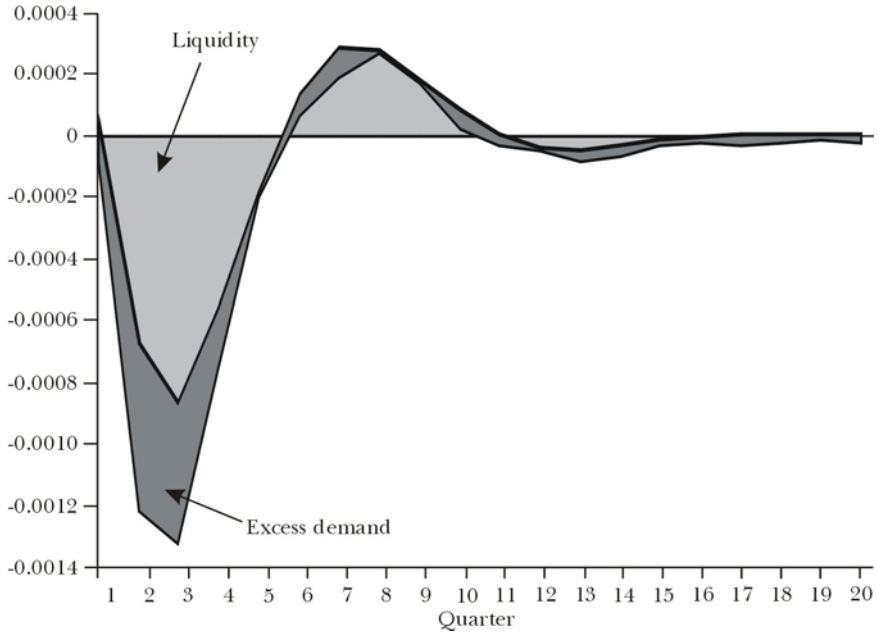
The movement in the exchange rate reflects both the portfolio decisions of investors –capital account transactions and excess domestic demand –current account transactions. In the model the former is reflected in changes in domestic currency liquidity measured by either money or reserves. The latter would be reflected in fluctuations in the output gap. Figure 4 shows the relative importance of both factors. As to be expected, liquidity effects, which in this simulation is captured by changes in M2, exerts more influence on the fluctuations in the exchange rate.[22] There is, however, a feedback relation arising from the demand for money.

Thus, the impact of domestic currency liquidity on inflation is intermediated through the exchange rate and indirectly through the output gap via changes in credit conditions, reflected in changes in bank reserves. The former conduit reflects a portfolio or wealth effect as changes in the interest differential induce portfolio shifts between domestic and foreign currency assets. Importantly, there is also a buffer stock effect which operating through the credit channel links the two conduits noted above. Changes in interest rates influence the level of credit, and consequently money, through the deposit creation process. This creates a dis-

[22] Given that agents are forward looking and form expectations rationally in this model, changes in money or liquidity conditions would influence inflation expectations. Money could also be acting as a proxy for other assets.

juncture between the supply of and demand for money, which through portfolio adjustments, is reflected in changes in the exchange rate and spending.[23]

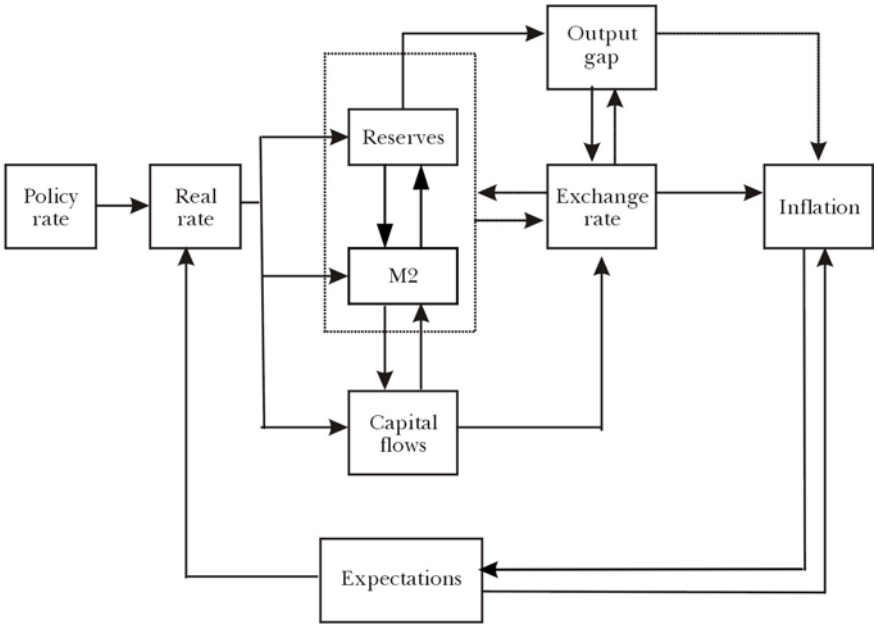
FIGURE 4. RELATIVE IMPORTANCE OF DIFFERENT CHANNELS ON EXCHANGE RATE



In summary, monetary policy has its greatest impact on inflation in the second quarter following an innovation. The simulated responses point to the fact that, particularly within the short-run, inflation stabilization is achieved mainly through the inducement of portfolio adjustment between foreign and domestic assets, which via the impact on the exchange rate, lowers the imported component of inflation. However, although relatively small, the persistent dampening effect on aggregate demand, operating through the credit channel, does constrain price movements over the longer horizon. The responses do reflect some amount of exchange rate overshooting. The schema of the transmission process

[23] Although not simulated, the buffer stock effect can also arise through a shock to the demand for money or supply (arising from fiscal policy for example), which creates dis-equilibrium. The effect of this shows up in both interest and exchange rate changes.

FIGURE 5. TRANSMISSION MECHANISM



arising from the simulations is shown in Figure 5, with the dotted lines depicting the indirect channels.

The analysis points to the potency of the use of the exchange rate as an intermediate target and short-term interest rates as the operating target. Although important to aggregate demand, liquidity conditions are more suited as an indicator for foreign exchange market developments as against a leading indicator of headline inflation directly. In this regard, although the credit channel is relatively weak, the behaviour of bank reserves or credit, as well as monetary aggregates is important. This points to the use of a monetary conditions index (MCI).

4. ALTERNATIVE POLICY SCENARIOS

Monetary policy can have disparate effects on the economy depending on the stance and the policy horizon adopted by the central bank. This section simulates the response of the economy under the following policy rules, which are forecast based or forward looking rules.

$$i_t = \theta i_{t-1} + \lambda_0 (E_t \Delta m_{t+1} - \Delta \overline{m}) + \lambda_1 (E_t y_t - \overline{y})$$

$$i_t = \theta i_{t-1} + \lambda_0 (E_t \Delta s_{t+1} - \Delta \bar{s}) + \lambda_1 (E_t y_t - \bar{y})$$

$$i_t = \theta i_{t-1} + \lambda_0 (E_t \pi_{t+1} - \bar{\pi}) + \lambda_1 (E_t y_t - \bar{y})$$

The first two are forward looking money and exchange rate rules, respectively, while the third is a forecast based inflation targeting rule. We evaluate these rules by conducting stochastic policy simulations and calculating the unconditional moments of the endogenous variables, namely inflation and output. The simulations are done with the constant removed, such that the standard deviation can be interpreted as the root mean square deviation of the variables from their targets, which is set to zero for the simulation. For comparative purposes, the values for θ and λ remain the same. The results are shown in Table 7. The table also shows the degree of exchange rate overshooting measured by the cumulative size of the deviation above the steady state divided by the number of quarters above the steady state. The smaller the average, the lower the degree of overshooting.

TABLE 7

	Inflation (%)	*Output (%)*
Baseline Rule		
Minimum	-0.03698	-0.01873
Standard Deviation	0.0104	0.005
Sacrifice ratio		-0.00059
Overshooting	0.0001	
Forward Money Rule		
Minimum	-0.04182	-0.01809
Standard Deviation	0.0099	0.005
Sacrifice ratio		-0.00068
Overshooting	0.00007	
Inflation Target		
Minimum	-0.04076	-0.01934
Standard Deviation	0.0102	0.004
Sacrifice ratio		-0.00058
Overshooting	0.00004	
Forward Exchange Rate Rule		
Minimum	-0.03778	-0.01675
Standard Deviation	0.0093	0.004
Sacrifice ratio		-0.00055
Overshooting	0.00005	

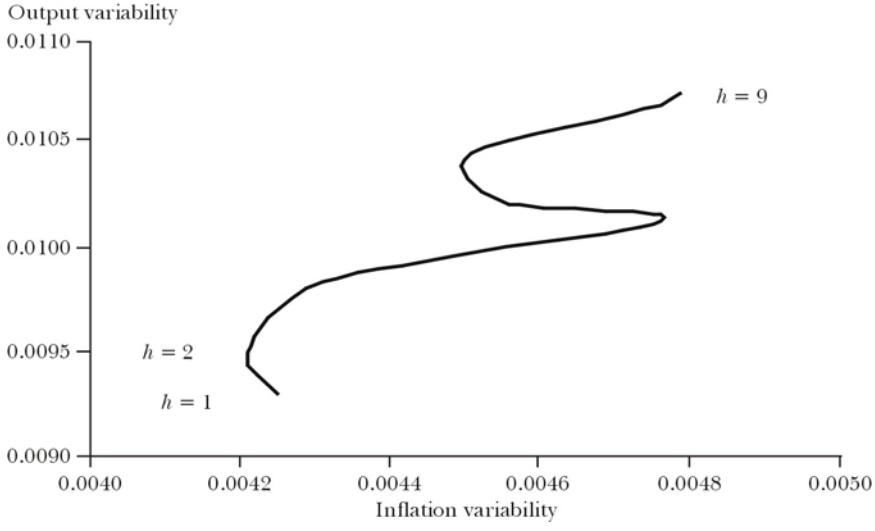
Both the forward exchange rate and inflation targeting rules result in the most stable output, with the degree of exchange rate overshooting being the lowest under inflation targeting. However, of these two regimes, the forward exchange rate rule is the

more efficient in terms of output and inflation stabilization, with the sacrifice ratio being the lowest. In other words, with this rule the central bank can achieve its target with the least impact on output.

