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Trevor Campbell

Is long-term private foreign investment for Barbados likely to improve without capital controls

1. INTRODUCTION

Within recent times, the removal of capital controls has been a major talking point in Barbados. This is not surprising in any way since Barbados is part of the CARICOM Single Market and Economy (CSME) and is obliged under the CSME Agreement to remove exchange control restrictions on capital account transactions within the union. To date, the process has been a slow and gradual one, the latest action being the removal of exchange controls for Barbadians desirous of purchasing equities on the regional stock markets. Nevertheless, it should be noted that these equities exclude those of CARICOM Governments where permission is still necessary from the Central Bank of Barbados for anyone wishing to engage in transactions of this nature.

In the Budgetary Statement of March 2007, the Government of Barbados announced its intention to abolish all remaining capital controls with respect to CARICOM. It should be noted,

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however, that since other countries within this Area do not have exchange controls on extra-regional capital transactions, any relaxing of capital controls by Barbados is tantamount to opening-up to the rest of the world. Although such a move may be more attractive to foreign investors, this may be viewed as risky since if the inflows are not used efficiently, the markets may question their sustainability and the capacity of the recipient country to service its external debt. Further a loss in confidence could trigger reversed capital flows leading to difficulties in the balance of payments and currency and banking crises.

It is against this background that an effort is being made to determine whether Barbados is likely to benefit from higher net long-term private sector foreign investment flows with the total removal of capital account controls. Section 2 will look at a review of some of the literature on capital account controls. Section 3 will focus on the trends in long-term foreign private sector investment capital flows for Barbados while in the following section, the Engle-Granger two-step procedure will be used to ascertain the long and short run results of this paper. This will be followed by a conclusion.

2. A REVIEW OF SOME OF THE LITERATURE ON CAPITAL ACCOUNT CONTROLS

The issue of capital controls is one in which the conclusions reached by the authors on this topic have been mixed. Campbell (2007) used an impulse response function to examine the impact of the removal of capital account controls on foreign direct investment (FDI) flows in Barbados. The study showed that FDI transactions would be unstable over the first six years but that some smoothing of FDI would occur in the years that followed with an equilibrium of $3 million reached in the twelfth year. One of the important things to note in the paper was that during the unstable and smoothing periods down to the equilibrium period, the FDI values always exceeded the original equilibrium, implying that Barbados stood to benefit from higher net FDI inflows if its capital account controls were removed.

The article by Asiedu and Lien (2004) set out to ascertain whether the presence of capital controls boosted or hindered FDI. Three types of capital control policies were identified, namely, the existence of multiple exchange rates, controls on the capital account and the stringency of requirements for the repatriation

and/or surrender of export proceeds. Overall, they found that capital controls deterred FDI but that the impact had changed over time. Prior to 1990, the only restriction that had a significant impact on FDI was the exchange rate structure. However in the 1990s, all three measures of capital controls were influential, implying that investors had become discriminatory and punitive over time.

An attempt was made by Desai, Foley and Hines (2004) to show how foreign affiliates of US multinational firms responded to capital controls and their removal. In their opinion, these foreign affiliates circumvented capital controls by regularizing dividend remittances and relocating profits. However, evading capital controls in this way was costly given the tax and other business considerations that would otherwise guide dividend repatriations and trade between related prices. Countries imposing capital controls had significantly higher interest rates than did otherwise similar countries without capital controls. Together, the costliness of avoidance and higher interest rates raised the cost of capital, significantly reducing the level of FDI. Capital account liberalizations were associated with reversals in these patterns.

It was argued by Jadhav (2003) that in terms of the standard indicators of effectiveness of capital controls, controls were effective in India. Despite strong inflows, there had been no major appreciation of the exchange rate, monetary independence had not been lost, a wedge between domestic and foreign interest rates was created and maintained and black market premia on the exchange rate had drastically declined to negligible levels with a concomitant decline in capital flight.

The study by Kaplan and Rodrik (2001) looked at whether capital controls in Malaysia were successful. The Asian financial crisis of 1997-1998 had wreaked havoc with the economies of some of the world's most successful performers. Unlike, Thailand, South Korea and Indonesia, which were forced to resort to International Monetary Fund-supported and design programmes to deal with the crisis, Malaysia took a different path and imposed sweeping controls on capital account transactions. They discovered that Malaysian policies produced faster economic recovery, smaller declines in employment and real wages and a more rapid turnaround in the stock market.

Responses were made by Edwards (1999) to a number of authors who argued that in order to avoid financial instability, emerging countries should rely on capital controls. Two types of controls were considered, namely capital outflows and capital

inflows. He reviewed the historical evidence on these two types of controls and concluded that controls on outflows were ineffective. They were circumvented and bred corruption. He further analysed Chile's experience with controls on inflows and felt that their effectiveness was exaggerated.

The impact of capital controls on the composition of capital flows for fifteen markets was examined by Montiel and Reinhart (1999). They concluded that capital controls did appear to alter the composition of capital flows, reducing the share of short-term and portfolio flows while increasing that of FDI.

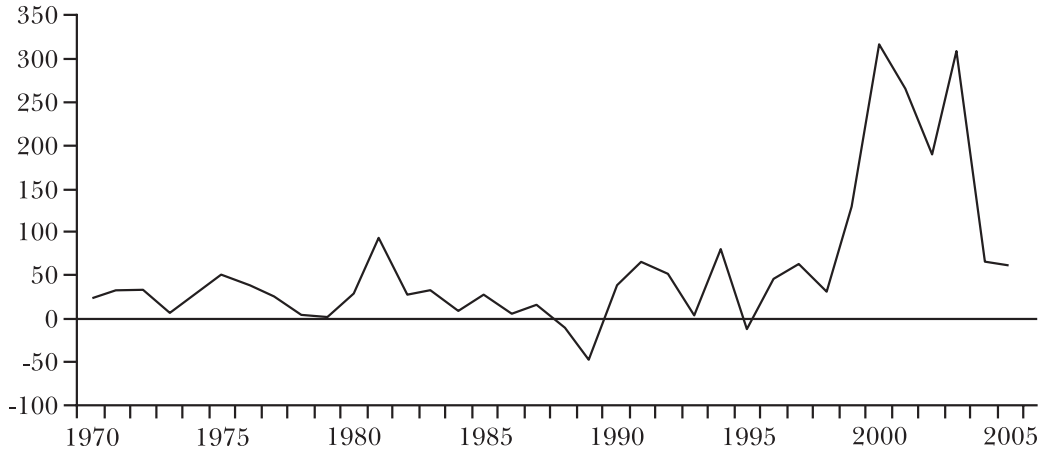
3. TRENDS IN LONG-TERM PRIVATE SECTOR FOREIGN INVESTMENT FLOWS FOR BARBADOS

In Barbados, long-term private sector foreign investment is broken down into FDI capital, portfolio investment capital and other investment capital. FDI capital is disaggregated into investment in branches, undistributed earnings and other FDI capital. Portfolio investment capital is broken down into equity and debt securities while other investment capital comprises long-term loans, long-term trade credits and miscellaneous investment capital. Prior to the introduction of the Fifth Edition Balance of Payments Manual of the International Monetary Fund, long-term loans were treated as a portfolio investment capital item but this was reversed thereafter.

In analyzing the trends in long-term private sector foreign investment for Barbados, one can easily recognize from Figure 1 shown below that this category has been for the most part positive, suggesting that when all components of this category are aggregated, Barbados generally benefits from net inflows from private sector activity over the long term. Between 1970 and 1976, net long-term private sector foreign investment flows totaled around $210 million, the highest being $51.2 million in 1976. Some of the investment activities which occurred were foreign loans obtained by two major public utilities and an injection of funds mainly from the USA for manufacturing and hotel construction. By 1979, net inflows slowed to a mere $1.6 million as Barbadians increased their portfolio investment holdings abroad.

Two years later in 1981, net long-term private sector foreign investment movements reached a high of $93.4 million but this was insufficient to offset a widening external current account deficit, aggravated by the recession in North America and the UK

FIGURE 1. NET LONG-TERM PRIVATE SECTOR FOREIGN INVESTMENT FLOWS, 1970-2005 (millions of $)



in addition to higher interest rates in those countries (see Annual Central Bank Report). By 1984, this figure had fallen steeply on account of substantial loan repayments by utility companies. Repayments of this nature by private firms led to decreases in investment capital in 1989 and again in 1990. It was not until 1994, the second year of eight consecutive years of real economic growth, that net long-term private sector foreign investment flows reached anywhere near the 1981 total ($81.6 million) primarily as a result of foreign investment in the hotel sector.

In 2000, Barbados recorded its largest total for net long-term private sector foreign investment flows, reaching $315 million. Most of these transactions were for hotel-related activities and public utilities. These strong performances continued into 2003 buoyed by investment in utilities, real estate and the receipt of funds from corporate divestment activities. However, in 2004, for the first time in the history of Barbados, long-term private sector foreign investment flows did not play a major role in financing the large external current account deficit. FDI inflows contracted as foreigners reduced these holdings with Barbados while at the same time, Barbadians increased their portfolio instruments overseas. Further, foreign long-term loans to Barbados slowed when compared to the previous year. The major finance for the external current account deficit was provided by short-term capital transactions, mainly trade credits (see Balance of Barbados). In the following year, the turn-around in net long-term private sector foreign investment flows was attributed to higher proceeds from real estate activities and lower amortization outlays by the private sector. The countries mainly responsible for supplying

long-term private foreign investment to and receiving such from Barbados are the USA, UK and Canada.

4. DETERMINANTS OF LONG-TERM PRIVATE SECTOR FOREIGN INVESTMENT FLOWS FOR BARBADOS

In addition to our explanatory variable of major focus, namely, the removal of capital controls, the other explanatory variables which have been used by various authors and applied in this study as possible determinants of long-term private sector foreign investment flows for Barbados are real foreign income, real domestic income, relative interest rates and the real exchange rate.

The relationship between the total removal of capital controls and net long-term private sector foreign investment flows is indeterminate. Such removals will be attractive to foreign investors and in this way, long-term private sector foreign investment capital flows will improve. On the other hand, such removals provide increased opportunities for Barbadians to invest abroad. In this situation, net long-term private sector foreign investment flows will contract. The relationship between real foreign income and net long-term private sector foreign investment flows is ambiguous. If such income will cause more foreign firms to invest in Barbados, then the dependent variable should rise. On the contrary, if an increase in real foreign income will make domestic investment in the home country more attractive than foreign investment, then the dependent variable may fall. Higher real domestic income should boost net long-term private sector foreign investment flows on the strength of more profitable investment opportunities and more readily available domestic funds for financing.

The relative interest rate is defined here as the ratio of the foreign interest rate to the domestic interest rate. With the domestic interest rate remaining constant, as the foreign interest rate increases, implying an expansion in the relative interest rate, local firms may have a tendency to reduce their borrowings from abroad and invest in additional foreign instruments and these will reduce net long-term private sector foreign investment flows.

Helmers y Leslie (1988) defines the real exchange rate as the ratio of the product of the nominal exchange rate and the foreign price index to the domestic price index. In Barbados, the nominal exchange rate is fixed and we shall hold the foreign price

index constant. If the domestic price index rises, implying that the real exchange rate falls, then net long-term private sector foreign investment flows should contract.

4.1 Model specification

A model of net long-term private sector foreign investment capital can be expressed as follows:

$$PSI = f\,(FY,\ DY,\ RINT,\ RER,\ DUMMY) \qquad (1)$$
$$\qquad\quad ?\quad +\quad -\quad +\quad ?$$

where *PSI* represents net long-term private sector foreign investment flows, *FY,* real foreign income, *DY,* real domestic income, *RINT,* relative interest rates, *RER,* the real exchange rate and *DUMMY,* the total removal of capital account controls. The signs under each explanatory variable explain the expected relationship with the dependent variable. The ordinary least squares technique was applied.

4.2 Data and variables

This study uses annual data from 1970 until 2005, the sources of which are the Annual Statistical Digest of the Central Bank of Barbados, the Balance of Payments of Barbados and the International and Financial Statistics Yearbook of the International Monetary Fund. Net long-term private sector investment capital flows have been deflated by gross domestic product for Barbados and are used as a measure of real net long-term foreign private sector investment capital flows. Real GDP of the USA has been used as a proxy for real foreign income while real GDP of Barbados has been used as a proxy for real domestic income. The prime lending rate of the USA is our proxy for the foreign interest rate and the prime lending rate of Barbados represents our domestic interest rate. The consumer price index of the USA has been used as a proxy for the foreign price index, while in the case of the domestic price index, the consumer price index of Barbados has been applied in this regard.

In trying to devise a measure for the removal of capital controls, we are guided by Eichengreen (2002) who argued that most studies construct a dummy variable for the presence or absence of controls. The dummy variable will assume values of zero prior to 1998 when there was not an aggressive policy towards capital controls and one thereafter. The year 1995 is used as the base

year and estimations have been performed with the econometric package EVIEWS 5.

4.3 Results

Having used the Johansen (1988) procedure, we have discovered that only one cointegrating relationship exists. Consequently, this allows for the application of the Engle-Granger two-step procedure. 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 for further reading).

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

The long-run results are shown in equation 2.

$$PSI = 16.3 + 0.01FY - 0.01DY + 0.01RINT + \\ + 0.06RER + 5.25DUMMY \qquad (2)$$

$R^2 = 0.578$; Adj. $R^2 = 0.510$; Durbin-Watson (D-W) = 1.79;
ADF = -5.11 (-3.54); PP = -6.20 (-3.54).

Equation 2 is the Engle-Granger (EG) cointegrating regression. However, on account of the small sample size, the bias in the EG estimator of the long-run relationship may be significant, hence the standard errors and t-values of the estimated regression coefficients are not reported, as these statistics are not valid (see Banerjee et al., 1986, pp. 253-78).

The results show that in the long-run equation, all of the variables are cointegrated since the ADF and Phillips-Perron tests reject the null hypothesis of stationarity at the 5% and even the 1% level of significance. The Durbin-Watson (DW) statistic indicates no first order serial correlation.

The sign of the variable, the real exchange rate, is consistent with our expectations. A per unit rise in the real exchange rate will reduce net long-term real private sector foreign investment

flows by $0.06 million. The positive sign attached to real foreign income suggests that expansions in this variable should attract foreign enterprises and by extension, foreign investment flows to Barbados. In this case, the data show that a $1 million increase in real foreign income will drive up net long-term real private sector foreign investment flows by $0.01 million. On the contrary, the negative relationship between real domestic income and the dependent variable runs contrary to what was anticipated. As real domestic income goes up by $1 million, net long-term real private sector foreign investment flows will decrease by $0.01 million. It is possible that the foreign inflows from profitable investment opportunities afforded to overseas firms which arise with higher real domestic income will be more than offset by the acquisition of increased portfolio investment holdings abroad by local enterprises. Further, the positive relationship between the relative interest rate and the dependent variable runs contrary to our theory. However, it may be the case that if foreign interest rates rise, they may still be more attractive to local businesses if these rates are still significantly lower than domestic interest rates. What can we say about the capital account control variable, proxied by a dummy variable? The coefficient in equation 2 suggests that when capital account controls are fully removed, net long-term real private sector foreign investment flows will be boosted by $5.29 million, which is desirable.

We now focus on the short-run determinants of net long-term real private sector foreign investment flows. In this instance, the error correction model is used. This model nests both the long-run behaviour and the short-run dynamics. Engle and Granger (1987) argue that an error correction model of variables can be formulated as long as those variables are cointegrated. We also make use of the Hendry General to Specific Methodology, which begins with an over-paramerterised model and using a step-wise process, eliminates all insignificant variables until a parsimonious representation of the model is obtained. Current and lagged variables were considered but our initial model was restricted to two lags on account of the small sample size. The results are now shown in equation 3, which is the error correction equation.

$$\begin{aligned}\Delta PSI = {} & -0.26 - 0.01\Delta FY_{-1} + 0.01\Delta FY_{-2} + 0.11\Delta RER + 5.01 DUMMY \\ & (-3.18)\ (-2.39)\qquad (2.17)\qquad (3.13)\qquad (2.51) \\ & - 0.68 U_{t-1} \\ & (-3.58)\end{aligned} \tag{3}$$

R^2 = 0.54; Adj. R^2 = 0.47; D-W = 1.87 B-G (prob = 0.76);
NORM (prob = 0.99); ADF = -6.03 (-3.56);
PP = -6.17 (-3.56); White (prob = 0.30).