4.1 Target horizon

Generally, the forward-looking rules are superior to the baseline rule. Forward-looking rules have been viewed, at least conceptually, as more advantageous as they explicitly account for the lags in the monetary transmission. The question for policy makers, however, is how *far forward is the looking;* that is, what horizon should we consider. In what follows we attempt to answer this question by varying the forecast horizon, h, for the forward exchange rate rule. Following, Taylor (1993) we then calculate where each value of h puts the economy on the output-inflation variability frontier. The results are shown in figure 6. The points in the southwest quadrant give the best inflation performance while simultaneously yielding the lowest output variability. From the figure it is clear that the optimal forecast horizon is positive and lies between one and two quarters ahead. During this period monetary policy has its largest marginal impact in that the interest rate and exchange rate changes required to achieve the target are minimized at these horizons. Beyond (and below) this horizon

FIGURE 6. OPTIMAL FORECAST HORIZON



the changes in monetary policy required are much greater, which results in a destabilization of output.[24]

This result follows from the lags in the monetary transmission process and as such forecast based rules are described as *lag encompassing*. In section 3.1 we saw where monetary policy had its greatest impact in the second quarter. Extending the forecast horizon beyond this transmission lag can lead to instabilities.[25]

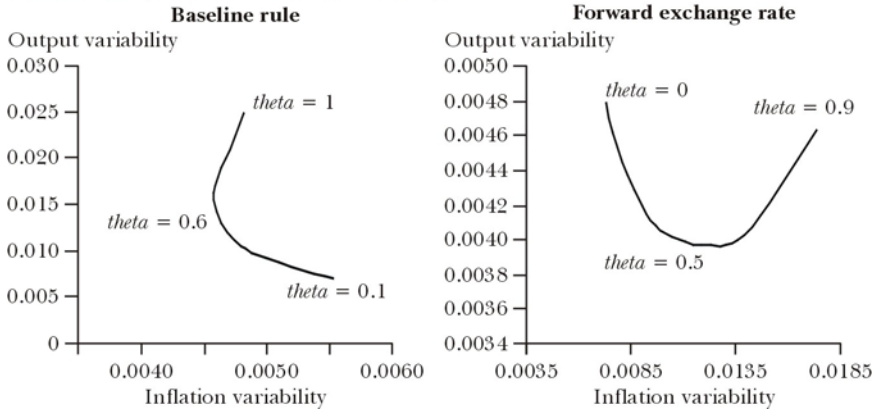
In summary, the analysis indicates that a forward-looking policy is to be preferred for Jamaica. A forecast horizon of one to two quarters delivers the best combination of inflation and output stabilization. This horizon yields the best inflation performance while simultaneously providing the lowest output volatility. This result arises out of the transmission mechanism of monetary policy.

4.2 Smoothing

The results and by extension the effectiveness of monetary policy depends on the degree of interest rate smoothing adopted by the central bank. The output-inflation variability frontiers with varying values of theta for both the base simulation and the forward exchange rule are shown in figure 7. With the baseline rule, a lower level of inflation variability can be obtained, with some increase in the degree of smoothing, without significantly impairing output stability. From the figure the optimal degree is 0.6.

Importantly, a lower level of smoothing will lead to more stable

FIGURE 7. INTEREST RATE SMOOTHING



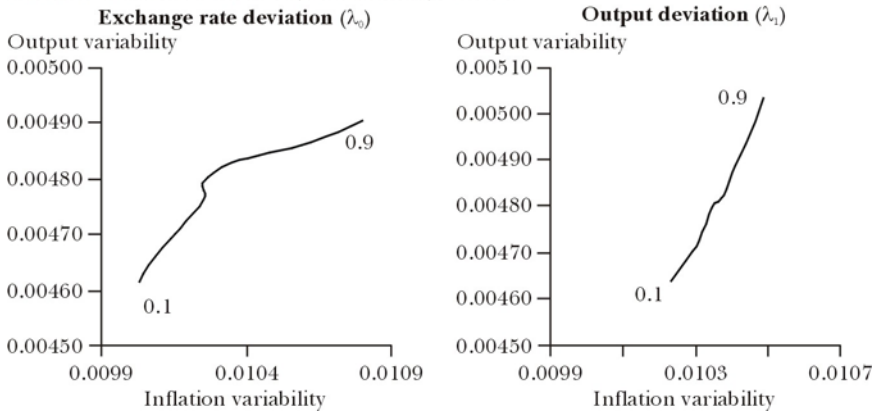
[24] Varying *j* did not alter the conclusion.
[25] See Bernanke and Woodford (1997).

output but at the expense of price stability under the current backward looking monetary policy rule. Generally, a higher degree of smoothing results in a more persistent interest rate response, which tends to have a larger impact on the exchange rate and hence inflation.[26] However, it comes at some cost to output, which from the graph can be significant. The optimal degree of smoothing under a forward exchange rate rule is not significantly different at 0.5. However, the pattern of response in the variability of output and inflation is reversed under the forward exchange rate rule. A greater degree of smoothing leads to lower inflation control but leads to greater output stability below a threshold.

4.3 Feedback response

The effectiveness of smoothing depends on the aggressiveness of policy. The welfare effects of smoothing are lower the more aggressive is policy. We therefore simulate the response of the economy with varying values of the lambdas. The higher the value, the more aggressive is policy to deviations from target. The variability frontiers are shown in figures 8 and 9 for the base simulation and forward-looking exchange rate rule, respectively.

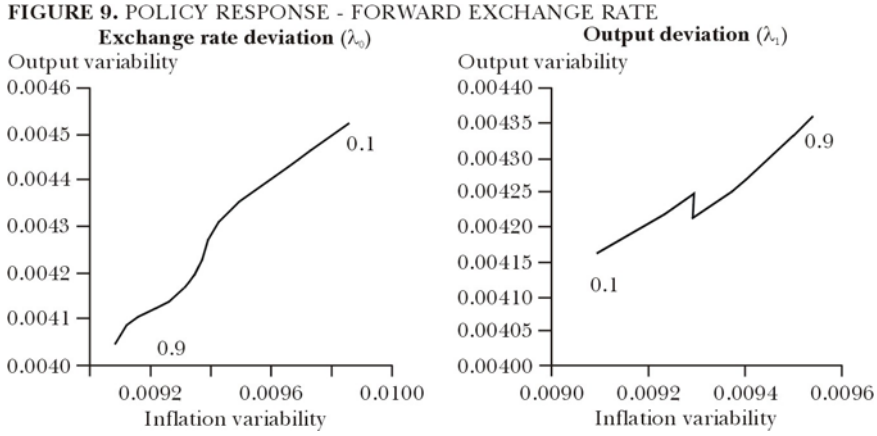
FIGURE 8. POLICY RESPONSE BASELINE RULE



Under the base rule the less aggressive is interest rate policy towards exchange rate stabilization the more stable is inflation and output. The rationale is that while aggressive monetary policy

[26] See Ball (1988).

FIGURE 9. POLICY RESPONSE - FORWARD EXCHANGE RATE



will stabilize the exchange rate, it leads to greater overshooting in the exchange rate and hence more fluctuation in prices and output in the medium term. More importantly, being more aggressive on output deviations does not lead to more stable output. Thus, placing a higher weight on inflation relative to output tends to be more welfare improving. A similar result on the relative importance of output stabilization is obtained under the forward exchange rate rule. In contrast with the base rule, however, more aggressive inflation stabilization does not lead to greater output fluctuation but both lower inflation and output variability. Thus, by adopting a forward looking rule, the monetary authority can pursue price stability without destabilizing the economy. In fact, under this rule greater price and output stability is possible. Batini and Haldane (1999) derive similar results and conclude that with forward looking rules there are gains to be had from placing a higher weight on inflation than output. This result arises from the fact that being forward looking, agents factor in a forward looking central bank's aggressiveness or anti-inflation stance in setting wages and prices. Against this background, a forward-looking rule for Jamaica would satisfy the *output encompassing* (smoothing) property of monetary policy.

4.4 Optimal policy

The previous sections evaluated various policy options based on the combination(s) that minimized the variations in output and inflation. These rules can be described as being "*efficient*".[27]

[27] See Ball (1997).

However, the optimal policy is defined as the one that minimizes the weighted sum of output and inflation variances.[28] This is the rule that minimizes the loss function of the policy maker. As such, in this section we compare the welfare loss of the above efficient rules to that of the *optimal state contingent rule*.

By setting the policy maker's discount factor to one, we can interpret the inter-temporal loss function as the weighted sum of the unconditional goal variables i.e.

$$E[L] = \theta Var(i_t - i_{t-1}) + \lambda_0 Var(\hat{\pi}_t) + \lambda_1 Var(\hat{y}_t)$$

where the hats denote the deviation of the variables from target (see Appendix A.2 for details). Table 8 compares the stochastic welfare loss from the optimal rule with the other policy rules. The welfare loss of the optimal rule is significantly lower than all the alternatives, however, what is important for the analysis is the comparative differences. Both the inflation targeting and forward exchange rate rule do better than the baseline and forward money rules. However, the difference in the welfare losses with that of the optimal state contingent rule is smallest with the forward looking exchange rate rule based on the one-quarter ahead horizon.

TABLE 8

	σ_π	σ_y	*Loss*	*Rank*
Optimal	0.0008	0.0007	0.0046	0
Baseline Rule	0.0104	0.005	1.1215	10
Forward Money Rule	0.0099	0.005	0.7059	9
Inflation Target				
(h=1, j=0)	0.0102	0.004	0.7021	7
(h=1, j=1)	0.0104	0.004	0.7129	8
(h=2, j=0)	0.0099	0.005	0.6881	6
(h=2, j=1)	0.0098	0.004	0.6402	5
Forward Exchange Rate Rule				
(h=1, j=0)	0.0093	0.00425	0.5905	1
(h=1, j=1)	0.0097	0.00408	0.6321	3
(h=2, j=0)	0.0095	0.00421	0.6119	2
(h=2, j=1)	0.0098	0.00394	0.6371	4

In general the forward-looking exchange rate rule takes us closer to the bliss point. This arises because such rules are conditioned on all the state variables that affect the future dynamics of inflation just as the optimal rule does.

[28] See Taylor (1994).

5. CONCLUDING REMARKS

In this paper we developed a small-scale macroeconomic model for the Jamaican economy. We used this model to simulate the impact of different shocks on the path of key variables in the model, namely inflation and output. In spite of its simplicity, the model captures the essential dynamics of the economy and hence the transmission mechanisms of monetary policy.

The analysis concentrates on the efficacy of different 'policy rules'. In practice there is no precise rule for all times, as to every rule there is an exception. What is important to the policy maker from this analysis is the emphases for policy that such mathematical rules embody in terms of the target variable, aggressiveness and horizon.

In this context, a number of conclusions on the future direction of policy emerge from these results:

i) In general, the welfare assessment indicate that monetary policy, at least in the near term, should continue with the current inflation targeting *lite* regime, with the change in the exchange rate being the intermediate target and interest rates the operating instrument. This is notwithstanding the fact that there is no significant difference in the welfare gains between this regime and a full-fledged inflation targeting regime. The central bank may have to continue with the current regime for some time as exchange rate movements are critical in the formation of inflation expectations and hence, for credibility, exchange rate changes should continue to serve as an important anchor for monetary policy. As the exchange rate pass-through wanes and the central bank's credibility becomes entrenched,[29] the monetary authority could move to a full-fledged inflation targeting regime.

ii) The central bank should, however, adopt a more forward-looking perspective to monetary policy. That is, it should incorporate more explicitly and apply a greater weight to the forecasts of macroeconomic variables when deciding the timing and degree of adjustment of interest rates, than on past information. Specifically, because monetary policy has the greatest impact up to two quarters, the forecast of the intermediate variable over this horizon should carry more weight in the de-

[29] This would be enhanced by reforms that insulate the central bank from fiscal dominance.

cisions on interest rates. This will require the use of forecasting models, as well as market intelligence.

iii) Although the monetary targets are replaced by the changes in the exchange rate as the primary intermediate target, they still convey important information on the stance of monetary policy and signals for potential changes in market conditions. In this vein the paper recommends:

   a) The range of indicators, such as excess reserves, credit market conditions or an MCI should feature more prominently in the analysis of liquidity conditions.

   b) The regular monitoring of base money indicators should be over a two-quarter horizon, in the minimum. More importantly, the forecasts thereof should be complemented with projections for the multiplier. This would permit a comparison between the projection for money supply and money demand. This juxtaposition can yield important insights as to the likely behaviour of asset markets.

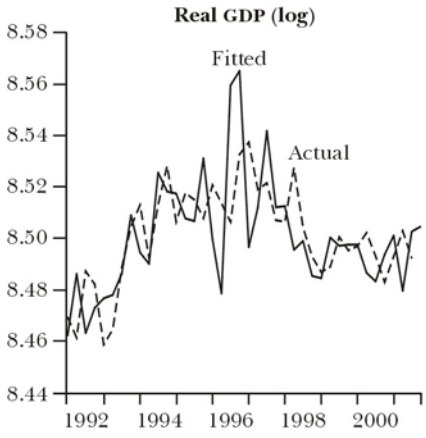
iv) The central bank should continue its strong preference for price stability viz a viz output stability. However, there are gains to be had from minimizing sharp movements in interest rates.[30]

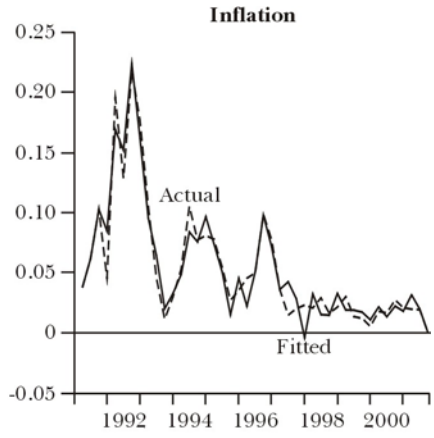
In terms of future work, there is a need to revisit a number of issues related to the design and implementation of monetary policy. These include the definition of money or liquidity and the determination of the market yield curve.

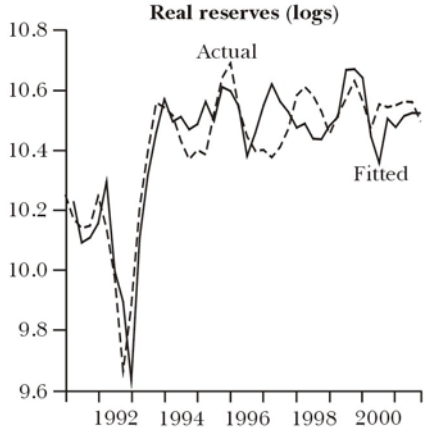
Appendix A.1

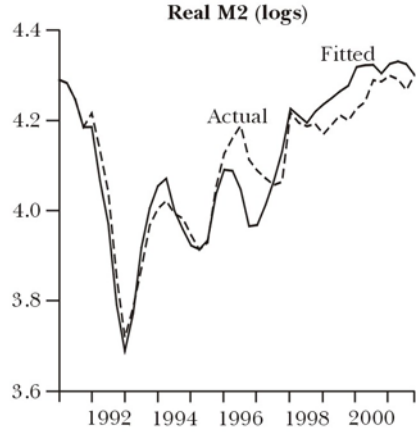
Model performance

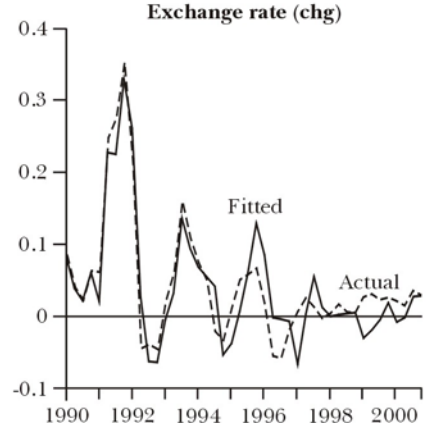
[30] Understandably, shocks to the economy could necessitate sharp monetary policy adjustments.


Real GDP (log)
Fitted
Actual
8.58
8.56
8.54
8.52
8.50
8.48
8.46
8.44
1992
1994
1996
1998
2000


Inflation
Actual
Fitted
0.25
0.20
0.15
0.10
0.05
0
-0.05
1992
1994
1996
1998
2000


Real reserves (logs)
Actual
Fitted
10.8
10.6
10.4
10.2
10.0
9.8
9.6
1992
1994
1996
1998
2000


Real M2 (logs)
Fitted
Actual
4.4
4.2
4.0
3.8
3.6
1992
1994
1996
1998
2000


Exchange rate (chg)
Fitted
Actual
0.4
0.3
0.2
0.1
0
-0.1
1990
1992
1994
1996
1998
2000

Appendix A.2

Optimal policy rule

The model can be re-written in the following state-space form

$$X_{t+1} = AX_t + Br_t + CZ_t + v_{t+1} \tag{A.1}$$

where

$$X_t = [\pi_t, \Delta s_t, \Delta s_{t-1}, \Delta s_{t-2}, y_{t-1}, \Delta y_{t-1}, \Delta y_{t-2}, r_t, r_{t-1}, \Delta r_{t-3}, \Delta res_{t-1}, \Delta res_{t-2}, \Delta res_{t-3},]'$$

$$Z_t = [\bar{y}_{t-1}, \Delta p^*_t, \Delta p^*_{t-1}, \Delta p^*_{t-2}]'$$

$$B = [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0]'$$

A is a 20 x 20 matrix and C is a 4 x 4 coefficient matrix constructed from the results of the estimation in section 2[31] v is 20 x 1 disturbance vector and Z is a vector of exogenously given variables. The 3 x 1 vector of goal variables is given by

$$Y_t = D_x X_t + D_r r_t \tag{A.2}$$

where $Y_t = [\hat{\pi}_t, \hat{y}_t, (r_t - r_{t-1})]'$, $D_x = [e_1, e_9, -e_{14}]'$, $D_r = [0,0,1]'$, where e_j for j=0,1,.....20, is a 1 x 20 row vector for j=0 with all elements equal zero and for j=1, …20, with element j equal to one and all other elements equal to zero.

The inter-temporal loss function for the policy maker is given by

$$E_t \sum_{\tau=0}^{\infty} \delta^\tau [(\pi_{t+\tau} - \bar{\pi})^2 + \lambda_0 (y_{t+\tau} - \bar{y})^2 + \lambda_1 (r_{t+\tau} - r_{t+\tau-1}) \tag{A.3}$$

Minimizing equation (A.3) with respect to r_t, subject to (A.1) yields the following class of linear feedback rule

$$r_t = fX_t$$

In the limit the unconditional loss function is

$$E[L_t] = E[Y_t' K Y_t] = trace[K\Sigma_{yy}]$$

where we set $K = \begin{pmatrix} 0.6 & 0 & 0 \\ 0 & 0.4 & 0 \\ 0 & 0 & 0.6 \end{pmatrix}$ and the optimal instrument rule is

[31] These are available from the authors upon request.

$$f = -(D_r' K D_r + B' V B)^{-1} (D_x' K D_r' + B' V A)$$

where V is the Riccati equation

$$V = D_x' K D_x + D_x' K D_i f + f' D_x' K D_i' + f' D_i' K D_i f + M' V M$$

$$M = A + Bf$$

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A look at inward foreign direct investment transactions for Barbados

1. INTRODUCTION

Foreign direct investment (FDI) is described by the World Bank (2002) as investment made to acquire a lasting management in an enterprise operating in a country other than that of the investor. It is generally defined as the holdings of ten percent or more of the voting stock of a foreign enterprise. In Barbados, FDI consists mainly of equity capital, retained earnings and loans from a parent company. Unlike commercial lending, it comprises part of a package of technology and management, both of which can boost productivity. These factors commend FDI for financing in developing countries.

Despite the importance of FDI in Barbados, there has been little empirical work on this topic as it relates to that country. FDI not only boosts Barbados' foreign reserves, which are the lifeblood of the economy, but it can also generate employment in the

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country. As employment rises, Government's tax intake is likely to expand and with rising tax revenue, government is in a better position to use some of these funds to improve the country's infrastructure. It is because of the above-mentioned reasons that a study of this nature has been undertaken.

The paper is organized as follows. Section 2 looks at a review of the literature on some aspects of FDI. Section 3 focuses on FDI trends in Barbados, its composition, and the geographical origin of FDI inflows The fourth section attempts to identify possible variables that may impact on FDI both in the long and short run using regression analysis and annual data spanning from 1970 to 2003 as well as a discussion of the results and this is followed by a conclusion.

2. A LITERATURE REVIEW SOME ASPECTS OF FOREIGN DIRECT INVESTMENT

Over the years, a significant amount of work has been done on FDI. Campbell (2003) sought to ascertain the impact of FDI on Barbados' external current account between 1970-1999, using regression analysis and annual data. The result showed that FDI impacted negatively on the current account both in the short run and long run. This implied that any benefits to Barbados arising from FDI transactions would be possibly offset by imports and the repatriation of profits to abroad, thereby exerting pressure on the country's foreign reserves.

Belgrave and Ward (1997) estimated the impact of FDI on the Barbados economy using data for 255 firms over the period 1985 to 1995, with the specific reference to the manufacturing sector. They looked at the influence of foreign equity on the survival of manufacturing firms, utilizing a binary-choice probit model. The results showed that the foreign equity variable did not explain firms' survival. Even when the sample was disaggregated by sector, the same result was obtained.

Recent literature emphasized the importance of exchange rate movements in determining FDI inflows. There was a school of thought that (expected) changes in the level of the exchange rate would not alter the decision by a firm to invest in a foreign country. While an appreciation of a firm's home country's currency would lower the cost of assets abroad, the (expected) nominal return goes down as well in the home currency, leaving the rate of return identical. However, Froot and Stein (1991) used a differ-

ent line of reasoning in suggesting that low values of the host country encouraged FDI. They focused on entry by acquisition and argue that currency depreciations make acquisitions by foreign firms more profitable by creating undervalued assets.

Hartman (1984) tested the impact of taxes on FDI by examining the behaviour of foreign affiliates in the United States of America (USA). The author was only able to gather data on the tax rates and returns of the host country (USA), but not the tax rates and returns of the parent (foreign) country. Thus, he separately regressed retained earnings FDI and new transfer FDI on the host country's tax rate, not controlling for these unobservable parent country tax rates. He found that retained earnings FDI responded significantly to the host country's tax rate. Transfer FDI, however, did not respond significantly to host country tax rates which could then be explained by not controlling for parent country tax rates (and differences in returns across the countries).

The literature was also consistent in arguing that FDI flows depended on the GDP (or the rate of growth of GDP) in both the home and host country. GDP in the host country was expected to attract FDI both because it suggested profitable investment opportunities and because the domestic funds for financing the investment were more readily available (Caves, 1989). GDP in the home country was also important, but the direction of the effect was ambiguous. A positive relationship to FDI might be expected for two reasons: the larger the GDP, the greater was the potential number of firms that could engage in FDI; and high GDP created the liquidity to finance FDI (Grosse and Trevino, 1996). A negative relationship might be expected because high or rising GDP made domestic investment more attractive relative to foreign investments (Caves, 1989).

Another strand of determinants was relative factor cost. Relative factor cost differentials are created by differences in productivity growth and differences in factor prices. The most consistent measure of relative factor cost is wages, a variable that is commonly used. Thus we expect that when wages in the host country rise relative to those in the home country, FDI is discouraged (see Globerman and Shapiro, 1998).

Government policies could also influence the attractiveness of the host country to foreign investors more directly through tax and regulatory initiatives. The priori expectation is that, other things being equal, increased business regulations will have the same effect by increasing the costs of doing business in the host country. Indirect policies such as screening agencies to review

FDI proposals could be seen as forms of business regulation directed specifically at foreigners, thereby discouraging inward FDI. However one prominent exception was stated by Kurdle (1995) who analysed U. S. FDI in Canada over time, with specific reference to the role of the Foreign Investment Review Act. He found that the Act had minimal impact on FDI inflows from the United States to Canada.