The numbers in parentheses in equation 3 are "*t*" statistics and U_{t-1} is the error correction term lagged one period. All other variables remain unchanged. Δ is the first difference operator, B-G is the Breusch-Godfrey Lagrange multiplier test for serial correlation, NORM is the Jarque-Bera test for normality based on a test of kurtosis and skewedness of the residuals while White is the White Cross product test for heteroscedasticity.

The results show that the model is a reasonable fit, adequately specified and satisfies the classical assumptions of normality, homoscedasicity and serial dependence. Three of the five variables help to explain net long-term real private sector foreign investment flows in the short run, namely lagged real foreign income, the real exchange rate and the removal of capital controls and they are all significant at the 5% level. Real domestic income and the relative interest rate appear to have no impact on the dependent variable in the short term.

In the case of the full removal of capital controls, the model shows that in the short run, when these controls are removed, net long-term real private sector investment flows will grow by $5.01 million, virtually the same level as during the medium and long term. The error correction term is negative and significant as required and its coefficient of 0.68 indicates a fairly swift speed of adjustment to its new long-run relationship.

5. CONCLUSION

This paper has attempted to show whether, using an Engle-Granger two-step procedure for the annual period 1970 to 2005, Barbados is likely to benefit from higher real long-term private sector investment flows if it completely relaxes its capital account controls. The results show that in the long run, real foreign and domestic income, relative interest rates, the real exchange rate and the removal of capital controls influence net long-term real foreign private sector investment flows. With the complete removal of capital account controls, net long-term private sector investment flows in real terms should improve by some $5.2 million, which is the strongest of the relationships with the dependent variable. In the short term, the removal of capital controls,

the real exchange rate and real foreign income influence net long-term foreign private sector investment flows. Once more, the removal of the capital control variable is the one which has the greatest influence on net long-term foreign private sector investment flows. On this occasion, after the removal of capital controls, net long-term real private sector investment flows will expand by $5 million, almost on par with the long-run result.

What do these results imply for Barbados? They suggest that with the abolition of capital controls, Barbados will record an increase of $5 million from net long-term real private sector investment flows in the short term while over the medium and long term, almost the same level of foreign investment will be maintained. The results of our model support the argument for the removal of capital controls since it appears that Barbados will benefit from higher foreign exchange receipts. With higher receipts, some improvement would be reflected in the balance of payments and liquidity in the banking system would expand. Growth in long-term foreign private sector investment flows should generate employment opportunities, which should in turn result in a rise in government revenues and allow Government to further develop Barbados' infrastructure.

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Shaun K. Roache

Public investment and growth in the Eastern Caribbean

I. INTRODUCTION

Public investment has a high profile in the small islands of the Eastern Caribbean Currency Union (ECCU).[1] In common with many small states, it accounts for a large share of GDP, averaging around 10%, compared to 3% for OECD countries (Figure 1). In part this not only reflects the limits of economies of scale in the provision of public goods, but also the regional perception that public investment is one of the main catalysts for economic growth and development.

[1] In this paper, the ECCU refers to the six independent states of Antigua and Barbuda, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines.

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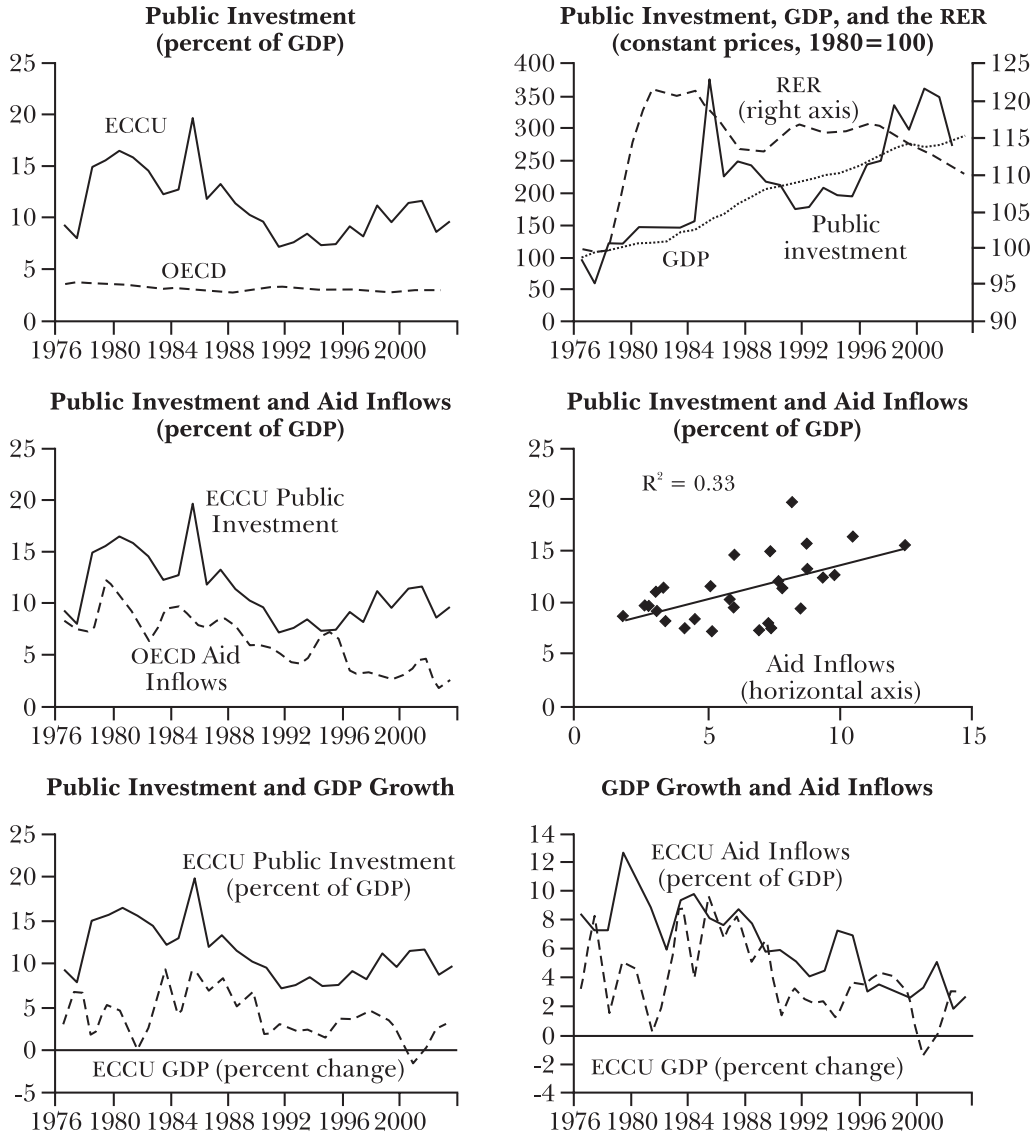
FIGURE 1. ECCU: PUBLIC INVESTMENT, GROWTH AND AID INFLOWS, 1975-2004



SOURCES: National authorities; Organization for Economic Co-operation and Development; and author's calculations.

This paper quantifies the effect of public investment on growth and the real exchange rate in the ECCU. Avoiding the imposition of too many priors on the data, an atheoretic approach is used. This has its drawbacks; the model will provide no information on *why* the results emerge as they do. However, this approach also has advantages. It allows us to make inferences based on past investment performance. It does so while avoiding imposing theoretical restrictions on an investment-growth process that, due in part to data limitations, is poorly understood.

The results, emerging from panel vector autoregressions indicate that the rate of return on public investment, as defined by Pereira (2000), is very likely negative. This means that the total change in real output induced by one EC (Eastern Caribbean) dollar of public investment, due to its short-run impact on demand, or the longer-run impact on supply, is below one EC dollar. This is not the only (or perhaps the best) way to measure the returns on public investment. However, it allows us to compare the results of the ECCU to those of other countries studied in the literature.

The plan of this paper is as follows: Section II provides a selective literature review. Section III describes the data. Section IV details the estimation procedures. Section V presents the results, and Section VI provides a brief conclusion.

II. LITERATURE REVIEW

Early work on the growth effects of public investment used the single-equation static production function approach and aggregate data. In its most basic form, this method assumes a production function in which output is a function of public capital K^G, private capital K^P, labor N, and technology A:

$$Y_t = F\left(A_t, K_t^G, K_t^P, N_t\right) \tag{1}$$

Assuming a generalized Cobb-Douglas form, and allowing lower case variables to denote logs, and ε to represent the elasticity of output with respect to factor *i,* this can be written as:

$$y_t = a_t + \varepsilon_G k_t^G + \varepsilon_P k_t^P + \varepsilon_N n_t \tag{2}$$

Celebrated early results emerged from Aschauer (1989a, 1989b) with public capital seemingly having a powerful influence on output growth and productivity in the United States. Using a variation on equation (2), one specification used the productivity of private capital as the left-hand side variable, with capacity utilization represented by *cu*:

$$y_t - k_t^P = a_0 + a_1 t + a_2\left(k_t^G - k_t^P\right) + a_3\left(n_t - k_t^P\right) + a_4 cu_t + u_t \tag{3}$$

Subsequent literature, surveyed extensively by Munnell (1992),

presented more ambiguous results; in many cases, growth effects were absent.

Other notable examples include Khan and Kumar (1997), which used the neo-classical growth model, a cross-section of 95 developing countries and decade-long sample periods. Per capita growth rates were regressed on initial GDP per capita, population growth and technical change, and investment rates for the public and private sectors. Results suggest that while both types of investments have a positive and significant effect on growth, private investment tended to have a larger impact. Kavanagh (1997) focuses on Ireland, often cited as a role model for small states, over the 1958-90 period. Using a production function approach and error-correction methodology, results suggested that public capital had a positive, but insignificant effect on output per capita.

There are three criticisms of the structural modeling of aggregate production functions approach. First, there remain outstanding econometric problems, such as non-stationarity in the possible absence of cointegration and endemic endogeneity (see Jorgenson, 1991). Second, it ignores the dynamic relationship between public investment and growth. Third, research based on aggregate data does not allow for the varying effects of different types of public capital stock; public investment in infrastructure and social services may impact growth in very different ways, both in terms of scale and timing.

More recent research attempts to address these issues, with much use made of vector autoregressions (VARs), a field comprehensively surveyed by Kamps (2004). Notable contributions include Pereira (2000), which focusing on the United States, uses data on aggregate and five specific types of public investment, output, private investment, and private employment. The estimated long-run effect on output of a one percentage, one-time random shock to aggregate public investment was 0.04, with variation according to the type of capital. Pereira and Fatima-Pinho (2006) used a similar VAR framework for the twelve euro-area countries. The same long-run effects on output were estimated to average 0.06 and ranged from -0.20 in the Netherlands to 0.20 in Italy.

Kamps (2004) assesses public investment in 22 OECD countries. Using vector error-correction models and recursive identification prcedures, impulse responses showed that the effect of public

capital on output is positive in the long-term, but with very large standard errors. The average long-run elasticity of output to a public investment shock is 0.12, although this varies widely across countries.

III. DATA —DESCRIPTION AND TRENDS

Estimations use annual data from 1975 to 2005. Public investment refers to capital expenditure undertaken by central government, public enterprises, and statutory corporations. The sources of the data are IMF staff reports and World Bank Country Economic Memorandums; this latter source proved particularly important for the pre-1995 period in which the Bank played an active role in developing public sector investment plans (PSIPs).

In almost all cases, these are taken from the presentation of the fiscal accounts, where it was not possible to identify the type of investment spending. Even when the World Bank helped develop the PSIP, the sectoral breakdown of investment data is on an approved and proposed basis only; in many cases, execution of the PSIP may be quite different from that proposed in the PSIP or the budget. Public investment was deflated using the average OECD deflator of capital expenditure for the federal government (excluding defence), and state and local governments. Summary statistics are presented in Table 1.

TABLE 1. ECCU PUBLIC INVESTMENT MODEL: SUMMARY STATISTICS[a]

	Observations	*Mean*	*Max.*	*Min.*	*Std. dev.*	*Skew*
Public invest.	171	5.6	236.2	-133.7	45.4	0.7
Country GDP	171	3.9	21.1	-20.4	4.9	-0.3
Bilateral RER	173	0.6	16.4	-6.6	3.4	1.5
OECD GDP	29	2.8	4.5	0.2	1.1	-0.4
Aid flows	174	-11.4	160.0	-1,033.0	121.6	-6.7

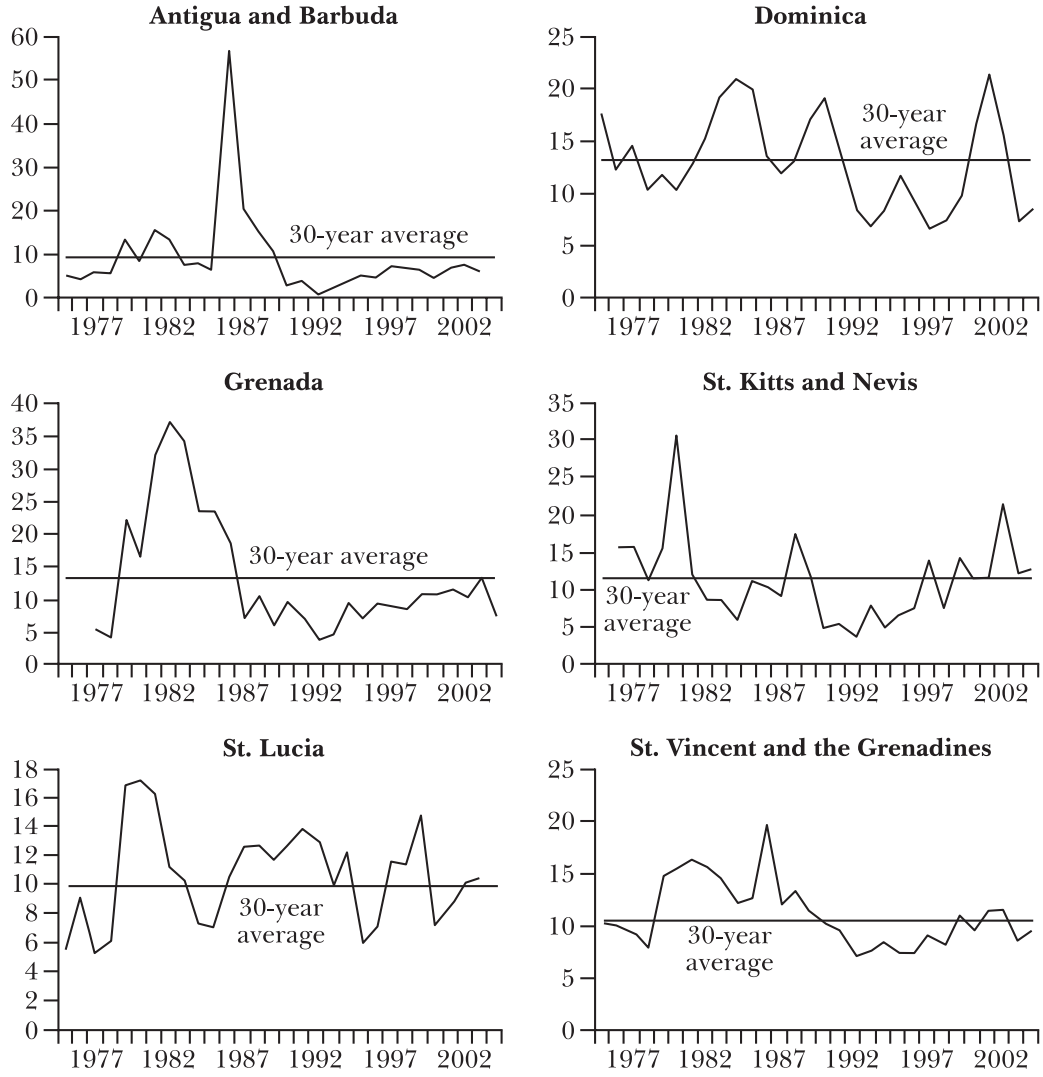
SOURCE: Author's calculations.

[a] All statistics based on the first difference of the log of real variables multiplied by 100.

Figure 2 shows the ratio of public investment to GDP for the six ECCU countries (in current EC dollars). There are at least two interesting points. First, this ratio is relatively high. Second, this ratio

is volatile, with the average for the ECCU showing a standard deviation of 3% (compared to 0.3% for the OECD average).

FIGURE 2. ECCU: PUBLIC SECTOR INVESTMENT, 1975-2004 (percent of GDP)



SOURCES: Country authorities: ECCB; World Bank; IMF; and author´s calculations.

Both the log of real GDP and the bilateral RER are nonstationary. The evidence that public investment is also $I(1)$ is weaker, but this appears to be due to the effect of one country in the panel. Tests for cointegration, based on Pedroni (1999) were mixed, but in the most general specifications of the test there was little evidence of panel cointegration (results of all unit root tests are available upon request).

IV. ESTIMATION

1. Panel vector autoregressions—pros and cons for the ECCU

The model used in this paper is a panel vector autoregression (PVAR). A reduced-form VAR entails certain limitations on the conclusions one may draw from the results. It is an atheoretic method that allows one to draw some inferences regarding the data-generating process, but it provides little guidance on the underlying economic relationships.

The advantages outweigh the disadvantages when assessing public investment in the ECCU, for four main reasons. First, many structural models rely on the existence of a fairly rich data set, including estimates of the public capital stock. While it is possible to derive estimates for the ECCU (e.g. Roache, 2006), the high incidence of natural disasters introduce huge uncertainty related to the rate of depreciation (or destruction) in particular years. Second, popular structural approaches tend to model other factor inputs, such as labor; the data for which simply does not exist in most of the ECCU countries. Third, a PVAR explicitly models dynamics, useful when considering the short- to medium-run impact of public investment, particularly in small economies in which the government plays a large role. Finally, and more generally, a PVAR approach avoids the thorny issue of endogeneity.

Using a panel VAR improves the degrees of freedom of the results, but obviously imposes the restriction that the *dynamics* (but not necessarily the fixed-effects) are homogenous across the ECCU countries. Almost all previous studies have tended to use single-equation VARs. In this case, the panel approach was used on the assumption that the role of the public sector in the ECCU economies is relatively similar.

2. Selection of endogenous variables

Three endogenous variables were used in the PVAR—real GDP, real public investment, and the bilateral real exchange rate (RER) with the United States. This small list of domestic variables was dictated by reliable data availability.

The selection of the RER was motivated by the possible relationships between public investment and competitiveness, of

which there are many. In the short term, a large rise in public investment could cause the internal real exchange rate to appreciate; since most physical capital is imported, the main price effect would be through greater demand for wages and a higher price for nontradable goods. In the long run, a higher public capital stock could encourage more private investment, boosting the domestic supply of tradables and nontradables and allowing the internal RER to depreciate. Conversely, Balassa-Samuelson effects might dominate, with higher tradable sector productivity leading to an appreciated RER.

3. Exogenous variables—OECD growth, aid, natural disasters and elections

The OECD growth rate was used as a control variable, contemporaneously and with a number of lags equal to those of the PVAR. Aid flows were also included as an exogenous variable to assess the effect of changes in external donor assistance. This is measured as explicit aid, rather than the implied benefits obtained from preferential trade agreements, an area explored in Mlachila and Cashin (2007). These data were deflated by the investment deflator, since it was assumed that most aid flows are used for investment projects rather than current spending. The model was run with and without the aid variable.

The inclusion of aid in the model may be controversial and likely raises as many questions as it answers. For example, is aid endogenous to any of the domestic variables, including the incidence of natural disasters? Correlations suggest that aid has only a weak contemporaneous relationship with the other variables. Also, a raft of panel regressions in which aid flows are on the left-hand side and domestic variables, including natural disaster dummy variables, are on the right-hand side suggested no relationship between domestic variables, including natural disasters.
Exogenous domestic variables include dummy variables for both natural disasters and elections. Natural disasters that affected either at least 25% of the population or caused more than 25% of GDP in damage were identified from the EMDAT database. Dummies were included for the year the disaster hit, and the following two years to control for the effect of disaster-related reconstruction, whose growth effects may be very different from regular

public investment. There has been research suggesting that public spending in the ECCU may be affected by the election cycle (Duttagupta and Tolosa, 2006). To control for this, dummies for the year before and the year of national elections in each country were also included.

4. Model specification and estimation

To allow for heterogeneity, a fixed-effects model is estimated. As is well known, it is inappropriate to treat individual effects as constants to be estimated for a dynamic model (Nickell, 1981). Although the bias goes to zero as the time dimension gets very large, Judson and Owen (1996) show this bias may remain significant even with a time dimension of 30, close to that used in this paper. Following Holtz-Eakin, Newey, and Rosen (1988), the model is estimated in the first difference of growth rates, to sweep away the fixed effects. Denoting the (3x1) vector of endogenous variables (growth rates) as **x**, the OECD growth rate as **w**, and the vector of dummies as **f**, this model may be written as:

$$\Delta \mathbf{x}_t = \mathbf{a}_0 + \sum_{l=1}^{m} \mathbf{a}_l \Delta \mathbf{x}_{t-l} + \sum_{l=1}^{m} \boldsymbol{\gamma}_l \Delta \mathbf{w}_{t-l} + \boldsymbol{\Theta} \mathbf{f}_t + \boldsymbol{\upsilon}_t \tag{4}$$

The vector of instrumental variables **z** that is available to identify the model is:

$$\mathbf{z}_t = \left[1, \mathbf{x}_{t-1}, \ldots, \mathbf{x}_1, \mathbf{w}_t, \ldots, \mathbf{w}_1, \mathbf{f}_t\right] \tag{5}$$

The model was estimated using the Generalized Method of Moments (GMM) and a weighting matrix that controlled for heteroscedasticity of an unknown form. The set of instruments was chosen to ensure that the test of overidentifying restrictions was satisfied. The lag length of two was chosen on the basis of log-likelihood tests and, at the margin, information criteria.

5. Impulse responses

The ordering used to obtain orthogonalized impulse responses was that public investment leads GDP, which leads the RER. This ordering is typical of the literature and was justified by Pereira (2000) on the basis that: *i)* shocks to economic growth take time to feed through the policy function influencing public investment;

ii) public investment has an immediate impact on growth. These assumptions are all fairly uncontroversial. Impulse response standard errors were derived using Monte Carlo simulations, as outlined in Hamilton (1994), p. 337.

V. RESULTS

1. The effects of aid flows

Aid, as noted above, is included in the study as a control variable; it is not the intention here to assess the effect of aid on growth. As might be anticipated from simple correlations, the inclusion of aid flows had little effect, only marginally reducing the public investment multiplier on growth.

2. The impact of public investment on growth

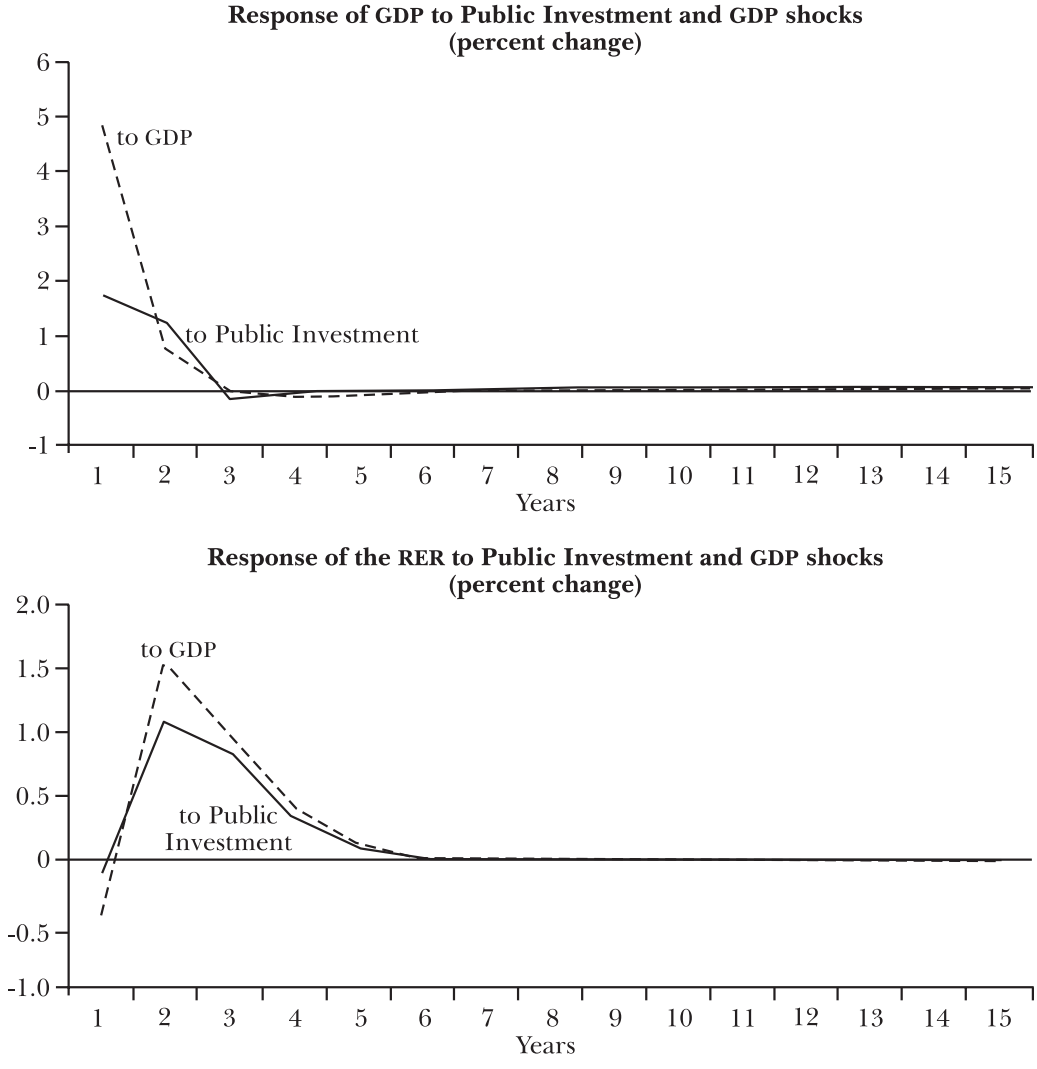
Impulse responses suggest that public investment has a positive but short-run impact on growth (see Figures 3 and 4). Given the assumption of no cointegration, the model by definition implies that public investment cannot permanently affect the growth rate, but can permanently affect the level of GDP. The effect of a one-time random one-standard deviation shock on growth effectively dies out after 4 years. This suggests that public investment generates a weak investment response from the private sector, given the likely lags involved in private sector decisions. In contrast, the major effect of public investment on growth is direct (in the sense that it boosts domestic demand), with relatively weak multipliers.

To measure the impact on GDP, we adapt the rate of return metric suggested by Pereira (2000). The first element in this calculation is the accumulated percentage age point impact on the level of GDP of a one-time random shock to real public investment. Abusing terminology (given the cointegration results), this is termed the long-run elasticity (σ) as in Pereira (2000).

$$\sigma = \frac{\partial Y/Y}{\partial I/I} \tag{6}$$

To control for the size of public investment in the economy, this elasticity σ is divided by the average public investment-to-GDP

FIGURE 3. ECCU: IMPULSE RESPONSE FOR GDP AND THE BILATERAL REAL EXCHANGE RATE TO ONE STANDARD DEVIATION PUBLIC INVESTMENT AND GDP SHOCKS



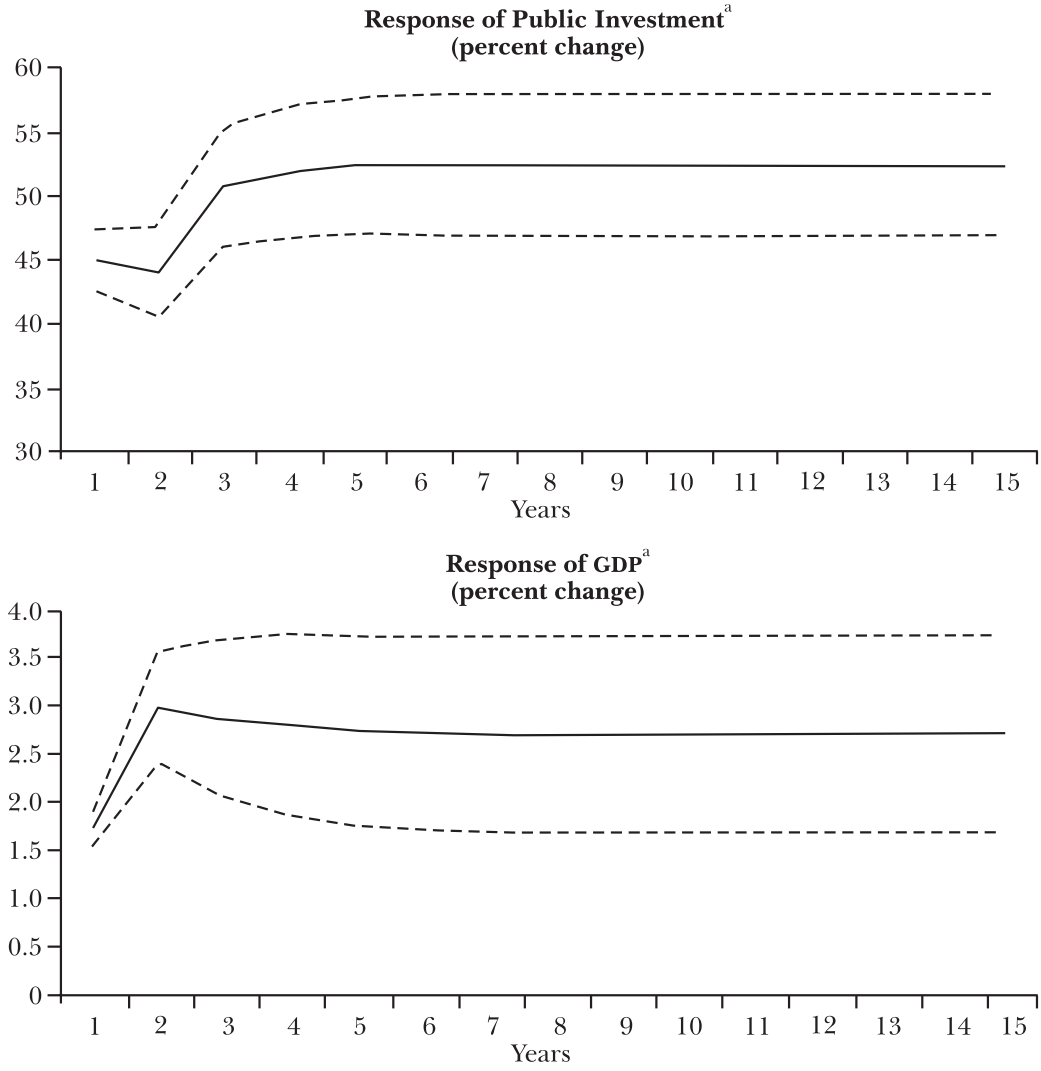
SOURCE: Author´s calculations.

ratio since 1990 $(I / Y)_A$. Since 1990, this ratio has exhibited stationarity, and the sample from which the average is chosen has little effect. This obtains the marginal product of investment (*MP*):

$$MP = \sigma \cdot \left(\frac{Y}{I} \right)_A = \frac{dY}{dI} \tag{7}$$

To make the calculation simple, assume a one percentage shock to public investment. The marginal output may then be assumed to flow over some realistic project horizon. In this case,

FIGURE 4. ECCU: ACCUMULATED IMPULSE RESPONSES TO AN ONE STANDARD DEVIATION SHOCK TO PUBLIC INVESTMENT



SOURCE: Author's calculations.