Codrington (1987) analysed the pattern of FDI inflows to Barbados between 1977 and 1985, noting that most of those flows went to public utilities, manufacturing and tourism activities. In the case of public utilities, most of the funding was provided by non-resident enterprises with a major controlling interest in the sale of telephone and electricity services. As for manufacturing, the Industrial Development Corporation was established in 1969 to attract FDI and a ten-year holiday was granted to manufacturers selling their total output outside of the Caribbean Community (CARICOM). Between 1977 and 1985, foreign ownership was most pronounced in the metals group where 83 per cent of the firms had at least 25 percent ownership. In the case of tourism, the Hotel Aids Acts of 1956 was the earliest attempt to develop the tourist industry in Barbados, exempting building materials and equipment for hotels from customs duties and permitting a seven-year tax holiday for some establishments. The formation of the Board of Tourism two years later also provided further stimulus to the industry. By 1970, North American and the United Kingdom interest controlled a large proportion of the available capacity. Fifteen years later, just over one half of the establishments had at least 25 percent ownership.

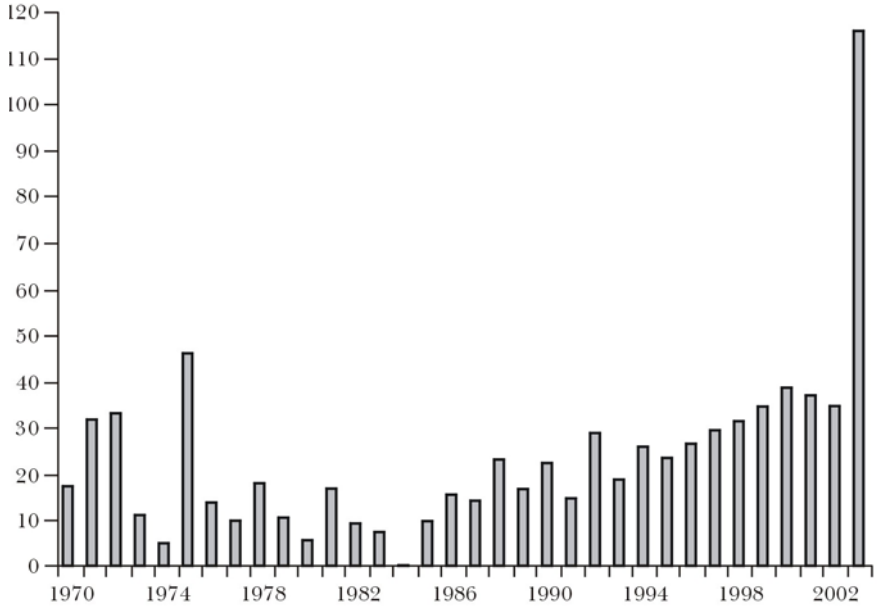
3. TRENDS IN FDI INFLOWS INTO BARBADOS

During the 1970s and early 1980s, long-term capital inflows averaged around $40 million per annum. FDI dominated these inflows, comprising mainly loans from parent companies to their branches and subsidiaries and undistributed earnings.

Although FDI inflows were less dominant compared to other investment capital inflows after 1985, their contribution to the development of Barbados still remained important. According to Codrington (1987) when details on the sectoral performance became widespread, FDI was dominated by manufacturing and oil companies which together accounted for seventy-eight percent of the total. Between 1977 and 1985 most foreign firms were in the

sub-sectors producing electronic components and clothing. They accounted 71% of direct investment in manufacturing. Firms, which assembled electronic components, attracted roughly three-fifths of branch investments and parent company loans, while producers of textiles received one-third of the reinvested earnings and accounted for nearly all market loans. Overall manufacturing attracted 10% of all foreign capital inflows during the period and about 32% of all direct investment.

FIGURE 1. FDI INFLOWS INTO BARBADOS, 1970-2003 (Bds$millions)



In the remaining period from 1986-2003, there was a steady increase of FDI into Barbados. During this interval total FDI inflows totalled $553 million, an average of $34.5 million per year. The highest level of FDI inflows occurred in 2003 when $116.5 million was recorded (see Figure 1), more than triple the amount the previous year. This high figure occurred mainly on the strength of the acquisition of a privately held local company by a foreign institution and to a lesser extent, higher investment in branches as well as an increase in undistributed profits. Prior to 1996, investment in branches was significantly higher than undistributed earnings but after 1996, the latter accounted for more than half of FDI.

According to the United Nations Conference on Trade and Development's (UNCTAD) Foreign Direct Investment (FDI)/ Transnational Corporation's (TNC) World Investment Report (2003), between 1990 and 2002, Canada has been Barbados' highest foreign direct investor, investing over $100 million during the period, an average of $8.3 million dollars annually. This was followed by the USA and then United Kingdom although investment from the latter appeared to have ceased after 1994. Other foreign direct investors during this period included China, Colombia, Germany, Malaysia and Republic of Korea.

The data in the above-mentioned Report showed that during the international recession of 1990 to 1992, foreign direct investment by Canada into Barbados expanded from 68.1% of total FDI to 86.1%. On the contrary FDI by UK declined from 18% to 4.7% while in the case of the USA, although its FDI into Barbados increased, its contribution to overall FDI was substantially slower during that period. Consequently, FDI into Barbados as a percentage of total FDI inflows moved downwards from 13.9% to 9.2%. China and Colombia both invested less than 1% into the Barbados economy during these three years.

The period from 1993 to 2000 was one where the Barbados economy recorded eight consecutive years of economic growth. During these eight years, Canadian FDI into Barbados grew steadily from 84.5% of total FDI into Barbados in 1993 to a high of 91.6% in 1997. FDI by Canada into Barbados continued to rise in the years that followed but its percentage of total FDI contracted to around 84% in 2000 as a result of rising FDI inflows into Barbados by other countries, especially the USA. The FDI pattern of the USA fluctuated somewhat from 10.7% in 1993, to 9.2% in 1994, then rose by five percentage points in 1995 and reached its highest rate of 18.8% of total FDI by 1999. However in the three years that followed, FDI from the USA into Barbados fell dramatically and at end-2002, reached 13.7% of overall FDI into Barbados.

4. IDENTIFYING VARIABLES THAT IMPACT ON FDI INFLOWS INTO BARBADOS

a) Model specification

Having been guided to some extent by the work of the authors mentioned in the literature review in section 2, we have identified

variables that are likely to impact on FDI into Barbados and our model of FDI inflows may be expressed as follows:

$$\underset{?}{FDI} = f(\underset{+}{YF}, \underset{-}{YD}, \underset{-}{RINT}, \underset{+}{PD} \underset{-}{PF} \underset{}{RW}) \quad (1)$$

where FDI is real foreign direct investment, YF is real foreign income, YD represents real domestic income, RINT is relative interest rates, PD is the domestic price variable, PF is the foreign price variable and RW represents relative wage costs. The signs under the explanatory variables indicate the expected relationships with the dependent variable.

The model is being estimated in logarithms so that it can be written in the following manner:

$$LFDI = \beta_0 + \beta_1 LYF + \beta_2 LYD + \beta_3 LRINT + \beta_4 LPD + \\ + \beta_5 LPF + \beta_6 LRW + U_t \quad (2)$$

where β_1 either ≤ 0 or ≥ 0, $\beta_2 \geq 0$, $\beta_3 \leq 0$, $\beta_4 \leq 0$, $\beta_5 \geq 0$, $\beta_6 \leq 0$ and U_t is the error term.

The impact of foreign income on FDI inflows into Barbados may be ambiguous depending on whether the higher income would cause more foreign firms to invest in Barbados or whether the higher income would make domestic investment in the home country more attractive than foreign investment. Higher real domestic income should boost FDI inflows on the strength of more profitable investment opportunities and more readily available domestic funds for financing. An increase in domestic interest rates relative to those in the home country is likely to discourage FDI inflows to Barbados, resulting in a negative relationship between the two variables. Finally, an expansion in the domestic wage costs relative to that in the host country is anticipated to impact unfavourably on FDI in the recipient country.

b) Data and variables

The sample period for the present study is largely dictated by the availability of data. This study utilizes annual data from 1970 to 2003. The source of data is the Annual Statistical Digest of the Central Bank of Barbados, the Balance of Payments of Barbados and the International Financial Statistics Yearbook of the International Monetary Fund (IMF). FDI is deflated by gross domestic product (GDP) for Barbados and is used as the measure of real FDI.

We use Barbados' consumer price index to measure domestic prices and the consumer price index of the USA as a proxy for foreign prices, since the USA is one of Barbados' major investors. We expect that as domestic prices rise, the economic climate would be less attractive for foreign countries to invest in Barbados and FDI inflows should contract. Likewise if prices in the home country increase, it may be advantageous for such countries to invest abroad and Barbados may be the beneficiary of such FDI inflows. Real foreign income is the combined income of the USA, UK and Canada. It is calculated by taking the real GDP of each country, weighting each number by the share of visitor arrivals for the respective country and then summing them. Real domestic income is proxied by the real GDP of Barbados. The wage indices for Barbados and the USA are being used as proxies for wages in Barbados and abroad. In all cases, the base year used is 1990.

c) Results

It has been discovered that, using the Johansen (1988) procedure, only one cointegration relationship exists. Consequently, the Engle-Granger (EG) two-step method can be applied in this paper. In this method, the coefficients from the cointegrating regression are estimated and then the residuals from the estimate are taken and used in their lagged form in a vector autogression (VAR) of the changes of the explanatory and dependent variables. This method is preferred to the Johansen (1988) maximum likelihood method because it is more powerful in small samples (see Inder, 1993, pp. 53-68).

The order of integration for each series was determined by the use of an Augmented Dickey-Fuller (ADF) test, which is a test of the null hypothesis of non-stationarity or unit root (integrated of order d or I(d) where $d \geq 1$ against the alternative hypothesis of stationarity (or integrated of order zero or I(0)). The ADF tests of the differences of each variable indicate that all of the variables are integrated of the first order, that is, I(1) (see table 1). The long-run results are shown in equation 3.

$$LFDI = 9.00 + 0.01YF + 0.03YD - 0.03INT + \\ + 0.33PF - 0.30PD - 0.034RW \qquad (3)$$

$R^2 = 0.66$; Adj $R^2 = 0.58$; Durbin Watson (DW) = 2.06;
ADF = -5.81 (-2.95); PP = -6.32 (-2.95)

Equation 3 is known as the Engle-Granger (EG) cointegrating regression. It should be stated, however, that on account of the small sample size, the bias in the EG estimators could be significant. Consequently, the standard errors and t-values of the estimated regression coefficients are not reported as these statistics are not significant (for further reading, see Banerjee, Dolado, Hendry and Smith, 1986, pp. 253-278).

TABLE 1

Variables	*Level*	*First Difference*	*Critical Value (5%)*
FDI	-2.911	-7.226	-2.96
Y_f	-1.149	-6.469	-2.96
Y_d	-1.384	-3.521	-2.96
INT	-2.216	-4.979	-2.96
Pd	-1.601	-4.400	-2.96
P_f	-2.439	-5.955	-2.96
W	-2.096	-3.429	-2.96

SOURCE: EVIEWS 5.0.

The results in equation 3 indicate that all of the variables are cointegrated since the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests reject the null hypothesis of stationarity at the 5% level of significance. The Durbin-Watson (DW) statistic indicates no first order serial correlation.

All of the variables have the correct sign. Equation 3 shows that in the long run, the variables impacting most on FDI inflows into Barbados are domestic and foreign prices. A per unit increase in domestic prices would decrease FDI inflows into Barbados by $0.30 whereas a per unit rise in foreign prices would expand FDI transactions in Barbados by $0.33. The results also indicate that rising relative interest rates will negatively impact on FDI inflows into Barbados while Barbados will benefit higher FDI as a result of increases in real foreign and domestic incomes.