[a] Standard error bounds calculated using Monte Carlo simulations.

a 20-year horizon with a constant output flow, that is (dY / 20) per period. The rate of return on public investment (r) is then the discount rate that solves the present value problem (5):

$$1 = \sum_{t=1}^{20} \frac{dY}{(1+r)^t} \tag{8}$$

The table below applies this method to the results from the estimate panel-VAR and the historical ECCU data. The baseline model is the two-lag model including OECD growth as an exogenous

TABLE 2. ECCU: RATE OF RETURN ON PUBLIC INVESTMENT

	Long-run elasticity[a]	*Marginal productivity*[b]	*Annual rate of return*[c]
Baseline model			
Upper bound[d]	0.08	0.76	-2.4
Central tendency	0.07	0.66	-3.6
Lower bound[d]	0.06	0.54	-5.3
Including aid flows as an exogenous regressor			
Central tendency	0.05	0.47	-6.3
Including aid flows and a time trend			
Central tendency	0.07	0.61	-4.3

SOURCE: Author's calculations.
[a] Accumulated long-change in the level of real GDP divided by the accumulated long-change in the level of real public investment due to a one-time one-percent shock in real public investment. [b] Calculated as the long-run elasticity divided by the public investment-GDP ratio and interpreted as the long-run real EC dollar change in real GDP divided by the long-run change in real public investment. [c] This is the internal rate of average annual percentage rate of return implied by the marginal product of capital over a 20-year period. [d] Bounds based on one-standard deviation confidence intervals on the change in growth and public investment..

regressor. Two other specifications, including aid flows and a time trend, are shown.

These return estimates are compared in the table below to recent results from the literature; the rate of return estimated for the

TABLE 3. ECCU: RATE OF RETURN COMPARED[a]

Country/region	*Study*	*Rate of return*
ECCU		-2.0
US[b]	Pereira (2000)	7.8
Austria	Pereira and Fatima-Pinho (2006)	-6.2
Belgium	"	-7.9
Finland	"	2.7
France	"	6.7
Germany	"	10.3
Greece	"	7.6
Ireland	"	6.8
Italy	"	11.4
Portugal	"	6.0
Spain	"	3.8
Average (excl. ECCU)		*4.5*
Standard deviation (excl. ECCU)		6.2

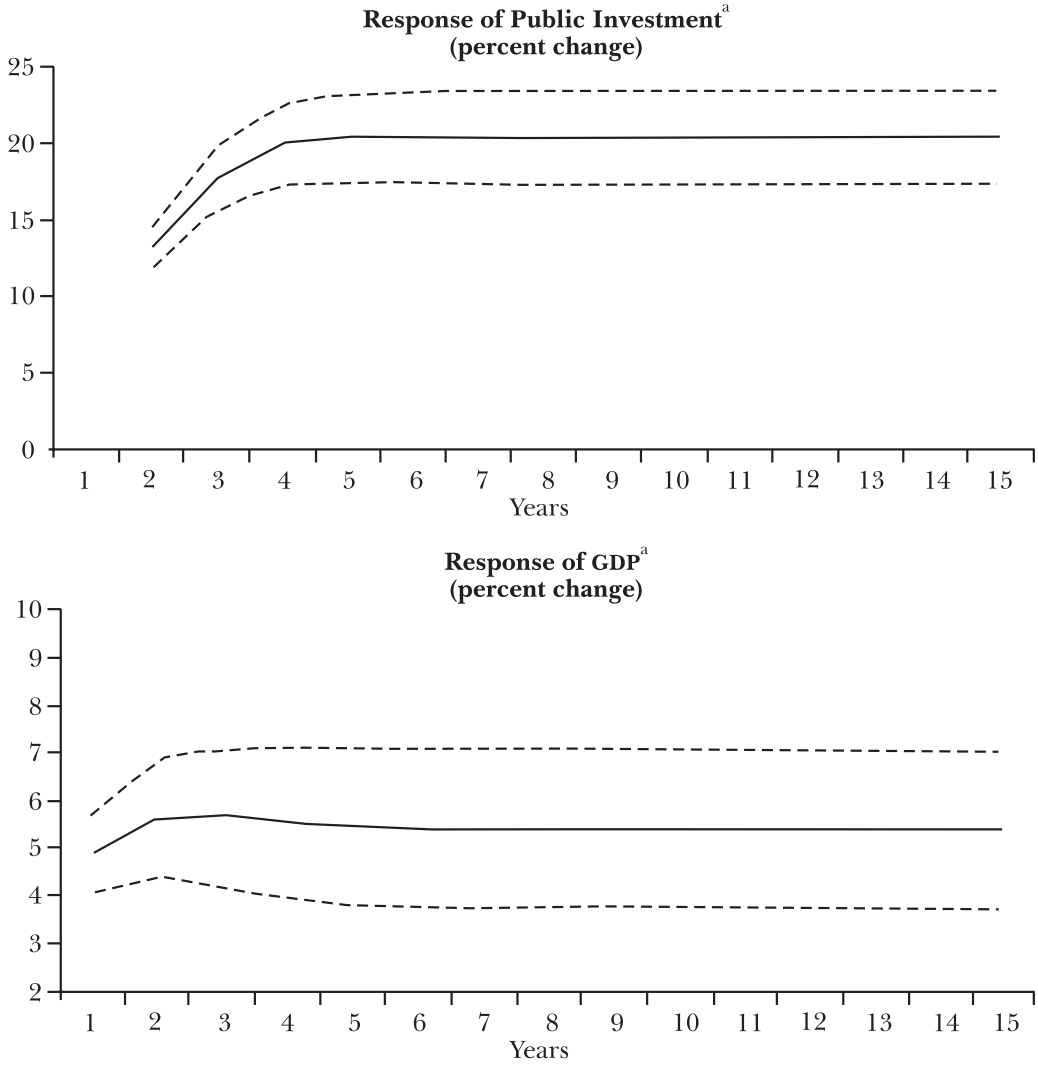
SOURCES: Author's calculations; Pereira (2000), and Fatima-Pinho (2006).
[a] Rate of return calculated as a "bullet" output flow after 20-years. [b] Measured in terms of private output.

ECCU appears to be at the lower end of the range. Note that the return calculation is slightly different than in the table above. To ensure consistency with the literature, the return calculation below is based on the assumption that payoff to public investment arrives as a lump sum after 20 years.

3. Granger causality test—public investment on output

The conventional way to assess whether past changes in public investment affect the contemporaneous level of growth is a Granger

FIGURE 5. ECCU: ACCUMULATED IMPULSE RESPONSES TO AN ONE STANDARD DEVIATION SHOCK TO GDP



SOURCE: Author's calculations.

[a] Standard error bounds calculated using Monte Carlo simulations.

causality test. For all three specifications, the hypothesis that public investment did not Granger cause output growth could be rejected at the 1% level of significance (using log likelihood tests, with and without small sample adjustments). These results should not be so surprising given that public investment, on average, accounts for over 9% of GDP, suggesting that demand effects alone could be significant.

4. The impact of growth on public investment

The effect of a growth shock on public investment is positive (see Figure 5). Higher growth may be supportive for tax and other revenues and allow the public sector to increase capital expenditure from its own resources. Standard errors are fairly wide, however. This is unsurprising. Ignoring the effect of natural disasters (which clearly play a role, even in the presence of some control variables), public investment in these economies may be influenced by factors outside of the model. The most obvious example is the availability of funds, whether from donors in the form of grants or concessionary loans, or from private sources.

TABLE 4. CORRELATION MATRIX OF MODEL VARIABLES[a]

	Public investment	*Country GDP*	*Bilateral RER*	*OECD GDP*	*Aid flows*
Public investment	-				
Country GDP	0.208[b]	-			
Bilateral RER	0.049	-0.129	-		
OECD GDP	0.101	0.352[b]	-0.244	-	
Aid flows	0.108	0.045	0.044	0.002	-

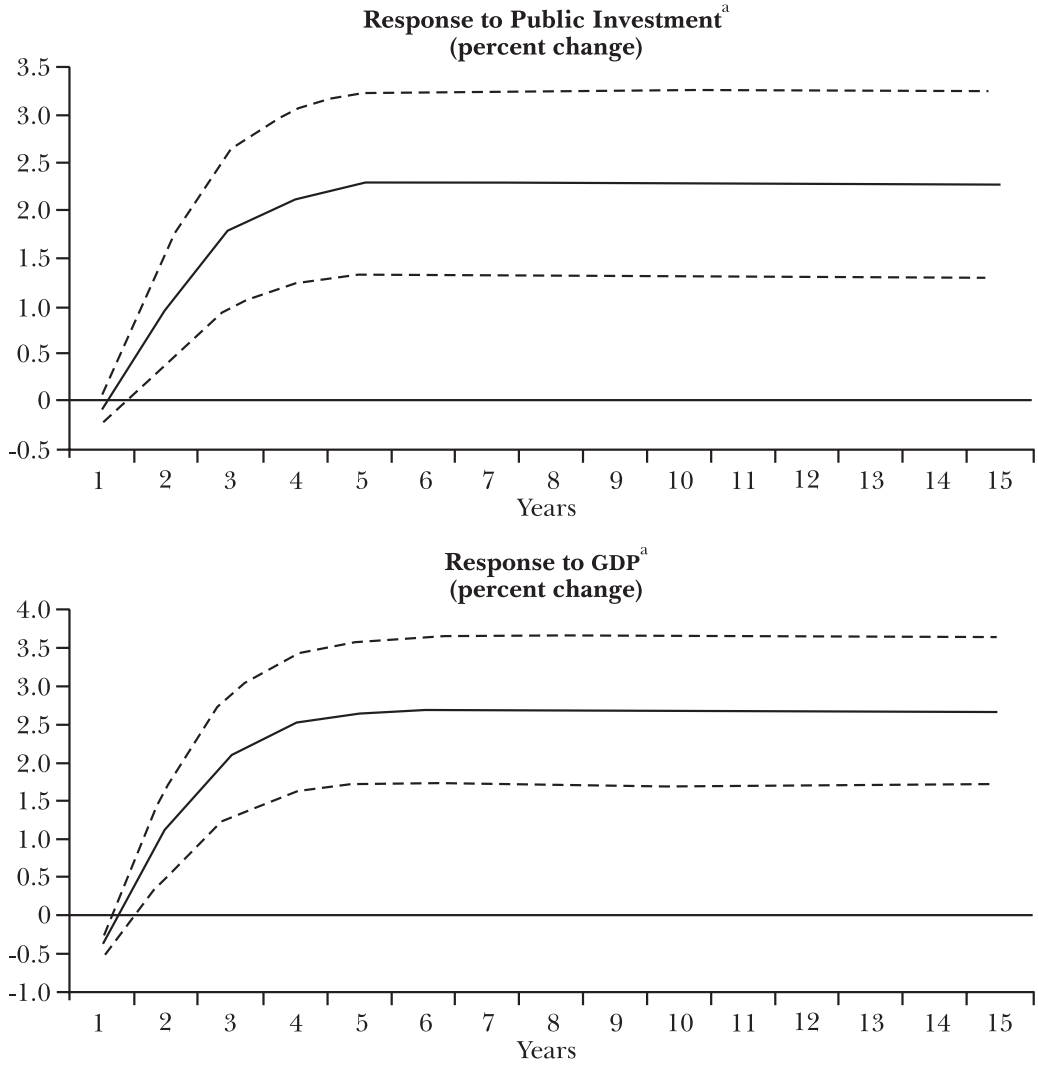
SOURCE: Author's calculations.

[a] Correlations use first difference of the log real variables. [b] Indicates that the correlation coefficient is significant at the percent level.

5. The impact of public investment and growth on the bilateral RER

Impulse responses suggest that the bilateral RER appreciates in the first three years following positive public investment and growth shocks, but the standard errors are very wide (Figure 6). In the long-term, higher levels of public investment appear to have little effect in reversing this effect, suggesting the short-run

FIGURE 6. ECCU: ACCUMULATED IMPULSE RESPONSES OF THE BILATERAL RER TO AN ONE STANDARD DEVIATION SHOCK TO GDP AND PUBLIC INVESTMENT



SOURCE: Author's calculations.

[a] Standard error bounds calculated using Monte Carlo simulations.

demand impact on prices is much more important than the long-run supply effect.

6. Effects of natural disaster and elections

The controls for natural disasters and elections worked as anticipated. The coefficients on both sets of dummies had the expected sign (see Table 5). The effects on growth were particularly pronounced, with growth falling sharply in the year of a disaster and then rising strongly the following year.

TABLE 5. VAR COEFFICIENTS ON NATURAL DISASTER AND ELECTION DUMMY VARIABLES

	Public investment	*Real GDP*	*Bilateral RER*
Natural disaster (same year)			
Coefficient	-36.4	-6.2	2.9
Standard error	32.5	2.5	1.9
Natural disaster (following year)			
Coefficient	24.6	16.5	-1.7
Standard error	36.8	6.8	2.4
Election (preceding year)			
Coefficient	12.1	1.2	0.3
Standard error	15.0	1.2	0.8
Election (same year)			
Coefficient	20.0	0.6	-0.8
Standard error	19.4	1.4	0.8

SOURCE: Author's calculations.

VI. Conclusions

Public investment plays an important role in raising and sustaining economic growth in the region. However, public investment must be efficient if it is to have the desired growth effect and reduce the risks that it will add to public sector indebtedness. The evidence from the ECCU over the last 30 years suggests that public investment has had only a temporary and limited growth effect. To the extent that investment is financed by borrowing, this suggests that public investment has had a larger impact on the debt stock than on GDP.

This paper does not seek to explain why public investment is relatively inefficient. The methods used only help to make inferences regarding its impact on growth. It also does not address the differential effects of various types of public investment. Attempting to explain why the rate of return is low and what types of public investment are most productive in the Eastern Caribbean remains a fertile area for future research.

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Staff, functions, and staff costs at central banks: an international comparison with a labor-demand model

1. INTRODUCTION

How many employees should a central bank have? What determines its labor demand? What are the central bank's staff costs? These questions have always been of particular interest to central banks, governments and multilateral organizations alike, but they have increased in significance in the past few years with the formation of the European Central Bank and the quest for efficiency in OECD central banks.[1]

[1] Wellink, *et al.* (2002) have identified improvements in efficiency attainable

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In fact, when we examine these staffs we can see that the number of employees differs widely between central banks. In the year 2004 the US Federal Reserve (FED) had 20,217 employees, whereas New Zealand's central bank operated with approximately 250 employees. In Latin America, Brazil's central bank employed 4,629 people, whereas Chile's had under 600. These differences also persist in some other developing countries, (*e.g.*, Thailand's central bank operates with about 4,500 employees and Bulgaria's with around 1,000).

The empirical evidence suggests that these differences do not reside exclusively on the size of the population or the characteristics of the economy but also on the number of functions developed by central banks (Vaubel, 1997; 2002). In an extensive work, Banco de la República (2005) has studied the functions carried out by 133 central banks and found out that operative functions (i.e., financial supervision, cash distribution, operation of retail payment systems, and banknotes printing) are more labor-intensive and therefore have the greatest impact on labor demand at central banks.

From the theoretical standpoint, staff costs should be taken into account when estimating labor demand (Hamermesh, 1993). To this respect, Brione (2005) compared the staff costs of 28 OECD central banks, and found wide differences (*e.g.*, the central banks of Austria, Italy and Poland have an average cost per employee three times higher than that of the central banks of New Zealand, Ireland and the Czech Republic). According to the author, these differences can be largely attributed to the heterogeneity in the functions performed by central banks.[2]

In this context, the present paper intends to find the determinants of labor demand at central banks, and to estimate the staff that these institutions require by taking into account how they

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by National European Central Banks after the centralization of several functions by the European Central Bank. In the same way, McKinley and Banaian (2005) have studied central bank's functions and its modernization trend in several OECD countries with the aim to identifying operational efficiency.

[2] On this particular subject, the Governor of Sweden's Central Bank, Mr. Lars Heikensten, has emphasized on the need of central banks becoming involved with cost-efficiency and to be more focused on their core functions (See, Heikensten, 2003).

carry out their operative functions, their staff costs, and the characteristics of the economy where they operate. To this effect, 78 central banks of different regions with information from the 2000-2004 period are studied, and the staff is estimated for 66 banks on which additional information could be obtained on their staff costs.

Thus, this paper wishes to contribute to the body of literature on central banks in three major aspects. First, identifying the usual strategies developed by central banks in the performance of their operative functions. In the theoretical aspect, we construct a real wages' *proxy* in order to characterize the labor-demand function and to validate the assumption of the flexible budgetary restriction of central banks. Finally, as to methodology, we uses a panel data model with random effects that contemplates the differences between central banks while at the same time allowing to identify the impact generated on the staff by changes introduced in their functions.

The paper is composed of four sections including this introduction. Section 2 discusses the recent evolution of central banks' staff, functions and staff costs. Section 3 describes the theoretical aspects of labor demand, reviews the empirical evidence for central banks, and the statement of the model. Also shows the results of the model and the staff estimations for central banks. Section 4 concludes.

2. STAFF, FUNCTIONS, AND STAFF COSTS AT CENTRAL BANKS

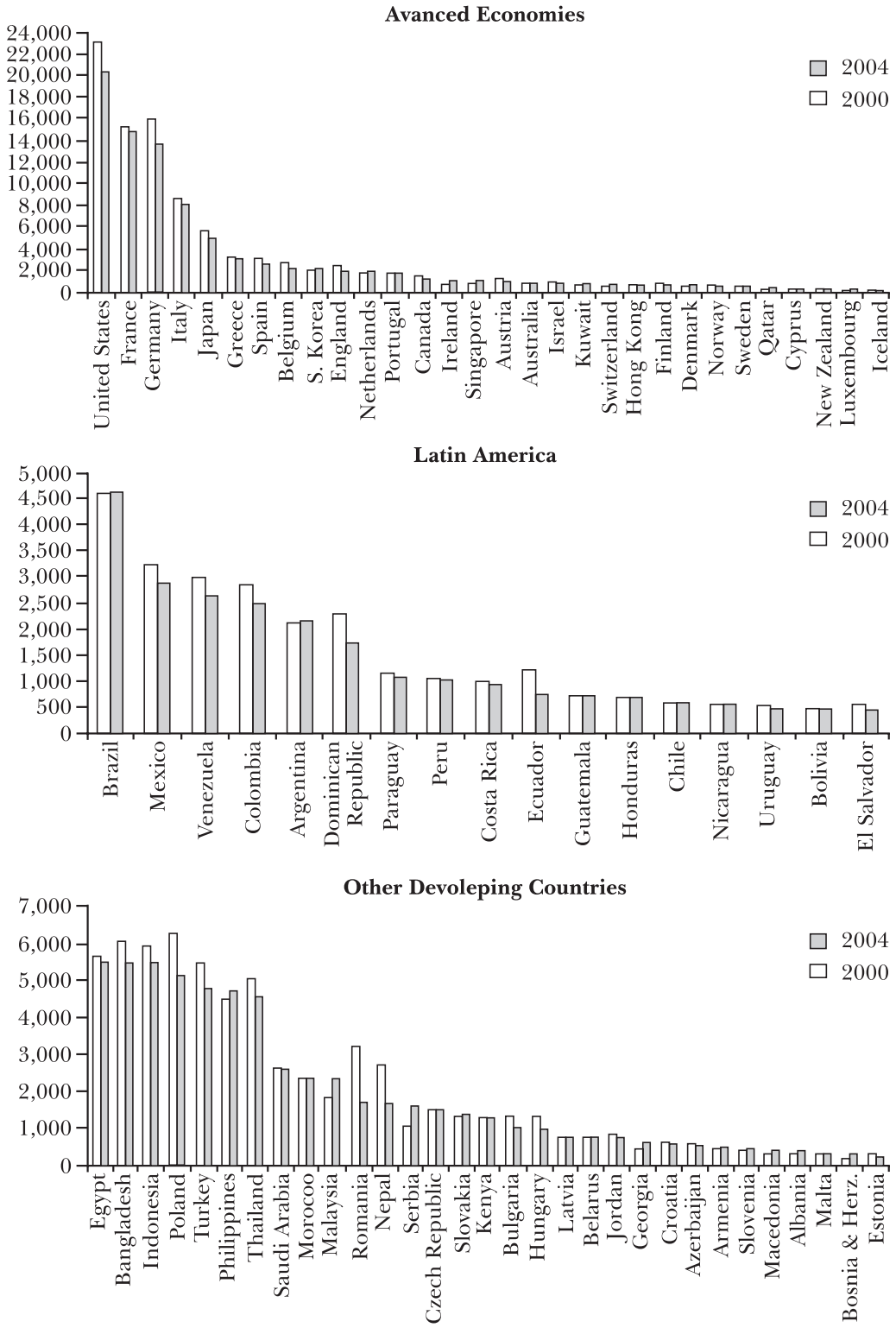
This section presents some facts that show how the gradual adjustment in central banks' staffs has been accompanied with changes in their operative functions and increases in staff costs. For a better comparative analysis, the selected sample was divided into three subgroups with homogeneous characteristics; two of them by similar degree of economic development, and the other one by geographic region.

2.1. Evolution of the central banks staff (2000-2004)

A. Advanced economies

This group comprises the central banks of 30 countries that share

FIGURE 1. CENTRAL BANKS STAFF PER COMPARISON GROUP (Employees)



SOURCES: Author's calculations based on Central Banks Annual Reports and the Central Bank Directory (2000, 2004).

as a common characteristic a per capita income of above USD 10,000 per year, according to the classification in IMF (2005). In this group, central banks with the highest number of employees were the FED, which after an approximately 13% reduction during the period, ended the year 2004 with 20,217 employees. Next in size are the central banks of France, Germany, and Italy, which are characterized by having an extensive presence at the national level. However, these central banks have also made important reductions in their staffs in the past few years; in particular, the reduction carried out by the German central bank (2,200 employees) is worth noting.

During the period under study, the largest staff reductions were presented in the central banks of Canada (26%), England (23%) and Finland (19%). In contrast, the most significant increases occurred in Qatar (71%), Ireland (49%) and Luxembourg (27%). In this group, the central banks of New Zealand, Luxembourg, and Iceland are notorious for their small staffs, with less than 250 employees each. In the year 2004, this group had an average of 2,957 employees, i.e., 8.3% below the figure of 3,226 for the year 2000 (See Figure 1).

B. Latin America

This group is conformed by central banks from 17 South and Central American countries, including Mexico and the Dominican Republic. Within this group, the central bank of Brazil had the largest staff, with 4,629 employees in 2004. It's remarkable that almost all central banks in this region made staff reductions, with the cases of Ecuador (39.2%) and El Salvador (21%) largely being associated with the dollarization of these economies in the years 2003 and 2001, respectively. Significant employee reductions also took place in the Dominican Republic and Colombia, of about 23% and 12%, respectively. The average number of employees of this region's central banks went down from 1,575 in the year 2000 to 1,434 by the end of 2004, representing an adjustment of approximately 9%.

C. Other developing countries

This subgroup is composed of 31 central banks from countries

with an annual per capita income of below USD 10,000 in 2004, and not pertaining to the Latin American region. Notorious for their large size are the central banks of Bangladesh, Egypt, Indonesia and Poland, all of which have more than 5,000 employees each. At their turn, the banks of Bosnia & Herzegovina and Estonia are worth mentioning for having less than 300 employees. During the period, important staff reductions took place at the central banks of Rumania (47%), Nepal (39%) and Hungary (27%).

It's noticeable that several of these countries are recent members of the European Union or candidates to become members.[3] In contrast, the central banks of Serbia, Bosnia & Herzegovina, Georgia and Macedonia, have seen their staffs increase in more than 40%. However, the average size of the staff in this group had a 8% decrease, going from 2,117 employees in the year 2000 down to 1,948 in 2004.

2.2. Functions of central banks

Functions developed by central banks are directly related to a wide array of goals, the most common of which are: To preserve the internal value of the national currency, to managerial the country's international reserves, to look after the country's financial stability, to secure a safe and efficient payment system, and to guarantee the issue and circulation of currency (See Fisher, 1994; De Hann and Kooi, 2000). Several of these objectives are related to a group of functions that, due to the related activities, are labor intensive. These functions are: financial supervision, currency operations, banknotes printing, coin minting, and payment systems operation.

Since these are operational functions that, in some cases, involve a moderate degree of risk, central banks have implemented modernization strategies aimed at gathering the involvement of the private sector for their development. Recent experiences also suggest the lack of a consensus about whether central banks

[3] On May 1st 2004 ten new countries became members of the European Union (*i.e.*, Cyprus, Slovakia, Slovenia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland and The Czech Republic); on January 1st 2007, Bulgaria and Romania became members, meanwhile Croatia, Macedonia and Turkey are waiting to become members of the Union..

should or not carry out these functions or on how should they perform them, these issues depends mostly on their relationship with the government and with the financial sector as well as with their historical tradition.[4]

A. Financial supervision

The supervision of the financial system is one of the functions that, for reasons of the country's institutional organization, has been delegated from the beginning to central banks, or has been the responsibility of a separate state-owned entity. That is why this particular function has not sustained any significant changes in its administration.[5]

There is neither a clear trend in the performance of this function or a wide consensus on who should take care of it. However, there are some arguments in favor of central banks performing it. First, in order to fulfill its role as last-instance lenders, central banks must have first-hand and detailed information on the solvency of commercial banks, and they could perform this function more efficiently if they gathered this information directly instead of having to request it from another entity (Peek *et al.*, 1999).[6] Another issue has to do with the potential scale economies that central banks may develop when they take care of that particular function, because they must monitor the movements of the financial system and for that task they usually have a Financial Stability Department (Green, 2003).

In order to review this trend, Figure 2 shows the percentage of central banks that performed this function in 2004 and its

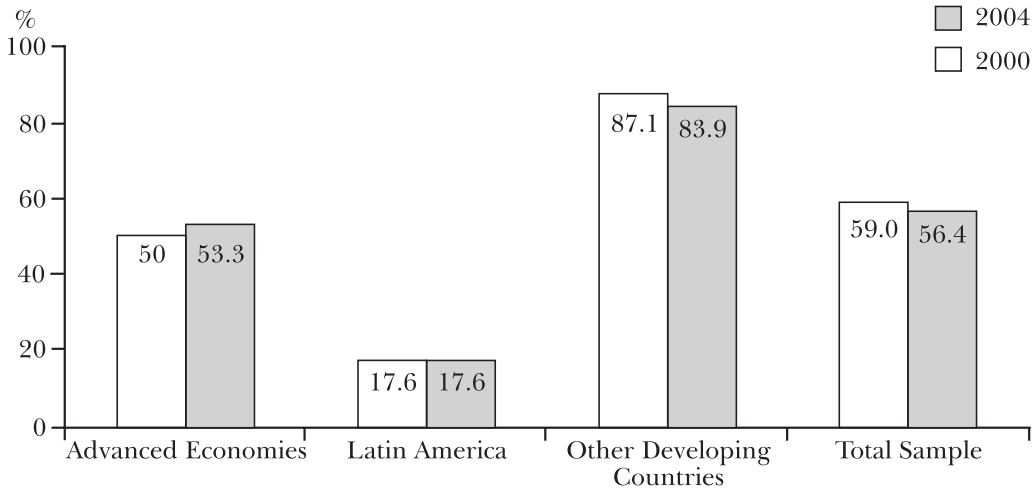
[4] For example, it is common in Latin America to find central banks that develop some type of cultural activity due to the historical support they have given to their country on these particular matters. However, the scope of these activities is very limited in most countries (See Annex 2).

[5] Although no administrative changes have taken place, it is worth noting that the ways to supervise the financial system have in fact sustained significant changes due to the growth of this sector, market globalization, and recent technological advances. For a complete revision of the structural changes in US financial regulation, see Freixas and Santomero (2002).

[6] In the same sense, Goodhart and Schoenmaker (1995) argue that when an independent central bank perform the financial supervision, a more efficient response is likely to be given to the combined challenges of monetary and financial stability (See also, Di Noia and Di Giorgio, 1999).

comparison with the year 2000. In the advanced economies group, about one half of these central banks supervise financial entities. Among these are central banks that carry out shared supervisory modalities, as in the case of Germany, where the Federal Financial Supervisory Authority (FSSA) and the central bank share supervisory tasks, and the latter is in charge of issuing guidelines and regulations on this matter (For details see Deutsche Bundesbank, 2002).

FIGURE 2. CENTRAL BANKS WITH THE FINANCIAL SUPERVISION FUNCTION



SOURCES: Author's calculations based on Central Banks Annual Reports and Central Bank Directory (2000, 2004).

During the period under study the only relevant change was the merger between Ireland's Financial Supervising Authority and central bank that took place in the year 2003, and that was arranged with the aim of taking advantage of synergies in common tasks and increasing the efficiency in the communication of information. In contrast with what occurred in Ireland, in 1997 England's central bank surrendered its banking supervision functions to the Financial Services Superintendence.[7]

In Latin America, financial supervision has been a role typically played by state-owned entities. In this region, only the central banks of Argentina, Brazil, and Paraguay carry out this function. Contrary to this trend, in the group of other developing countries the supervision of financial entities is mostly a function of

[7] Briault (2002) has shown that this change has been beneficial for the development of the financial sector in England.

central banks. Only the central banks of Turkey, Bosnia & Herzegovina and Estonia do not perform this task, the latter country delegated it to a state-owned entity by the end of the year 2003.

B. Currency operations

Currency operations mainly involve cash handling, distribution, quality check, and destruction. To carry out these activities, central banks may apart themselves from the traditional model, that was characterized by the bank performing the whole activity with its own resources. More particularly, central banks may gather the partial or complete support from third parties, provided that a certain level of supervision is maintained (See Table 1).

TABLE 1. CURRENCY OPERATIONS MODALITIES

- *Traditional Model*: The central bank takes charge of all currency operations.
- *Sharing Model*: The central bank delegates part of these activities to a custodial entity, generally related to commercial banks or to securities transporters.
- *Participative Model*: The central bank acts as stockholder in a private firm that assumes most of these activities. These firms are usually created at the central bank's initiative, seeking to establish partnerships with financial entities or specialized firms.
- *Freelance Operation*: The central bank has a minimum participation, limiting itself only to the destruction process, and leaving to third parties (*e.g.*, private banks) the larger currency operations (i.e., cash handling, distribution, and quality check).

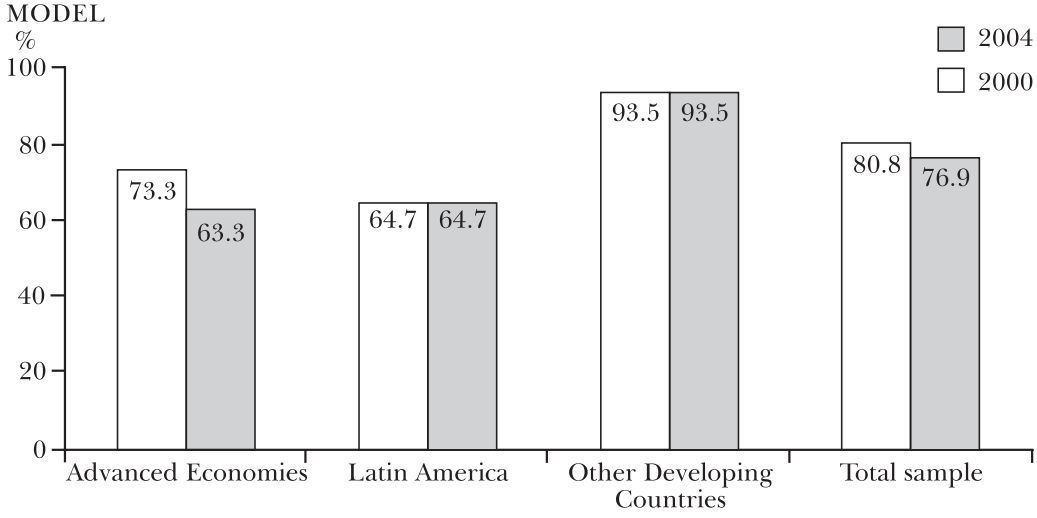
SOURCES: Banco de la República (2005) and Central Banks Annual Reports.

Figure 3 shows the percentage of central banks that carry out all or most of currency operations, mainly following the traditional model. Central banks pertaining to advanced economies show a trend toward delegating some activities related to currency operations to third parties. However, most of them still follow a traditional model (*e.g.*, Spain, France, Italy, Germany, and US).[8]

During the period under analysis, the central banks of Austria,

[8] In an effort to minimise the cost of providing currency, the Federal Reserve recently issued for comment notice of a proposed policy that would involve the development of a custodial inventory program combined with a fee assessed on such cross-shipped currency (McKinley and Banaian, 2005, p. 76).

FIGURE 3. CENTRAL BANKS USING A TRADITIONAL CURRENCY OPERATIONS MODEL



SOURCE: Author's calculations based on Central Banks Annual Reports (2000, 2004).

Finland and Norway delegated most of their currency operations through a participative model. In the year 2001, the Austrian central bank created a joint-venture with commercial banks in the form of an independent enterprise that assumed all currency operations, with the exception of destruction. In the same year, the central bank of Norway delegated to the private firm *Nokas* all currency operations and the administration of its 9 branches, keeping to itself a third part of the shares in this company. Under a similar view, the Finland's central bank generated a partnership with a cash-processing company owned by commercial banks.