Let us now focus on the short-run determinants of FDI into Barbados. In this regard, we use the error correction model, which nests long-run behaviour and short-run dynamics. Following Engle and Granger (1987), an error correction model of variables can be formulated as long as those variables are cointegrated. We further apply the Hendry General to Specific Methodology, which commences with a model that is over-parameterised and with the use of a step-wise process, eliminates all insignificant variables until a parsimonious representation of the model is attained. Before reaching our solution, both current

and lagged variables were considered, however our model was restricted to two lags on account of the small sample size. The results are now shown in equation 4.

$$\begin{aligned}\Delta FDI = {} & -0.524 + 0.24\Delta FDI_{-1} - 0.01\Delta YD - 0.005\,\Delta YD_{-1} - 0.26\Delta PD - \\ & \quad (-0.94) \quad (2.90) \qquad (-2.70) \qquad (-4.03) \qquad (-3.97) \\ & -0.17\Delta YD_{-1} + 0.52\Delta PF - 0.014\Delta RINT - 0.016\Delta RINT_{-1} - \\ & \quad (-2.19) \qquad (2.80) \qquad (-2.18) \qquad (-2.19) \\ & - 0.02\Delta RINT_{-2} - 0.84U_{t-1} \qquad (4) \\ & \quad (-2.31) \qquad (-5.98)\end{aligned}$$

$R^2 = 0.88$; Adj $R^2 = 0.83$; DW = 1.76; B-G (prob = 0.74); NORM (prob = 0.71); ARCH (prob = 0.79); ADF = -5.28 (-2.96); PP = -5.30 (-2.96)

The numbers directly the coefficients are the "t" statistics while U_{t-1} is the error correction term lagged one period. All other variables have been addressed before. Δ is the first difference operator, B-G is the Breusch-Godfrey Lagrange multiplier test for serial correlation and NORM is the Jarque-Bera test for normality based on a test of kurtosis and skewedness of the residuals. ARCH is the Engle's k^{th} order autoregressive conditional heteroscedasticity test statistic.

The results of equation 4 suggests that the model is adequately specified and satisfy the classical assumptions of normality, homoscedasticity and serial dependence. The R^2 and Adjusted R^2 values show that the model is a good fit. Five variables help to explain FDI inflows into Barbados in the short run, namely, real current and lagged domestic income, current and lagged domestic prices, lagged foreign prices, current and lagged relative interest rates and FDI inflows lagged one period. Real foreign income has no impact on FDI inflows into Barbados in the short run, suggesting that when real foreign incomes rise, persons may be more interested in other areas such as long-stay and cruise travel to Barbados rather than in direct investment. Further, all of the independent variables are highly significant with none of them falling below the 5 percent level of significance.

A per unit rise in domestic prices would reduce FDI inflows by $0.43, while on the contrary, a similar increase in foreign prices which would boost FDI transactions by $0.52. In both cases, the short run impact of these variables on FDI into Barbados is greater than that over the long run. The case of relative interest

rates is interesting, in that not only is FDI affected by current interest rates but also by rates lagged one and two periods. Real domestic income will impact positively on FDI inflows but the relationship is not a strong one while the short run adjustment of FDI inflows is $0.24. The error term is negative and significant as required, thereby confirming the long-run cointegrating results and its coefficient of 0.84 indicates a fairly rapid of adjustment to its new long-run equilibrium relationship.

5. CONCLUSION

The paper attempts to analyse inward FDI transactions for Barbados between 1970-2003. During this period most of Barbados' FDI came from Canada while the UK played a significant investing role in the early years but this waned after 1995. Investment from the USA was relatively small up until the early nineties but started to expand around 1996 and has remained high ever since. Indeed despite Canada's dominance with regard to FDI, its ratio to total FDI has fallen somewhat because of the sharp increases in FDI from the United States. It is also interesting to observe that countries such as China, Malaysia, Germany, Columbia and Republic of Korea have been investing in Barbados, although their share of total FDI into Barbados is small to date.

As far as identifying variables that explain FDI into Barbados is concerned, this paper shows that in the long run FDI will be influenced by real domestic and foreign income, domestic and foreign prices, relative interest rates and relative wages. In the short run, FDI will be influenced by real domestic income, relative interest rates, domestic and foreign prices and FDI lagged one period.

It is clear therefore that if Barbados is to attract additional FDI to its shores, it must have the appropriate investment climate to achieve this objective. For example, it will be necessary for the country's domestic incomes to rise if FDI is to expand in Barbados. If this is to occur, then real economic activity in Barbados must increase. However, the Government of Barbados must ensure that the foreign exchange capacity of the country is adequate in this regard, otherwise higher incomes may result in a rise in imports, which may in turn, undermine the balance of payments and the foreign reserves. The results of this study also imply that it is in the interest of Barbados to ensure that its wage levels and interest rates are not too far out of line with its competitors, since

these have the potential to drive foreign direct investors to other destinations. Finally, it is important to Barbados that over the medium and long term, the global economy remains robust since, in this way, the profitability of businesses is likely to be boosted and Barbados could benefit from a rise in FDI.

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Brigitte Desroches

The transmission of world shocks to emerging-market countries: an empirical analysis

1. INTRODUCTION

The first step in designing effective policies to stabilize an economy is to understand business cycles (Lucas, 1977). The central stylized fact of an international business cycle is that when one country's output is above (below) its trend, the output of many other countries also tends to be above (below) their trend. No country is isolated from the world economy and external shocks are becoming increasingly important. With the accelerating pace of globalization, the question of how different countries react to different shocks has gained heightened significance.

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The study of co-movement, or integration, is important because its results can guide policy in an era of accelerating globalization. This paper identifies the channels of business cycle transmission to evaluate the extent to which economic fluctuations in the emerging-market (EM) countries are caused by shocks that originate in industrialized countries.

The paper documents the sources of macroeconomic fluctuations in EM countries (focusing on Asia and Latin America) by measuring the relative importance of domestic and external shocks. Previous studies have typically examined only industrialized countries. Although there is no a priori reason to believe that business cycles are transmitted differently to industrialized and EM countries, there could be interesting differences in the way EM countries import business cycle disturbances. The results of this study on EM countries could help policy-makers design more appropriate policies for those countries. For example, this paper helps explain the relative importance of the different shocks that drive output and real exchange rate fluctuations in EM countries. Consistent with the Mundell-Fleming model, two specific shocks are measured that could be transmitted from one country to another: a world real output shock and a world real interest rate shock. To assess whether the discrepancies in the transmission of shocks among countries is due to different economic structures or to the exchange rate regime, this paper divides the sample into groups of countries, based on the region to which a country belongs, its openness to trade, its exchange rate regime, and its capital flows.

This paper contributes to the literature in three ways. First, country characteristics are used to determine the source of the divergent responses to shocks for the different EM countries. Second, the sample analyzed contains 22 EM countries, considerably more than is typically found in the literature.[1] Third, this paper treats world variables as being exogenous, considering all EM countries to be small open economies.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature. Section 3 presents the empirical framework and section 4 provides details on the data and the specification of the model. Section 5 summarizes the results and presents the different groups of countries. Section 6 concludes.

[1] For example, Hoffmaister and Roldós (1996) examine the case of Brazil and Korea, Kydland and Zarazaga (1997) analyze the case of Argentina, and Rodríguez-Mata (1997) studies economic fluctuations in Costa Rica.

2. REVIEW OF THE LITERATURE

There is a substantial literature on the transmission of business cycles. As well, the idea that fluctuations in the developing South are caused largely by shocks that originate in the industrialized North is widely studied in the traditional North-South literature. The basis of the argument is that the South specializes in the production of primary goods and therefore relies on the North for its manufactured goods and for demand for its primary output. Kouparitsas (1996) builds a general-equilibrium model of North-South trade and finds that it contains a strong mechanism for the transmission of business cycles from one region to the other. In his model, 70 per cent of the variation in Southern consumption is caused by Northern aggregate output.

The most commonly used empirical framework in the literature is a small open-economy version of the structural vector autoregression (SVAR) model proposed by Blanchard and Quah (1989). The SVAR model adds economic restrictions to an otherwise statistical model to identify the sources of macroeconomic fluctuations. SVARs are widely used, because they provide an appropriate framework in which to examine the transmission of shocks. Researchers can identify the relevant shocks and describe the response of the system to shocks by analyzing impulse responses (the propagation mechanism of the shocks) as well as variance decompositions.

Using the empirical framework identified above, Hoffmaister and Roldós (1997) compare business cycles in Asia and in Latin America using panel data. They confirm the stylized facts that earlier studies have found for the U.S. economy: the main source of output fluctuations is domestic supply shocks, even in the short run.[2] External factors account for approximately 20 per cent of output movements. Hoffmaister and Roldós also conclude that, in Latin America, external shocks (particularly world interest rate shocks)[3] and demand shocks affect output fluctuations more than in Asia.

Other studies analyze stylized features of macroeconomic fluctuations. For example, Agénor, McDermott, and Prasad (2000) find that there are many similarities between macroeconomic

[2] Similar conclusions are reached in Hoffmaister and Roldós (1996), which analyzes Brazil and Korea.

[3] This is consistent with the important role that Calvo, Leiderman, and Reinhart (1994) assign to world interest rate shocks.

fluctuations in EM and industrialized countries, as well as important differences. Some of the studies focus on specific stylized facts and then construct theoretical models that can replicate those facts; e.g., Kydland and Zarazaga's (1997) work on Argentina and Rodríguez-Mata's (1997) analysis of fluctuations in Costa Rica. In all studies, industrialized countries are found to have a significant impact on EM economies. For example, a study by the International Monetary Fund (IMF, 2001) shows that a 1 per cent change in G-7 growth is associated with a 0.4 per cent change in growth in developing countries. Their results also show that a 1 per cent fall in world real interest rates translates into a 0.3 per cent increase in the growth of developing countries. However, most of the studies based on stylized facts focus on unconditional correlations between different variables (e.g., output, exchange rates, and prices). In such a framework, the unconditional correlations may be small, because they average the effects of different types of shocks. It is therefore important to develop and estimate a structural model.

3. EMPIRICAL FRAMEWORK

This section describes the empirical framework used in this study. Most previous researchers follow the SVAR model proposed by Blanchard and Quah (1989).[4] It is useful because it relies on long-run restrictions that stem from economic theory. In this study, however, the short-run dynamics are unrestricted, and therefore the empirical framework chosen differs by treating the world aggregates as being exogenous. Consequently, EM countries have no impact on world variables in the long run or the short run.

The empirical model permits an assessment of the importance of external shocks relative to domestic shocks in explaining macroeconomic fluctuations in EM countries. The world aggregates are treated as being exogenous and the EM countries' domestic variables are treated as being endogenous. The foreign shocks are identified by a small-economy assumption. The implication of using such a framework is that domestic variables are not allowed to affect world aggregates in the short run or the long run. This framework is realistic because the analysis considers EM countries.

[4] This methodology is also proposed by Shapiro and Watson (1988), and extended to large open economies by Clarida and Gali (1994).

The structural form of the model is:

$$A_0 y_t = (B_0 x_t + A_1 y_{t-1} + u_t) , \tag{1}$$

where x_t is a vector of exogenous variables (i.e., world real output and interest rates), y_t is a vector of endogenous variables (i.e., domestic real output, real exchange rate, domestic prices), A_0 represents the contemporaneous relations among the variables, A_1 is a matrix finite-order lag polynomial, and u_t is a vector of disturbances. The structural model is not directly estimable. The reduced form, however, is obtained by multiplying equation (1) by A_0^{-1}:

$$y_t = (A_0^{-1} B_0 x_t + A_0^{-1} A_1 y_{t-1} + A_0^{-1} u_t) , \tag{2}$$

$$y_t = (C_0 x_t + C_1 y_{t-1} + e_t) , \tag{3}$$

where the e's are the reduced-form innovations with zero mean and $E[ee'] = \Omega$.

Equation (3) can be used to obtain the vector moving-average representation:

$$y_t = \sum_{i=0}^{\infty} C_1^i C_0 x_{t-i} + \sum_{i=0}^{\infty} C_1^i e_{t-i} , \tag{4}$$

where $C_1^{\,i} = A_0^{-1} A_1$ and $C_0 = (A_0^{-1} B_0)^i$.

The following impulse responses are analyzed:

$$\frac{\partial y_t}{\partial x_t} = C_0 \quad \text{and} \quad \frac{\partial y_t}{\partial x_{t-i}} = C_0 C_1^i . \tag{5}$$

Throughout this paper, impulse responses trace the response of current and future values of each of the variables to a one-unit increase in the current value of the exogenous variables.

4. DATA AND SPECIFICATION OF THE MODEL

To analyze the sources of fluctuations in the real exchange rate and real per capita output in EM countries, several specifications of the model are examined. This section describes the data used and the specification of the benchmark model.

4.1 Data sources

The data consist of annual observations from 1970 through

2002 for 22 EM countries: 13 Latin American and 9 Asian economies are examined (see the country list in the appendix). Most data series are taken from the International Financial Statistics (IFS): i) domestic per capita output is measured as GDP at 1995 prices (line 99b divided by 99bipzf);[5] ii) the real exchange rate is calculated as the relative price of non-traded goods in terms of traded goods, proxied by the ratio of the CPI (line 64) divided by the product of the nominal exchange rate (line rf) and the PPI (line 63) of the United States;[6] the domestic price level is measured by the CPI.

The G-7 economies are used as a proxy for world aggregates. World real GDP is a sum of the G-7 economies (line 99b.czf/99birzf, converted into U.S. dollars using line rf.zf...h from the IFS). The world interest rate is an average over the G-7 countries (treasury bill rate, line 60c).[7] The time-varying weights used in this average are based on each country's share of real GDP in the total. The real interest rate is obtained by subtracting CPI inflation from the interest rate of each of the G-7 countries.

4.2 Time-series properties

The modelling techniques used assume that all the series are stationary, and that levels of these series are not cointegrated. These assumptions are supported by the data. Augmented Dickey-Fuller (ADF) tests are performed on all of the series[8] for all of the countries in the sample, and the null hypothesis of a unit root cannot be rejected.[9] It appears, however, that the first differences of these series are stationary. As well, Johansen's test of cointegration suggests that there is no evidence of cointegration (the null hypothesis of zero cointegration vectors (r=0) is not rejected).[10]

[5] Data on population are taken from the World Bank database, line SP.POP.TOTL.

[6] This consumption-based real exchange rate is used by many authors; for example, Hoffmaister and Roldós (1997).

[7] Data for Japan are from the BIS database.

[8] The series consist of world real GDP, world real interest rate, domestic real GDP, and the real exchange rate.

[9] There are three exceptions. The null hypothesis of a unit root in the real exchange rate is rejected for Bangladesh, Thailand, and the Philippines. However, the same specification will be imposed for all countries.

[10] The results are available from the author.

4.3 Specification of the VAR

The shocks in the model fit nicely with the transmission process in the Mundell-Fleming framework. Therefore, the most important channels through which shocks are transmitted are world real output and the real interest rate.

The specification of the benchmark model is as follows. The vector of endogenous variables includes the first difference of the log of real per capita output as well as the first difference of the log of the real exchange rate for each of the 22 EM countries. Based on the Akaike Information Criterion (Akaike 1973) and the Schwarz Criterion (Schwarz 1978), two lags of each endogenous variable are included in the VAR. As well, the VAR includes two exogenous variables: world real output and world real interest rate. The first differences of those series are included contemporaneously in the model.

For each country in the sample, the benchmark model is constructed to help explain the transmission of shocks from industrialized to EM economies. As well, to compare the way in which EM countries respond to shocks with the way in which industrialized countries respond to them, the same empirical framework will be used for a control group of industrialized countries that are small open economies (Canada, the United Kingdom, and Australia). This permits an assessment of whether the response to shocks in EM countries is any different than in industrialized small open economies; previous studies do not make this assessment.[11]

5. RESULTS

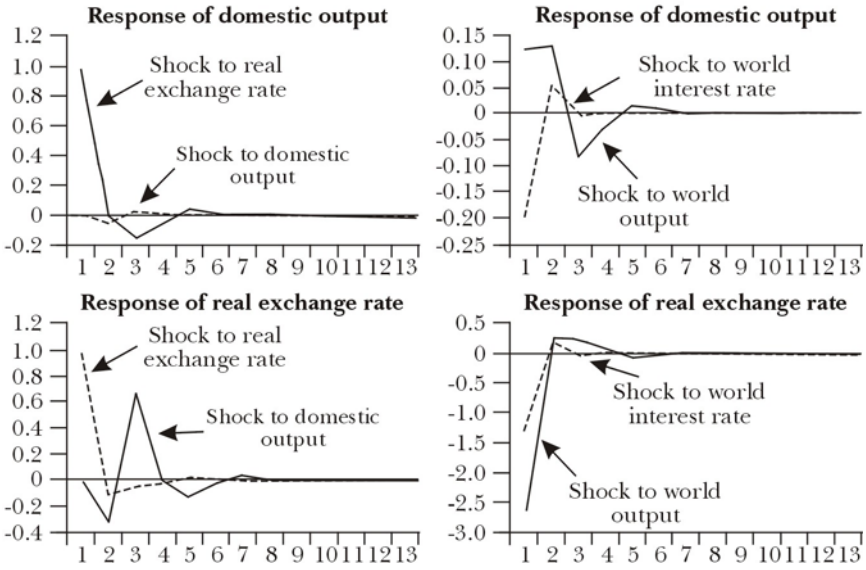
This section describes the impulse-response functions (IRFs) obtained with the benchmark model and contrasts them with the results for the control group. Different groups of countries are compared in section 5.2; this comparison is the most promising way to understand the discrepancies in the response of domestic variables to external shocks. A sensitivity analysis is also performed.

5.1 Benchmark model

To assess the response of domestic variables to world shocks for

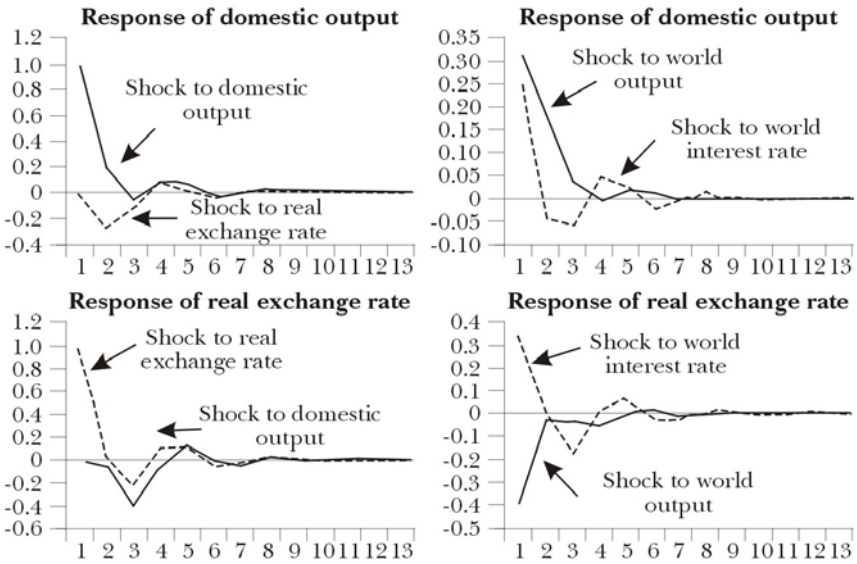
[11] Other studies focus on industrialized countries, but, to the author's knowledge, there has never been a study that analyzes the transmission of shocks of industrialized and EM countries within the same empirical framework.

FIGURE 1: ARGENTINA



different EM countries, IRFs are used. They represent the reaction of each variable to shocks in the different equations of the system. Across all 22 countries, the response of the domestic variables is different; no clear pattern can be discerned. Only two gen-

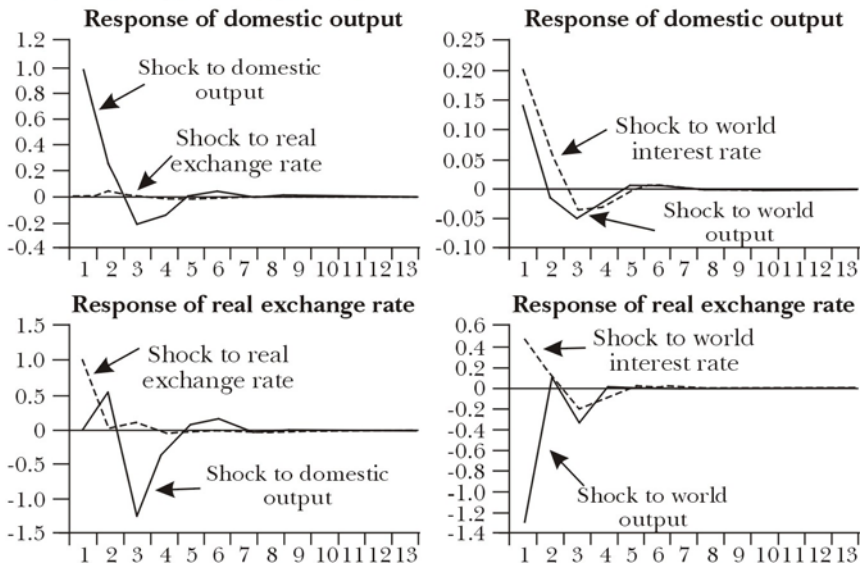
FIGURE 2: THAILAND



eral conclusions can be drawn (Figures 1 and 2). First, the domestic variables (real per capita output and real exchange rate) respond similarly to domestic shocks across the sample. Second, for a substantial fraction of the sample, the initial impact of a domestic shock is larger than that of a world shock.

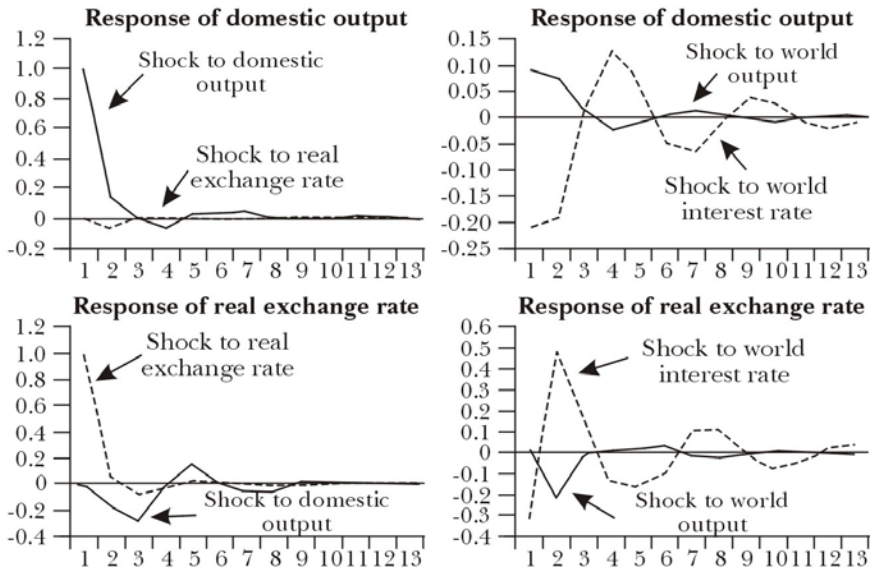
But the similarities across the sample end here. The conclusions regarding the propagation mechanism following an external shock are not as obvious. There are important divergences across the sample. As well, the EM countries analyzed demonstrate a different adjustment to shocks than the control group of industrialized countries (see Figure 3 for the IRF of the United Kingdom, which is representative of the industrialized country group). Indeed, the adjustment to shocks is more erratic in EM countries. No major conclusions can be drawn regarding the similarity of the transmission of shocks. Therefore, the particular responses of EM countries do not stem only from the fact that they are small open economies: they respond differently than industrialized small open economies. Other characteristics must explain their particular responses.