In contrast, the central banks of New Zealand and Canada follow a sharing model, implementing the figure of custodial banks, through an association between commercial banks and securities transporting firms, whereas England and Ireland have adopted a freelance model where the market naturally assumes most currency operations.[9] Hong Kong has an atypical modality amongst the central banks of this group, because the government there has authorized three commercial banks to issue, distribute, and destroy cash under a special regulation.[10]

[9] Baxter *et al.* (2005) provides an analysis of the different strategies used by central banks of Austria, Canada, England, Malaysia, and Norway to perform these currency operations.

[10] Commercial banks in charge of these activities are the Bank of China Ltd., Standard Chartered Bank Ltd., and The Hong Kong and Shanghai Banking Corporation Ltd., which operate under a set of terms and conditions set forth by

About 65% of Latin American central banks adhere primarily to the *traditional model*, with the exceptions of Brazil, Mexico, and Chile, which use shared schemes. Distribution processes are carried out in Brazil through the branches network of *Banco do Brasil*, a state-owned bank with more than 1,800 branches in the whole national territory. Similarly, Brazil's central bank is the only one in this region that does not carry out directly the banknote-destruction process. Mexico's central bank gathers the support from commercial banks, which take care of this function through 549 branches since 1996. Likewise, commercial banks and securities transporters in Chile perform banknotes exchange and quality check, whereas the central bank only performs notes destruction after a verification process of unfit banknotes (See, Leiva, 1998).

All central banks in the group of other developing countries, with the exception of Estonia and Malaysia, follow primarily a traditional model for currency operations. Some possible explanations for the prevalence of this model are the lack of integration with the financial sector and the size of the market, which has been insufficient to generate mechanisms that contribute to facilitate these processes.

Branches for currency operations

Usually, whenever a central bank adheres closely to a traditional currency operations model, it does so through its own network of branches. The size of these networks differ widely between central banks due to diverse factors (*e.g.*, geographic, demographic, or economic). Central banks that traditionally have had a wide network of branches are those from France, Germany, Italy, the United States, and Spain. However, in the past few years several of these banks have reduced the size of their networks and will continue to do so, but without abandoning their significant regional presence.[11]

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the government. For more details about operational functions in EMEAP central banks see Nishihara (2006).

[11] This network reduction has been implemented as the market in the cities where the central bank used to be present have started to create the mechanisms to assume these activities either by themselves or under contracts with other

Germany's central bank has implemented a restructuring plan for its network of branches, going down from 118 in the year 2000 to 85 in 2004, and will pursue this policy until only 47 branches are left in the year 2007. The French central bank closed 26 branches during 2004, ending that year with 185, and the plan contemplates closing 115 more branches between 2004 and 2006 in an attempt to reach a final network of just 96. Similarly, the central bank of Spain closed 30 branches between the years 2000 and 2004, reaching its goal of a 22-branch network.

There is another important group of central banks that began to restructure their branches since the last decade. Among them, the Australian central bank reduced between 1998 and 2003 its network of 8 cash-distribution centers to just one that operates with the banknotes press. Likewise, the central bank of Canada went from 9 branches down to just 2 between 1993 and 1997. As for Latin America, Colombia's central bank has closed 13 currency operations branches since 1997, with 15 remaining to date, whereas the central bank of Chile closed 9 branches since 1992 and only 2 are left today.[12]

Most central banks in the group of other developing countries have not sustained significant reductions in their network of branches. Worth remarking due to their extensive networks are the central banks of Turkey (21), Morocco (20) and Poland (16), with the latter having created 3 additional branches since the year 2001. An interesting case is the branch structure of Thailand's central bank, with three regional offices, each operating several independent currency operations and management centers. Under a similar scheme, the central bank of Indonesia manages 8 regional offices.

C. Banknotes printing and coin minting

Banknotes printing and coin minting are industrial functions associated with the central banks' core task of issue currency.

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firms (Baxter, *et al.*, 2005). An assessing on the technical efficiency of the 37 currency operations branches of the FED in the US can be seen in Bohn *et al.* (2001). For a similar study in the central bank of Colombia, see Sarmiento (2005).

[12] For more details on this and other changes in the operative functions of Colombia's central bank, see Annex 7.

There are several forms to meet the cash needs of a given economy. In some countries, either the central bank or the government are in charge of cash production; whereas in other countries, the central bank purchases the currency from private firms under contract or import it from other countries.

Table 2 shows that the vast majority of central banks do not produce their national currency. For banknotes, primarily in advanced economies, a growing trend is observed toward assigning this function to private entities. During the period under analysis, the central banks of Sweden and England sold their banknote presses to private companies, the former to *Crane & Co. Inc*. in 2001 and the latter to *De la Rue* in 2003. Similarly, the central bank of Austria segregated the production of banknotes in a subsidiary that acts as a private enterprise since the year 2000.[13]

TABLE 2. CENTRAL BANKS WITH BANKNOTE PRINTING AND COIN MINTING FUNCTIONS (2004)

	Advanced Economies		*Latin America*		*Other Developing Countries*	
Production	*%*	*Countries*	*%*	*Countries*	*%*	*Countries*
Notes &coins	10.0	Denmark Greece Ireland	11.8	Colombia Venezuela	19.4	Albania Armenia Morocco Philippines Serbia Slovenia
Only notes	20.0	Belgium France Italy Norway[a] Hong Kong Portugal[b]	5.9	Mexico	25.8	Azerbaijan Bangladesh Egypt Macedonia Romania Slovenia Thailand Turkey
Only coins	0.0	...	5.9	Peru	3.2	Nepal

SOURCES: Author's calculations based on the Central Banks Annual Reports and Bank Note Printers Directory (2000–2004).

[a] Norway's central bank is planning to delegate this activity in 2007. [b] Under a joint venture with *De la Rue*.

[13] In April 2001 the European Central Bank assigned to each one of the national central banks of the Euro zone the responsibility of producing certain denominations of banknotes with a view to guaranteeing a uniform level of quality and to allow the Eurosystem to take advantage of scale economies (ECB, 2003).

Some other significant changes have taken place in the past few years. In 1999 the central bank of Portugal created a joint venture with *De la Rue* for the banknotes production.[14] In 1998, Australia's banknote press was established as a subsidiary of the central bank, which acts as a stockholder.[15] In the same year, the Bank of Finland sold 60% of the shares it owned in *Setec Oy,* an independent company established in 1991, when it segregated its banknote press. Unlike these countries, the banknotes printing in Hong Kong is performed by *Hong Kong Note Printing, Ltd*., an enterprise acquired by the central bank back in 1996.

Most Latin American countries import their banknotes, with only the central banks of Colombia, Mexico and Venezuela operating their own banknote presses. Banknote printing in Brazil and Chile are under the responsibility of the government, whereas in Argentina a private company performs this activity. No changes in the administration of this function have occurred in this region. However, it is important to remark that structural changes, such as the dollarization processes in Ecuador and El Salvador during this period, lead to central banks or government ceasing to be concerned with this task.

In the group of other developing countries, the proportion of central banks that print their own banknotes is higher than in the other two groups, although more than one half does not carry it out at all. In some cases, the government performs this activity, although it is more frequent for the government to import notes from other countries. Some central banks that import banknotes are Malaysia, Indonesia, Nepal, and Croatia. A different practice is that of Bulgaria's central bank, which in the year 2002 segregated its banknotes press to a subsidiary firm (*Printing Woks*). The Polish central bank acquires the banknotes from a local privately-owned company.

Table 2 also shows that coin minting is a function that very few central banks perform directly. This function has been traditionally carried out by governments, although the production has

[14] The *Carregado* complex is a center specialized in banknote manufacture and cash distribution. Both Bank of Portugal's Treasury & Issue Department and *Valora*, i.e., the banknote-production unit, operate inside this complex.

[15] *Note Printing Australia* is a complex, which in addition to meeting the country's cash-demand, has specialized in the exportation of banknotes to other countries, and is known for the high quality of its plastic-substrate banknotes.

been assigned to private companies in some countries. In the advanced economies group only the central banks of Ireland, Greece and Denmark perform this function directly. In Austria, as occurred with the banknotes press, the central bank segregated coin production to a subsidiary in 2000. Coin minting in Finland is carried out by a private company, *Mint of Finland Ltd.*, the same that has been producing coins for Sweden since 2002. Coin production in Hong Kong is performed by *UK Royal Mint* and *Royal Canadian Mint*.

Only three Latin American central banks mint their own coins (Peru, Venezuela, and Colombia), whereas this function is performed by the government in Argentina, Brazil, Chile, and Mexico. Likewise, coin minting is mostly a government function in the group of other developing countries. The only central banks of this group that mint coins are those of Serbia, Morocco, The Philippines, Albania, Armenia, and Nepal.

D. Payment systems operation

One of central banks' major objectives is to look after the efficiency and security of payment systems. Due to the systemic risk involved in inter-bank transactions and the monetary interventions made by the central banks through these mechanisms, the role central banks play in payment systems operation and supervision is central for the well performance of the economy (See, CPSS, 2005a).

As to payment systems efficiency, Khiaonarong (2003) found three different approaches taken by central banks in their operation: minimalist, public, and competitive. These approaches differ in the degree of participation of central banks and cost-recovery policy, and have an impact on the efficiency of payment systems[16]. Similarly, the author considers that payment systems should be studied independently according to the value or volume of transactions. Therefore, to the effects of this paper, the operation of retail and large-value payment systems was studied separately.

[16] Classifying the sample of central banks under the three said approaches is a laborious task that requires an independent study in which we are actually working. Annex 3 describes the approaches and gives some examples for a several group of central banks.

Retail Payment Systems

Retail payment systems (RPS) are used for minor inter-bank transferences and payments made with credit cards, debit cards and cheques. Central banks differ in the operation of these systems because some of them do it directly, whereas others have established independent partnerships with financial entities, and in some others, both central banks and private entities manage their own systems and may or may not compete with each other. Whenever central banks do not operate directly the payment systems, they play an oversight role.

On the other hand, RPS may be operated either manually or automatically. Manual operation, particularly when related to check clearance, is labor-intensive. However, in some countries both manual and automated RPS coexist.

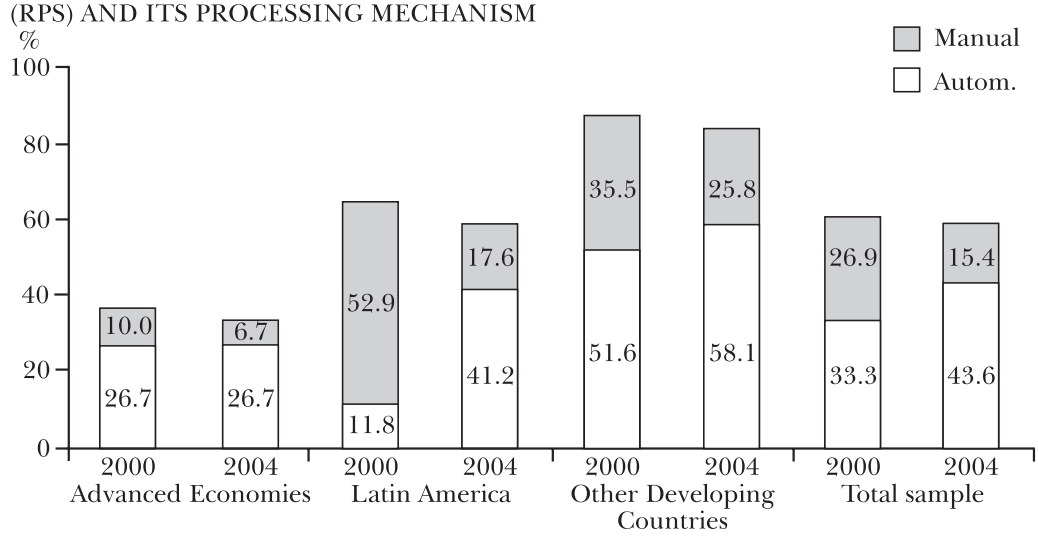
Figure 4 shows the proportion of central banks directly operating RPS, and its processing mechanism (automated or manual). As can be seen, only one third of the central banks in the advanced economies group operate RPS directly; this includes the central banks of Germany, Italy, Spain, and the FED. The FED plays a different role, because it competes directly with the private sector in all the systems, and maintains a full cost-recovery policy, legally supported by the *Monetary Control Act* of 1980.[17]

More than 65% of the central banks in the advanced economies group have created partnerships with financial entities for payment systems operation. Most of these changes took place during the 80's with the central bank of Canada starting the process, followed by England's central bank.[18]

[17] This law provides that the FED must set fees that allow for the recovery of all direct and indirect costs, and to guarantee a return on capital, as a private firm would do. From that time onwards, the enforcement of this regulation has resulted in great improvements in the efficiency of payment systems (See, Bauer and Hancock, 1993; Wheelock and Wilson, 2004).

[18] The central bank of Canada has delegated the operation of both retail and large-value payment systems, and has limited its role to oversight, and to provide accounts-settlement services. Since 1980 the Canadian Payments Association (CPA), conformed by financial institutions and the central bank, operates the two national payment systems: the LVTS, for large-value transactions, and the ACSS for retail transactions. The CPA operates as a non-profit organization and maintains a full cost recovery policy (Dingle, 2003). In England the Association for Payment Clearing Services (APACS) has been operating both retail and large-

FIGURE 4. CENTRAL BANKS OPERATING DIRECTLY RETAIL PAYMENT SYSTEMS (RPS) AND ITS PROCESSING MECHANISM



SOURCES: Author's calculations based on BIS Central Banks Reports on Payment Systems Annual Reports (2000, 2004) and the Central Banks Annual Reports (2000, 2004).

In this group, RPS are operated automatically by most central banks. Only the banks of Cyprus and Portugal do it manually. Cyprus's central bank has found this to be the most efficient way to operate due to the small size of the financial system and the high costs that automation would carry. In Portugal, the manual system coexists with automated systems pertaining to private entities, but they do not compete with each other because the central bank's manual system operates in small towns where the private sector is absent. During the period under study, the only change occurred in France's central bank, which ceased to operate manually the Provincial Clearing Houses and authorized a privately-owned automated clearing house to assume this role.

Most Latin American central banks operate directly RPS. As to the processing mechanism, central banks have shown a strong trend towards automation after the initial reforms implemented by the central banks of Mexico and Colombia at the beginning of

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value payment systems since 1985. This association is conformed by commercial banks, financial institutions, building companies, and the central bank. The APACS assumed the control of the firms CHAPS Clearing Company, BACS Ltd. and Cheque and Credit Clearing Company Ltd., which used to operate payment systems independently. Given its private nature, it follows a full cost recovery policy. Since then, the central bank has limited its functions to oversight payment systems.

the 90's. The most recent automation processes took place in Ecuador and the Dominican Republic. However, the central banks of Honduras, Nicaragua, and Paraguay still operate manually these payment systems.

In many cases, automation has also resulted in changes in the administration of payment systems through the creation of associations with financial entities in which the central bank maintains a significant interest, but without using its own staff. This obeys to the necessity of sharing with the financial sector the elevated costs involved in these automation processes.[19] Examples of central banks that have ceased to operate retail systems directly are Brazil in 2001 and Peru in 2000. Previously, the central banks of Argentina and Mexico ceased to perform this task in 1997 and 1995, respectively.[20]

In the group of other developing countries the percentage of central banks operating retail payment systems directly approaches is 85%, the highest amongst the studied groups. Some central banks discussed here are those of Malaysia, Hungary, Slovenia and Georgia. Likewise, an increase has been observed in the automation of payment systems, although more than one fourth of the central banks still operate them manually. Among the banks that have ceased to operate these systems directly are those from Bulgaria, Poland, the Czech Republic, and Thailand, with the latter having made the change during the period under analysis.

Large-value payment systems

Almost all central banks operate large-value payment systems (*LVPS*) directly due to the high risk involved in these transactions.