FIGURE 3: UNITED KINGDOM



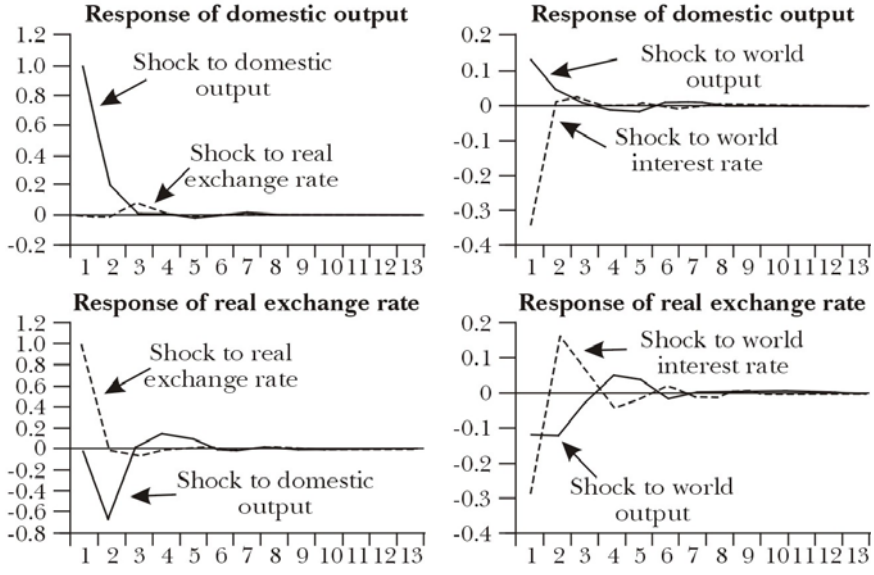
The responses of domestic variables to world shocks vary markedly across the countries studied (see Figures 1 and 2). Four groups of countries are studied to assess whether these differ-

FIGURE 4: ASIA



ences are a result of different economic structures (i.e., openness to trade and capital flows) or a result of differences in exchange rate regimes. Section 5.2.2 reports on this assessment; it is the most important contribution this paper makes to the literature.

FIGURE 5: LATIN AMERICA



5.2 Country groupings

In an attempt to explain the discrepancies between the response of domestic variables (real output per capita and real exchange rate) to external shocks, four groups of countries are used. First, because the different responses could be caused by factors that are specific to the different regional groups, this paper investigates whether the response is similar among Asian and Latin American countries. Whether the exchange rate regime can cause the different patterns observed across EM countries is also examined, as well as the size of each country's trade sector and the level of each country's capital flows.

5.2.1 Regional groups

The macroeconomic experiences of the EM countries in Latin America and Asia during the past 25 years have differed markedly. The two regions have different inflation rates, savings rates, and fiscal responsibilities. It is therefore plausible that the different characteristics of the IRFs derive from the dissimilarities between the two regional groups. If so, then common features should be observed within Asian and Latin American countries as well as discrepancies between the two regional groups.

Figures 4 and 5 show the average IRFs of Asian and Latin American countries, respectively. The average responses between regional groups reveal important discrepancies across certain countries, but no clear pattern is apparent within a regional group. The different responses therefore are not caused by the different characteristics of the regional groups. Figures 4 and 5 also show that the response of domestic output to a world output shock is very similar across regional groups. As expected, a world output shock has a positive impact on domestic output, followed by an adjustment, and the impact dies out after six periods.

Another important feature of the model is the response of the real exchange rate to a world interest rate shock. Across countries, there are different responses of the real exchange rate. Dividing the sample into regional groups does not yield a good explanation for this difference. In many countries, there is the typical response of real depreciation following a world interest rate shock. Indeed, following a positive world interest rate shock, the interest rate differential between the EM countries and the world interest rate widens and capital flows would be expected to move out of the EM countries, thus causing the real exchange rate to

depreciate. In some countries, however, the reverse is observed and a real appreciation occurs. This cannot be explained on the basis of the regional group, because there is no clear pattern among Asian or Latin American countries.

It can therefore be concluded that regional groups do not provide a good explanation for the differences among the EM countries for the transmission of shocks. Another potential reason for divergence is the exchange rate regime.

5.2.2 Exchange rate regime

To explain the divergent responses of the real exchange rate to a world interest rate shock, exchange rate regimes are examined. To do so, the IMF's official classification of exchange rate regimes is used, based on self-identification by member countries.[12] Ghosh et al. (1997) use the IMF's data to develop a different classification scheme for 136 countries over the period from 1960 to 1990. They aggregate the nine-regime classification scheme reported by the IMF into a tripartite scheme where exchange rate regimes are classified as either pegged, intermediate, or flexible (Table 1). Their classification scheme is adopted in this paper and their grouping extended to 2002 based on IMF reports (IMF, 1990-2002). The countries' exchange rate regimes are averaged over 1990-2002. The classification for each country is provided in the appendix.[13]

TABLE 1: TRIPARTITE CLASSIFICATION SCHEME, EXCHANGE RATE REGIME

ER regime classification	*IMF classification*
Pegged	- Currency boards - Single-currency pegs - Basket pegs
Intermediate	- Crawling pegs - Target zones
Flexible	- Floats with some intervention (but no predetermined range for intervention) - Pure floats

[12] The IMF publishes this classification annually (IMF, 1990-2002).

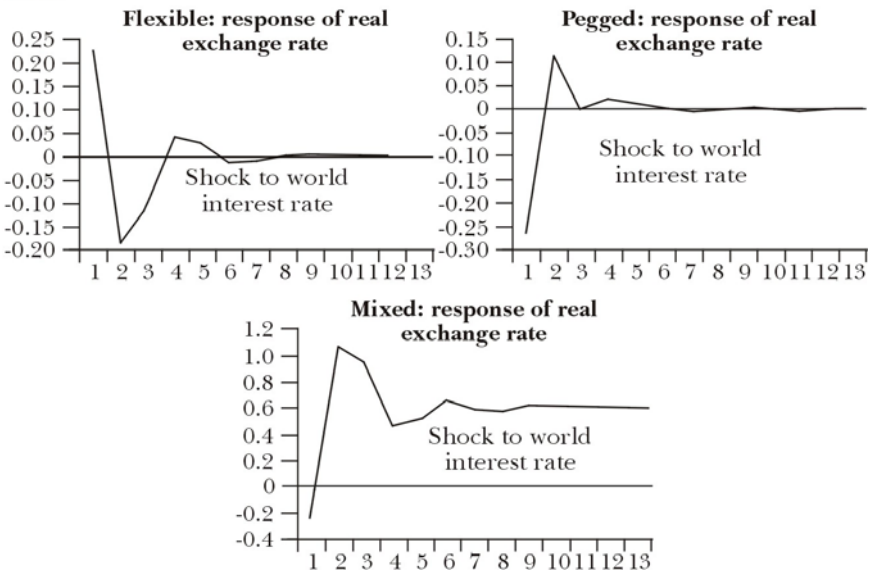
[13] A country that has either an intermediate ER regime or is moving from flexible to pegged, and vice versa, would be considered in the analysis to fall under "mixed."

A priori, it is not clear whether the responses to shocks would be larger in a fixed or in a floating exchange rate regime. In a floating exchange rate regime, the exchange rate can absorb some of the adjustment, and the variables might not have to change by as much as they would in a fixed-rate regime. On the other hand, countries that have floating exchange rates (especially if the volatility is very high) may sometimes be regarded as more risky than those that have credible pegs.

Hoffmaister, Roldós, and Wickham (1997) examine the sources of macroeconomic fluctuations in sub-Saharan African countries[14] and find that external shocks appear to have a greater influence on fluctuations of output and the real exchange rate in fixed exchange rate regime countries, because the exchange rate does not (partially) buffer those countries from external shocks.

It is found that the type of exchange rate regime is a critical determinant for the transmission of external shocks. Indeed, the finding described in section 5.2.1, that some countries experience a real appreciation following a world real interest rate shock, can be better understood when considering the exchange rate regime. As Figure 6 shows, countries classified as having a flexible ex-

FIGURE 6: EXCHANGE RATE REGIMES: RESPONSE TO THE REAL EXCHANGE RATE



[14] Hoffmaister, Roldós, and Wickham (1997) compare the CFA franc countries with the non-CFA franc countries.

change rate exhibit an expected real depreciation when the world real interest rate increases. Countries under a fixed exchange rate regime, however, have a counterintuitive response: they experience a real appreciation.

The model shows that, if a country is under a fixed exchange rate, or if it is considered as having an intermediate exchange rate regime, it will experience a real appreciation following a world interest rate shock. The reason for this counterintuitive reaction is that, since the exchange rate is fixed, the adjustment must come through prices. Consistent with the Mundell-Fleming framework, a world interest rate shock would result in a decline in the domestic price level, as well as a fall in the foreign price level.

Many authors (Agénor and Aizenman 1999, among others) who hypothesize that there are important nominal rigidities in EM countries report numerous distortions and a dualism in the labour market in those countries. This suggests that the domestic price level does not move instantaneously in response to unanticipated disturbances, but adjusts slowly over time. It is therefore possible for the currency to experience a real appreciation, as observed for countries that have a fixed exchange rate or an intermediate exchange rate regime.[15]

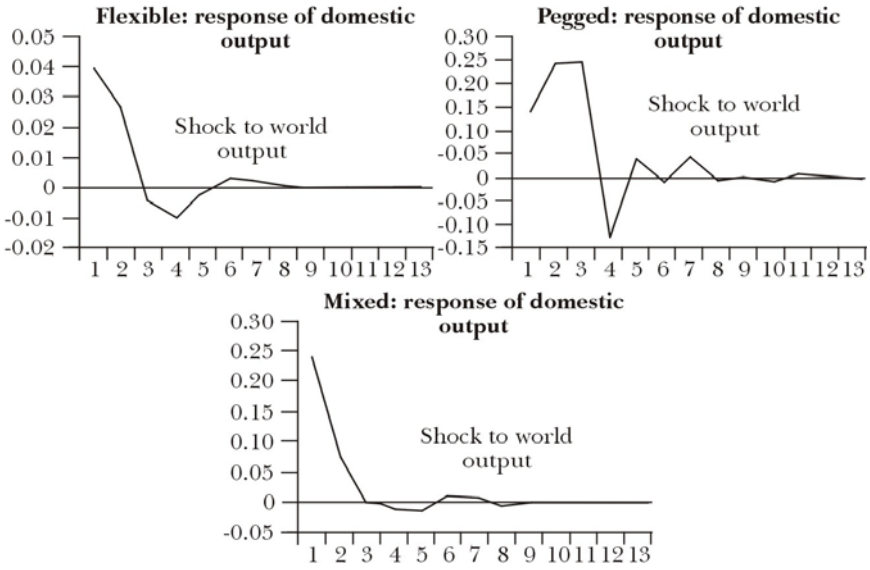
In addition, the model suggests that countries under a fixed or a flexible exchange rate regime are less vulnerable following a world real output shock than countries under an intermediate regime. A flexible exchange rate acts as a shock absorber (Figure 7), as expected, since the initial impact and the response of domestic output is rather small. The same is observed for the fixed exchange rate: those countries are more protected from shocks. It can therefore be concluded that a country is more vulnerable to external shocks when it is not at either end of the exchange rate regime spectrum. It is possible, however, that this result occurs because of self-selection, since inherently unstable countries cannot maintain exchange rate regimes at either end of the spectrum. Countries at both ends of the spectrum are therefore more stable by definition.

5.2.3 The size of the trade sector

A third country grouping is considered. The hypothesis to be

[15] This could also reflect other factors, such as the nominal exchange rate adjustment with respect to third countries.

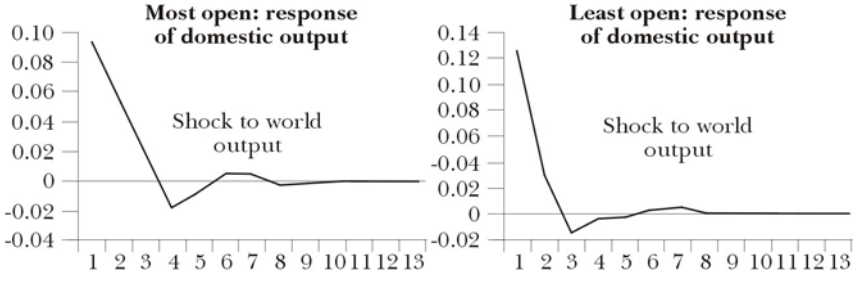
FIGURE 7: EXCHANGE RATE REGIMES: RESPONSE OF DOMESTIC OUTPUT



tested is simple: the more open a country is, the more it should react to foreign variables. Countries that are more open are therefore expected to react more to external shocks. To assess this possibility, countries are divided into two groups: "most" and "least" open. The measure of trade openness is a standard openness ratio (ratio of imports and exports to GDP).[16] If the ratio is higher than the median, the country is considered to be in the more open group. Otherwise, it is considered to be in the least open group.

First, the response of domestic output following an external output shock is examined. As Figure 8 shows, trade openness does

FIGURE 8: TRADE SECTOR: RESPONSE OF DOMESTIC OUTPUT

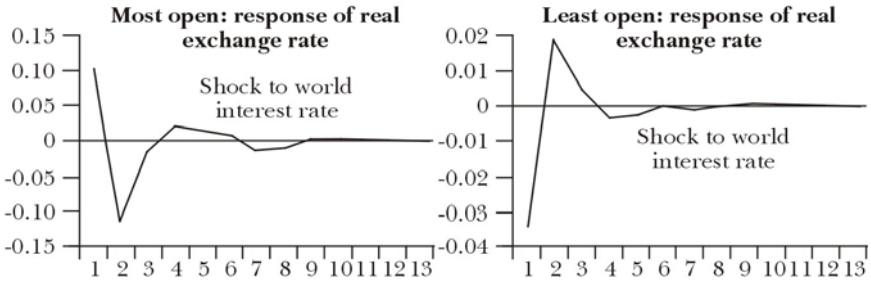


[16] Data on trade are taken from the IFS, line 70..dzf and 71..dzf.

not affect the transmission of the shock. Whether the country is in the more or the least open group, the dynamics are the same: a positive world output shock has a positive impact on EM countries.

Figure 9 shows that trade plays a role in the response of the real exchange rate to a world interest rate shock. Indeed, on average, a country that is more open will have the response described in section 5.2.2 (real depreciation), whereas countries that are relatively closed will experience a counterintuitive response (real appreciation). This supports the hypothesis given in section 5.2.2. Most countries that have a fixed exchange rate regime and that experience a real exchange rate appreciation are relatively closed.[17] This reinforces the explanation for the nominal price rigidities, because those countries do not face as much competition through trade.

FIGURE 9: TRADE SECTOR: RESPONSE OF THE REAL EXCHANGE RATE



5.2.4 Capital flows

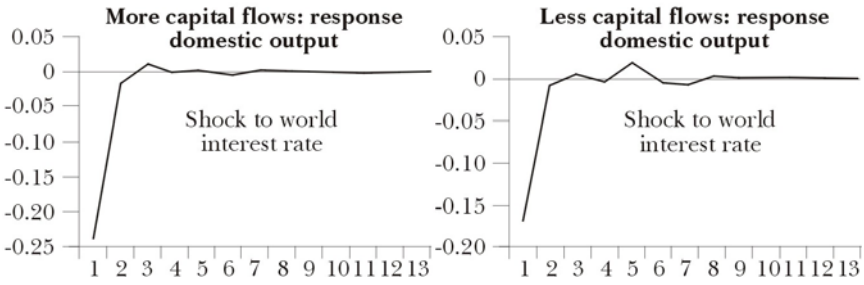
The premise of the capital flows grouping is that, if a country has a low level of capital flows across its borders, it will be less affected by world interest rate shocks. To assess this premise, a measure of gross capital flows to GDP is used.[18]

As Figure 10 shows, countries that have restricted capital flows initially react less to a world interest rate shock. Low capital mobility dampens the effect of the foreign shock to the asset markets. This result suggests that, as expected, financial linkages are more important, in terms of transmission of business cycles, for economies that are more open to capital flows. Figure 11 shows that the

[17] Examples of such countries are Argentina and Bangladesh.

[18] Data on gross capital flows are taken from the World Bank database (line bg.kac.fnei.gd.zs).

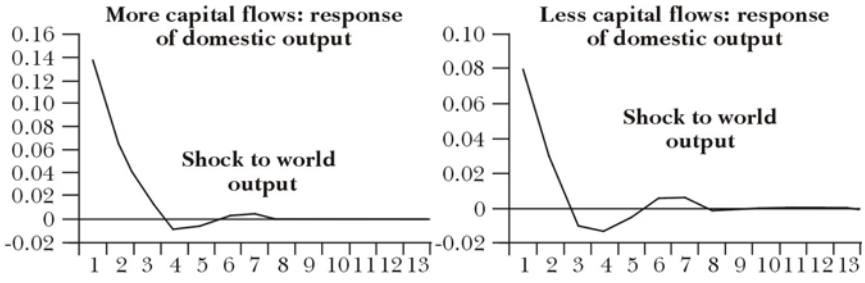
FIGURE 10: CAPITAL FLOWS SECTOR: RESPONSE OF DOMESTIC OUTPUT



initial impact of a world output shock on domestic output is smaller for a country that has a low level of capital flows.

The results are in line with stylized facts that, if world interest rates rise after a period of low levels of interest rates and abundant liquidity, countries that have a high level of capital flows are more vulnerable to capital outflows as interest rates in industrialized countries rise. It is therefore consistent with what is observed in the sample that the impact on domestic output is more negative for countries that have more open capital accounts.

FIGURE 11: CAPITAL FLOWS SECTOR: RESPONSE OF DOMESTIC OUTPUT



Furthermore, it is found that the level of development plays a role in explaining the transmission of shocks. The results show that countries that have higher levels of real GDP per capita are affected negatively by a world interest rate shock, whereas countries that have lower real GDP per capita are affected positively. Countries that have higher levels of development have better-functioning financial systems and therefore borrow more on international capital markets. Although the increase in world interest rates diminishes the relative attractiveness of EM bonds and increases the cost of borrowing, a recovery in industrialized countries also affects emerging markets through the trade channel (re-

sulting from stronger growth in industrialized countries). These offsetting effects will have different impacts on different countries. The results show that, following a world interest rate shock, countries that have higher levels of real GDP per capita are affected more by the financial channel, and countries that have lower real GDP per capita are affected more by the trade channel.

5.3 Sensitivity analysis

To test the robustness of the benchmark model, a sensitivity analysis is performed. The results show that the model is robust to different specifications. For example, when a fifth variable is added to the model (domestic prices), the results described in sections 5.1 and 5.2 still hold.

Different world aggregates are also considered. World output, as proxied by the G-7 economies, is replaced by U.S. real output, and the U.S. federal funds rate is substituted in place of the world interest rate shock. The adjustment pattern is, in most cases, the same, but the response is higher following a U.S. shock than following a G-7 shock.

6. CONCLUSION

The study of co-movement is important because its results can guide policy in an era of accelerating globalization. As the latest slowdown of the world economy has demonstrated, business cycles are transmitted across countries. This paper has identified channels of business cycle transmission to evaluate the extent to which economic fluctuations in the EM countries are caused by shocks that originate in industrialized countries.

The sources of macroeconomic fluctuations in EM countries (focusing on Asia and Latin America) have been documented and the relative importance of domestic versus external shocks has been measured. Consistent with the Mundell-Fleming model, two specific shocks were measured that could be transmitted from one country to another: a world real output shock and a world real interest rate shock. The analysis has helped explain the relative importance of the different shocks that drive output and real exchange rate fluctuations in EM countries.

The results obtained show that there are major differences in the transmission mechanism across different EM countries. To assess whether the discrepancies in the transmission of shocks is due to different economic structures or to the exchange rate re-

gime, a sample of 22 EM coutries has been divided into groups, based on the region to which a country belongs, its openness to trade, its exchange rate regime, and its capital flows. The results indicate that the exchange regime is a critical factor, although the restrictions on capital flows also play a crucial role. It has also been shown that the role played by regional groups and trade openness is not as important in determining the transmission of business cycles. When the impact of external shocks on real output and the real exchange rate for EM countries is analyzed, exchange rate regimes as well as restrictions on capital flows that exist in those countries should be the two major factors considered.

This paper has provided a number of preliminary results. Other, more detailed models could be used to further explain the transmission of business cycles, in order to help policy-makers design improved macroeconomic policies in an increasingly integrated world economy.

Appendix

CLASSIFICATION OF 22 EMERGING-MARKET COUNTRIES

	Regional group	*Measure of trade openness*	*Measure of restrictions on capital flows*	*Exchange rate regime*
Argentina	Latin America	Least open	More flows	Pegged
Brazil	Latin America	Least open	Less flows	Mixed
Chile	Latin America	Most open	More flows	Mixed
Colombia	Latin America	Least open	Less flows	Mixed
Costa Rica	Latin America	Most open	Less flows	Mixed
Dominican Republic	Latin America	Most open	Less flows	Flexible
Ecuador	Latin America	Most open	More flows	Pegged
El Salvador	Latin America	Least open	Less flows	Mixed
Guatemala	Latin America	Least open	More flows	Flexible
Mexico	Latin America	Most open	Less flows	Flexible
Peru	Latin America	Least open	Less flows	Flexible
Uruguay	Latin America	Least open	More flows	Mixed
Venezuela	Latin America	Most open	More flows	Mixed
Bangladesh	Asia	Least open	Less flows	Pegged
India	Asia	Least open	Less flows	Flexible
Indonesia	Asia	Most open	Less flows	Flexible
Malaysia	Asia	Most open	More flows	Pegged
Pakistan	Asia	Least open	Less flows	Flexible
Philippines	Asia	Most open	More flows	Flexible
Singapore	Asia	Most open	More flows	Flexible
Sri Lanka	Asia	Most open	More flows	Flexible
Thailand	Asia	Most open	More flows	Mixed

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