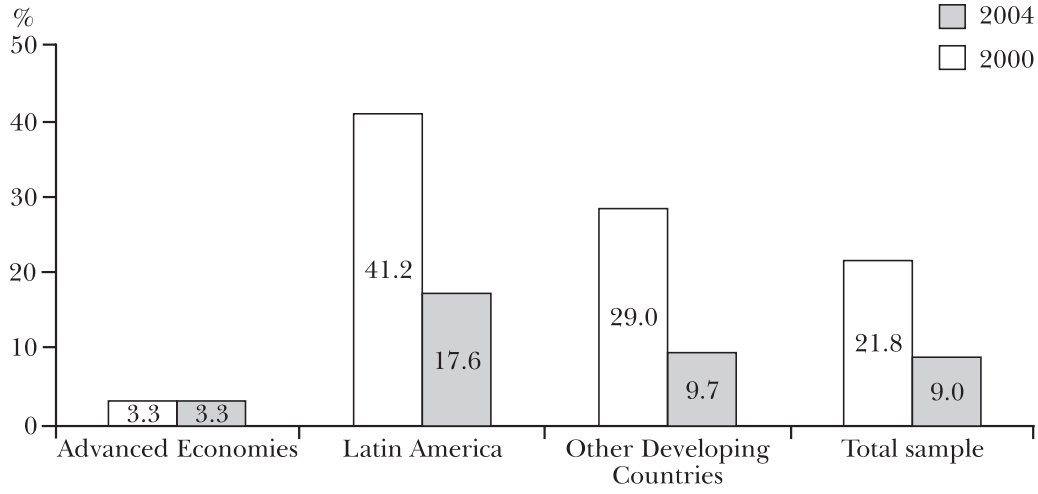
[19] Costs and investments involved in automating and updating payment systems are in general very high. To this respect, Khiaonarong (2005) showed that these costs were above USD $28 million in the SEACEN countries during the period 2000-2004.

[20] Differences still remain in the region on cost recovery and subsidies policies. For example, Venezuela's central bank does not charge any fee, and subsidizes all of the transactions. In Nicaragua, a symbolic fee is charged, with most of the operation being subsidized by the government, whereas in Costa Rica all operation costs are recovered through fees. In the other countries of the region cost recovery is partial (See, Bernal and Merlano, 2005). For other differences in payment systems within the region, see Arango and Bernal (2003).

However, some central banks, such as Canada's and England's, have delegated the *LVPS* operation to the same associations that operate RPS, although the central banks maintain settlement accounts for financial agents and provides final settlement of payments among participants. Additionally, they play an oversight role.[21]

Among central banks differences are mainly presented on the processing mechanism (manual or automated) of these systems. Figure 5 shows that the proportion of central banks currently operating *LVPS* manually in advanced economies is very low (3,3%). Also, it's noticeable that during the period central banks from Latin America and other developing countries initiated a strong trend towards automation.[22]

FIGURE 5. CENTRAL BANKS OPERATING LARGE-VALUE PAYMENT SYSTEMS (LVPS) MANUALLY



SOURCES: Author's calculations based on the BIS Reports on Payment Systems (2000, 2004) and the Central Banks Annual Reports (2000, 2004).

Currently, only 7 out of the 78 central banks of the sample operate large-value payment systems manually. These are: Albania, Egypt, Rumania, Paraguay, Guatemala, Honduras, and Cyprus.

[21] Something similar occurs with the central bank of Chile, which in April 2004 implemented a real-time gross settlement system (RTGS) for operations made by the Large-value Clearing House *Combanc*, a company operated by commercial banks and oversighted by the central bank (For more details, see Herrera, 2006).

[22] In the Latin American region, Colombia's central bank has led the implementation of policies aimed at improving intra-day liquidity of systems operating under the RTGS system (See, Bernal and Merlano, 2005).

As with retail systems, the central bank of Cyprus is the only one operating large-value systems manually in the group of advanced economies, because it has considered this to be more efficient given the low number of transactions and the high costs involved in automation.

Also worth noting, competition for this type of payment systems between the central bank and a private agent is uncommon. The most representative case is that of the United States, where the FED also competes with the private sector for the operation of *LVPS*. Another interesting case is Argentina, where two private companies in addition to the central bank operate large-value systems. However, no direct competition exists because the central bank operates a real-time gross settlement (RTGS) system, whereas private entities operate a multilateral net-off system.[23]

2.3. Central bank staff costs

After examining staff sizes and labor-intensive functions, a question on staff costs arises. The study by Mendzela (2003) was the first to compare cost levels. Using data from the year 2001, he estimated indicators relating gross operational expenses to population and GDP as a measure of efficiency in 18 OECD central banks. With information from the same year, McKinley and Banaian (2005) calculated average expenses per employee in 32 central banks and used this as an input to their model designed to estimate operational efficiency.

However, a closer approach was made by Brione (2005) in his comparison of 28 OECD central banks between 1999 and 2004. This author found wide differences between the staff costs of central banks, which could obey to the heterogeneity of functions they develop. He suggests that a deeper insight should be taken into the tasks performed by central banks in order to get better comparisons.

Under a similar view, this section analyzes the staff costs of 66 of the 78 central banks studied above.[24] For these data to reflect

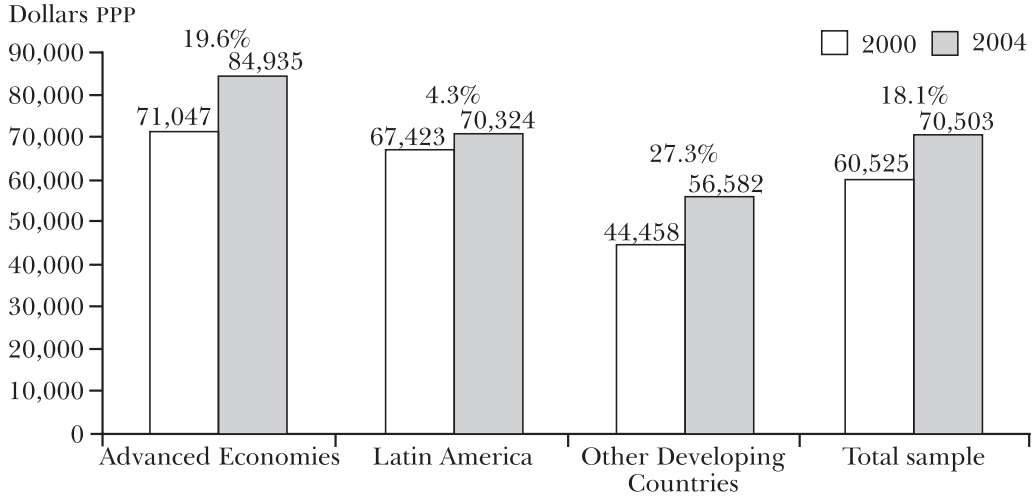
[23] For more on recent developments in large-value payment systems and operation modalities, see CPSS (2005b).

[24] Staff costs include: wages, mandatory legal contributions to schemes of social security and additional benefits (social welfare, additional health programs, and compensations, among others, with training and travel expenses excluded).

the differences related to the acquisitive capacity of the wages, staff costs were calculated on a per-employee basis using the purchasing power parity (PPP) exchange rate during the period 2000-2004.

Figure 6 shows that central banks from advanced economies had the highest costs per employee during this period. For the year 2004, these costs were on average 20% above the whole sample, and 50% higher than those observed in the group of other developing countries. On the other hand, Latin American central banks exhibited costs per employee very close to the average of the sample.

FIGURE 6. AVERAGE COST PER CENTRAL BANK EMPLOYEE AND PERCENT VARIATION



SOURCES: Author's calculations based on the BIS Reports on Payment Systems (2000, 2004) and the Central Banks Annual Reports (2000, 2004).

The largest increase in staff costs during these five years occurred in the group of other developing countries (27.3%), a result that could be interpreted as an adjustment in the face of a certain lag with respect to the world average. However, it should be noted that staff costs also sustained significant increases in the central banks of advanced economies (19.6%). In contrast with what

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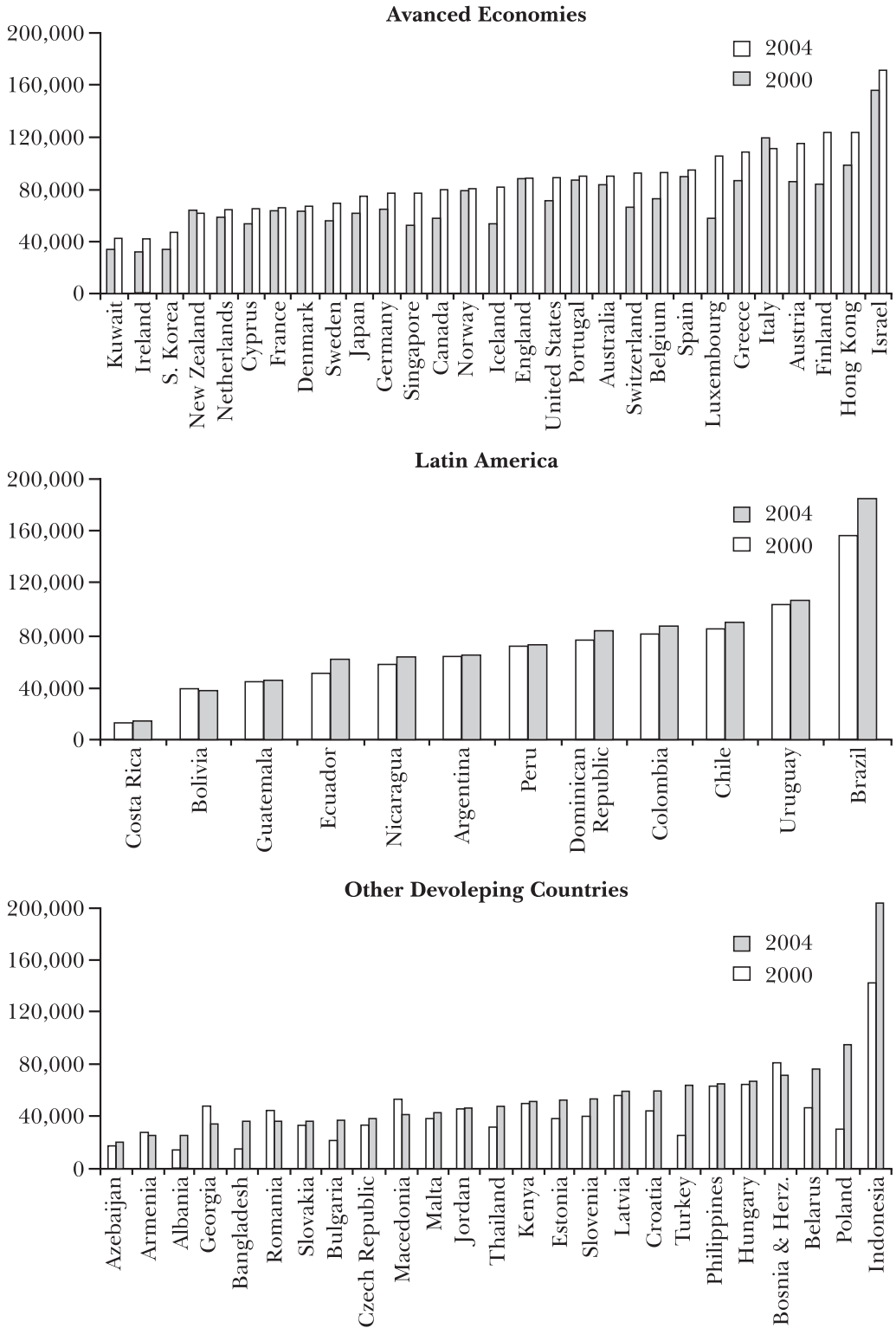
Data on staff costs were obtained from the Financial Statements of Central Banks Annual Reports. Central banks excluded from the sample due to lack of detailed information were: Saudi Arabia, Egypt, El Salvador, Honduras, Malaysia, Mexico, Morocco, Nepal, Paraguay, Qatar, Serbia and Montenegro, and Venezuela.

FIGURE 7. AVERAGE COSTO PER CENTRAL BANK EMPLOYEE (Dollars PPP)



SOURCES: Author's calculations based on Central Banks Financial Statements, Annual Reports (2000, 2004) and IMF (2005).

occurred in these groups, Latin American central banks exhibited the lowest increase during the period (4.3%).

For a more detailed analysis, central bank staff costs were compared within each group. Figure 7 shows that the highest cost per employee in 2004 in the group of advanced economies were found in the central banks of Israel followed by Hong Kong, Finland, and Austria.[25] The highest increases during the period (above 50%) occurred at the central banks of Luxembourg and Iceland. In contrast, the only central banks that exhibited reductions were those of Italy and New Zealand, this latter, together with Korea, Ireland, and Kuwait, showing the lowest staff costs in the year 2004.

Brazil's central bank has the highest staff costs in the whole Latin American region. The highest increases during the period (close to 20%) occurred in Ecuador and Costa Rica, although the latter has the lowest costs in the region. The only reduction took place at Bolivia's central bank.

In the group of other developing countries, Indonesia's central bank has the highest staff costs, with an increase of more than 50% during the period. However, the largest increases in the 5-year period (*i.e.,* above 100%) occurred in Poland, Bangladesh, and Turkey, with the greatest reductions (above 15%) being those of Romania, Macedonia and Georgia. The banks with the lowest costs in this group are Azerbaijan, Armenia, and Albania.

3. LABOR DEMAND AT CENTRAL BANKS

This section delves deeply into the theoretical aspects of the labor-demand function and its application for central banks. Recent studies on labor demand in central banks and the estimations of the econometric model are discussed.

[25] In the case of Israel, this confirms a recent concern raised by Mr. Stanley Fisher, Governor of the Central Bank, who has led significant reforms in the contracting scheme aimed at curtailing high staff costs. One of his relevant proposals is for new employees to be engaged with wages 30% below those currently in force, a concept largely supported by a recent paper that shows that average wages in the Bank of Israel are among the highest in the whole country (Central Banking, 2005). For more details on Fisher's proposals, see Gerstenfeld (2005).

3.1. Labor-demand function

The microeconomic theory indicates that labor, being a production factor, will be demanded as the demand for other goods or services increases. Therefore, the demand for labor is conceived as a derived demand since it depends on the good or service it contributes to produce or provide (McConnell *et al.*, 2005).

In order to verify this premise, let us assume that a firm engages two production factors: labor (L) and capital (K), in order to produce a final good (Y); with the real wage (w) and the unit cost of the capital (r), representing the relative prices of the two factors considered. Thus, for the firm to maximize benefits a minimum cost function that relates price and optimum amount of each factor should exist. This cost function will also depend on the production level and on the price of the factors:

$$C \equiv wL^{*} + rK^{*} = C(Y, w, r) \tag{1}$$

Once the cost function is defined, demand for labor can be found by applying the Theorem of Shepard, that is, a partial differentiation of expression (1) with respect to real wage (w):

$$L^{d} = \frac{\partial C(Y, w, r)}{\partial w} = L(Y, w, r) \tag{2}$$

Equation (2) above shows that labor demand (L^{d}) is a function of the relation between costs and output level. Since this is a short-term demand, labor is assumed to be the only variable factor. Therefore, for the purposes of the econometric estimation the equation (2) can be expressed as a log-linear function as follows (See, Hamermesh, 1993):

$$\ln L_{it}^{d} = \alpha_0 + \alpha_1 \ln Y_{it} + \alpha_2 \ln w_{it} + e_{it} \tag{3}$$

Equation (3) shows that a firm's short-term labor demand will depend primarily on the labor-output elasticity (α_1) and on the labor-real wage elasticity (α_2). As will be shown hereinafter, this approach is closer to the case of the central banks.

A. Empirical evidence

Literature on labor demand in central banks is scarce. One of the first approaches was made by Vaubel (1997), who selected

some of the central bank's functions as proxies of its output, and also considered variables such as number of inhabitants, per-capita GDP, and geographic area as measures of the magnitude of a central bank's output. The author intended to identify the impact of the central bank's independence on the staff and for this he also used some institutional variables (*e.g.*, indicators of central bank independence, and exchange rate regime).

Later on, Vaubel (2002) calculated a similar model for a group of 21 central banks from OECD countries, further linking banknote printing, currency quality check, and securities management as proxies of central bank's output.[26] The study intended to find the staff the European Central Bank should have in relation with the size of the staff of central banks within the Euro zone and other advanced economies.

In a recent study, Banco de la República (2005) estimated a labor-demand function for 133 central banks using data from the years 1998 and 2003. In contrast with Vaubel's works, this paper included payment systems operation and coin minting variables (See, Table 3).

Although Vaubel's works have shed light on the role of labor demand at a central bank, both of them have limitations in the set of variables selected. A possible explanation for this may be that these works are focused on a more institutional perspective (Public Choice) than on labor economy. Therefore, aspects such as the central bank's independence and exchange rate regime are given a greater importance than those about the performance of operative functions.

On the other hand, Banco de la República (2005) analyzes a wider array of functions in a relevant sample of central banks (133), thus having a greater robustness to its estimations. However, as with the above-discussed models, these estimations are cross sections examining the situation at a given point in time. For this reason, they do not link the effects on the staff that could be exercised by changes in the central bank's functions over time.

From the theoretical standpoint, the works discussed hereinabove

[26] In contrast with the model stated by Vaubel (1997), this model excludes geographic area, participation in central banks associations, and monetary base (M_1), because these variables had exhibited no significance in Vaubel's first estimation.

TABLE 3. ESTIMATIONS OF LABOR DEMAND IN CENTRAL BANKS

Author	*Variables*[a]		*Sample*[b]	*Years*[c]	*Estimation Method*
Vaubel (1997)	- Monetary Supply (M_1) - Financial Supervision - Central bank independence - Exchange rate regime - Participation in central banks Association	- Population (in millions) - GDP per capita (USD) - Geographic area	(n=97)	1993	MCO Cross-section
Vaubel (2002)	- Banknote Printing - Currency quality check - Discounting of private bills of exchange and other commercial paper - Central bank independence - Exchange rate regime	- Population (in millions) - GDP per capita (USD)	(n=21)	1999	MCO Cross-section
Banco de la República (2005)	- Financial supervision - RPS operation[d] - Manual operations of RPS[d] - Banknote Printing - Coin Minting	- Population (in millions) - GDP per capita (USD)	(n=133) (n=133)	1998 2003	MCO Cross-section

SOURCES: Vaubel (1997; 2002) and Banco de la República (2005).

[a] Variables included in the models as proxies of central bank's output. All models use the number of central banks employees as a dependent variable and also use log-linear functions. [b] Number of central banks included in the sample. [c] Year of information for which a staff estimation was made. [d] Retail payment systems.

also share their exclusion of the labor factor price to characterize the labor-demand function, under the assumption of a very low employment-wage elasticity in central banks. However, as the previous section has shown, the theory indicates that real

wages should be included in the labor-demand function.

B. The model

Following the specifications of equation (3) above, short-term labor demand for central banks is given by:

$$
\begin{aligned}
Ln(L_{it}) = {} & B_{0i} + B_1.Ln(N_{it}) + B_2.Ln(Y_{it}) + B_3.Ln(S_{it}) + B_4.Ln(CO_{it}) + \\
& B_5.Ln(BP_{it}) + B_6.Ln(CM_{it}) + B_7.Ln(RPSat_{it}) + B_8.Ln(RPSm_{it}) + \\
& B_9.Ln(LVPSm_{it}) + B_{10}Ln(W_{it}) + u_{it}
\end{aligned} \tag{4}
$$

In equation (4) a central bank's staff *(L)* is a function of the country's population *(N),* GDP per-capita (*Y*), and previously discussed operative functions. These functions are represented with *dummy* variables and are referred to financial system supervision (*S)*, currency operations (*CO),* banknote printing (*BP*), coin minting (*CM)*, automated operation of retail payment systems (*RPSat*), manual operation of retail payment systems (*RPSm*), and manual operation of large-value payment systems (*LVPSm*). Finally, a proxy to real wages is included (*W*).

Functions included in the model are those in which the central bank has a high operational component, and labor intensive. Some core functions (*e.g.,* monetary policy conduction, international reserves management) are not segregated in the model because they are homogeneous functions across all central banks. However, the model's constant is assumed to capture the minimal staff devoted to these functions.

On the other hand, the variables of GDP per-capita and number of inhabitants are deemed to serve as measures of the magnitude of the central banks' output, and these variables are expected to have a positive sign.[27] For real wage, its relation with the demanded amount of labor is assumed to be inverse and a negative effect is to be expected on the central bank's labor demand (See Annexes 4 and 5).

[27] Economic magnitude variables are very relevant for our analysis, since they allow to differentiate the size of the activities developed by central banks. For example, transactions volume or currency demand in the United States are different from those of other countries largely due to the high level of economic development and extensive population as compared with the activity of a country such as, let us say, Estonia or Costa Rica.

C. Methodology

In order to estimate equation (4), a panel data model with dynamic effects was used, with the following expression:

(5) $$y_{it} = X_{it}\beta + u_{it}$$

Equation (5) represents the traditional panel model, where in Y_{it} is the dependent variable that varies for each central bank i (i = 1, ..., 66) during any given period of time t (t = 2000, ..., 2004), X_{it} is referred to the set of explanatory variables, and u_{it} represents the error term, which at its turn is composed of:

(6) $$u_{it} = \mu_i + \varepsilon_{it}$$

In expression (6), μ_i represents individual effect (either fixed or random) and ε_{it} is observation error.[28] In practice, including an estimator with dynamic effects generates differentiation because different values are allocated to each observation, thus admitting differences in the minimal staff between central banks.[29] Similarly, the usefulness of implementing a panel model lies in that it allows to examine dynamic changes in time (*e.g.*, changes in the functions of central banks).

3.2. Results

The model stated in equation (4) was estimated through the generalized least squares (GLS) method and under the random-effects condition that results from applying Hausman's test. For the first estimation (Model 1), coin minting (*CM*) and manual operation of large-value payment systems (*LVPSm*) variables were non-significant; moreover, they showed a wrong sing to the expected one. Therefore, a new estimation was made with the

[28] The difference between a fixed-effects model and a random-effects model resides in that the latter adduces a random variable that changes for each individual, whereas in the former the effect is a fixed number. The selection of the model depends on the correlation between the individual effect and the explanatory variables, which is reviewed with Hausman's test (See, Hsiao, 2003).

[29] An interesting exercise would be to obtain different coefficients for all variables at each central bank by using a Swamy model. However, the number of years from which data were obtained is very short and does not allow using this type of models (See Amemiya, 1978).

exclusion of these variables. In the new estimation (Model 2), output magnitude variables, *i.e.,* GDP per capita (*Y*) and population (*N*), showed a high degree of significance.[30]

Table 4 shows that of all functions, financial supervision (*S*) had the highest significance and coefficient, suggesting that changes in its operation have the largest impact on the central bank staff. This finding is supported by the case of Ireland's central bank, which increased its staff in 226 employees (22%) between 2003 and 2004, when it assumed the financial supervision function.

The findings on the currency operations (*CO*) variable were consistent with both theoretical position and empirical evidence, because this function encompasses numerous activities that typically are labor-intensive due to their extensive infrastructure.[31] Likewise, the coefficient suggests that when a central bank changes the operations of this function through a traditional model for other less interventionists schemes (*e.g.,* sharing, participative, or freelance), a significant staff reduction should be expected.

The banknote printing (*BP*) function was also significant, indicating this to be a relevant function for determining labor demand. This could obey to the fact that its direct operation involves a large industrial infrastructure and a trained staff devoted exclusively to this task.[32] Likewise, manual operation of retail payment systems (*RPSm*) was significant at 10%. This shows the impact of manual processes on these systems (*e.g.*, manual clearing of cheques). In contrast, the variable that represents automated operations of retail payment systems (*RPSat*) was non-significant, but showed the expected sign, suggesting that when these payment systems are automated, the staff a central bank needs is very small, although probably more specialized or highly trained.

[30] These results are consistent with the estimations of Vaubel (1997; 2002) and Banco de la República (2005), which also used these variables as measures of the magnitude of central banks' output.

[31] For example, in 1998 Sweden's central bank implemented a currency operations participative model that resulted in 250 employees being transferred to a new enterprise (PSAB), and other 75 employees accepted a voluntary retirement plan (See, Sveriges Riksbank, 2006).

[32] As was shown in a previous section, a significant number of central banks have established partnerships with private operators for banknote printing (*e.g.,* Australia, Portugal, and Austria), or have completely delegated this function (*e.g.*, Sweden, England, Finland).

TABLE 4. MODEL RESULTS

Dependent variable Ln(L); Panel data (330 obs.); Random effects; GLS regression

Variables	*Model 1*	*Model 2*
Constant	0.9040 (2.01)[b]	0.8652 (1.93)[b]
Ln *(N)*	0.6450 (17.82)[c]	0.6489 (17.98)[c]
Ln *(Y)*	0.0730 (2.61)[c]	0.0816 (2.92)[c]
Ln *(S)*	0.1958 (3.09)[c]	0.1962 (3.08)[c]
Ln *(CO)*	0.1439 (2.55)[b]	0.1504 (2.65)[c]
Ln *(BP)*	0.1186 (2.08)[b]	0.1099 (1.96)[b]
Ln *(CM)*	W.S. (-0.64)	..
Ln *(RPSm)*	0.1643 (2.58)[b]	0.0910 (1.64)[a]
Ln *(RPSat)*	0.0406 (0.75)	0.0179 (0.34)
Ln *(LVPSm)*	W.S. (-0.69)	..
Ln *(W)*	-0.0728 (-2.54)[b]	-0.0804 (-2.80)[c]
Wald (p-value)	379.89 (0.00)	375.24 (0.00)
Hausman (p-value)	3.3925 (0.89)	2.9472 (0.91)

SOURCE: Author's calculations.

NOTES: Statistics are shown between parentheses. W.S: Wrong sign; Wald's test: Joint significance of the variables (Prob. > Chi 2); Hausman's test: Differences in coefficients are not systematic (Prob. > Chi 2).

[a] Indicate that the statistics are significantly different from zero at 10%. [b] Indicate that the statistics are significantly different from zero at 5%. [c] Indicate that the statistics are significantly different from zero at 1%.

On the other hand, the real-wage variable (*W*) was highly significant, and had the expected negative sign. However, the coefficient shows that labor-wage elasticity is lower in central banks

than in private firms.[33] This could also suggest the presence of a certain budgetary flexibility in central banks, a feature already highlighted by Heikensten (2003).

3.3. Estimations and international comparison

Based on the results of the model, a staff prediction was carried out with the purpose of comparing central banks and identifying recent changes in their labor demand during the period 2000-2004. These results should not be interpreted as measures of efficiency.[34] Staff deviations from predicted values represent either staff excesses or deficits, possibly associated with differences in labor productivity. Also, they might be attributable to some other factors not directly captured by the model (*e.g.*, organizational structure, bureaucracy, technology and staff qualification), but related with the staff size.

A. Advanced economies

Estimation results of this group from the year 2000 indicate that more than one half central banks (55.2%) had a staff larger than the model's prediction. However, an adjustment implying a reversion of this staff-related status was noticed in the year 2004. In fact, 16 out of 29 central banks recorded a staff smaller than the estimate. Among these central banks are those from Canada and Belgium, which had the most overstaffed central bank in the year 2000, whereas for 2004 they recorded a staff below the estimate in 10.2% and 9.7%, respectively. A similar situation was observed in another important group of central banks (*e.g*, Germany, Spain, United States, and England). In contrast, the largest staff excesses in 2004 were seen at the central banks of Iceland,

[33] Comparing a wide group of countries, Hammerseh (1993) found that labor-wage elasticity for homogeneous labor, both in private firms and in the economy's aggregate, ranges between 0.15 and 0.75, that is, far above the value recorded in the central banks under study (0.08).

[34] This is opposite to the results interpretation made by Vaubel (1997). Estimating efficiency measures require linking inputs and outputs directly through either a cost or production function to finding an efficient frontier for the comparison. Mester (2003) provide a discussion on the techniques for measuring efficiency in central banks.

Singapore and Switzerland, with a positive deviation of about 8% (See Table 5 and Annex 6).

TABLE 5. DEVIATION OF ACTUAL FROM PREDICTED STAFF IN CENTRAL BANKS, 2000-2004 (in percentage)

Advanced Economies			*Latin America*			*Other Developing Countries*		
Country	*2000*	*2004*	*Country*	*2000*	*2004*	*Country*	*2000*	*2004*
Australia	0.17	0.15	Argentina	-0.06	-1.87	Albania	-12.49	12.06
Austria	-5.60	-10.26	Bolivia	2.57	-6.37	Armenia	-2.86	8.26
Belgium	16.07	-9.72	Brazil	-3.99	3.20	Azerbaijan	12.83	11.65
Canada	22.81	-10.24	Chile	4.16	-3.39	Bangladesh	6.92	-2.85
Cyprus	-5.02	1.52	Colombia	13.28	-8.23	Belarus	-7.71	-1.32
Denmark	-1.15	3.25	Costa Rica	32.44	19.97	Bosnia & H.	-19.74	7.20
England	8.95	-3.97	Dom. Rep.	8.16	-15.69	Bulgaria	18.73	-4.15
Finland	-1.98	-10.99	Ecuador	9.10	-31.11	Croatia	0.85	-6.07
France	2.57	-6.94	Guatemala	-5.12	9.22	Czech Rep.	-0.18	-0.07
Germany	7.20	-12.99	Nicaragua	-0.62	-1.77	Estonia	-23.66	-5.15
Greece	5.27	-5.32	Peru	0.90	-4.09	Georgia	7.35	15.42
Hong Kong	1.10	-1.64	Uruguay	12.23	-1.40	Hungary	20.70	-10.15
Iceland	-7.60	8.20				Indonesia	2.68	-4.24
Ireland	-9.40	2.08				Jordan	-1.62	5.42
Israel	5.62	-5.78				Kenya	-17.95	-4.67
Italy	6.37	-7.87				Latvia	-0.26	4.64
Japan	4.91	-5.51				Macedonia	1.30	13.79
Kuwait	-3.15	4.48				Malta	-0.54	-0.04
Luxembourg	-15.77	6.81				Philippines	23.36	-1.34
Netherlands	0.97	0.50				Poland	40.37	-11.35
New Zealand	11.21	3.29				Romania	-2.18	-28.87
Norway	-12.27	-3.47				Slovakia	-0.09	2.36
Portugal	2.47	-7.56				Slovenia	11.96	3.90
S. Korea	-1.99	2.78				Thailand	4.98	-2.92
Singapore	-8.24	8.17				Turkey	1.19	-8.51
Spain	7.19	-10.72						
Sweden	-12.18	1.56						
Switzerland	-9.72	7.91						
USA	5.84	-9.46						
Mean	0.51	-2.47		6.09	-3.46		2.56	-0.28
SD	8.83	6.58		10.23	12.47		14.05	9.52

SOURSE: Author's calculations.

B. Latin America

The results of the staff estimations for Latin American central banks suggest that for the year 2000, 71.4% of central banks in this group were overstaffed. For the year 2004 the staff adjustment in the region was of 8%, this being the largest average adjustment

among the groups of comparison. The most favorable changes occurred in Ecuador, Dominican Republic, and Colombia.[35] In spite of its extensive adjustment, the central bank of Costa Rica continued being the largest overstaffed of the region.

C. Other developing countries

Staff estimates in other developing countries show that in 2000, 52% of the central banks were overstaffed. For 2004, central banks from European Union member or candidate countries were seen to make significant staff reductions and to sustain the largest adjustments versus the estimates (*e.g.* Poland, Romania, Hungary, and Bulgaria). In contrast, most of smallest central banks presented important staff increases during the period and several of them had staff excesses in 2004 (*e.g.*, Georgia, Albania and Bosnia & Herzegovina).

4. CONCLUSIONS

This paper shows that most central banks sustained significant staff reductions, with the cases of England, Germany, and the United States being worth noting. In Latin America the central banks of Ecuador, Dominican Republic and Colombia should also be mentioned, whereas for other developing countries, the most important reductions were carried on by the banks of Romania, Poland, and Hungary, also driven by their access to the European Union.

However, central bank staff reductions were accompanied by an increase in their costs, which could be largely attributed to a higher degree of specialization of the staff, often resulting from their focusing on their core functions. Overall, as central banks cease to perform operative functions, they will require less low-qualified personnel, resulting in an increase in the ratio of highly qualified employees and, in the short term, in higher staff costs.

In the past few years the quest for efficiency in most central banks has driven modernization strategies based on the private

[35] In the case of the Ecuador's central bank this wide difference could be attributed in part to the recent process of dollarization of its economy. Results for Colombia's central bank are analyzed in Annex 7.

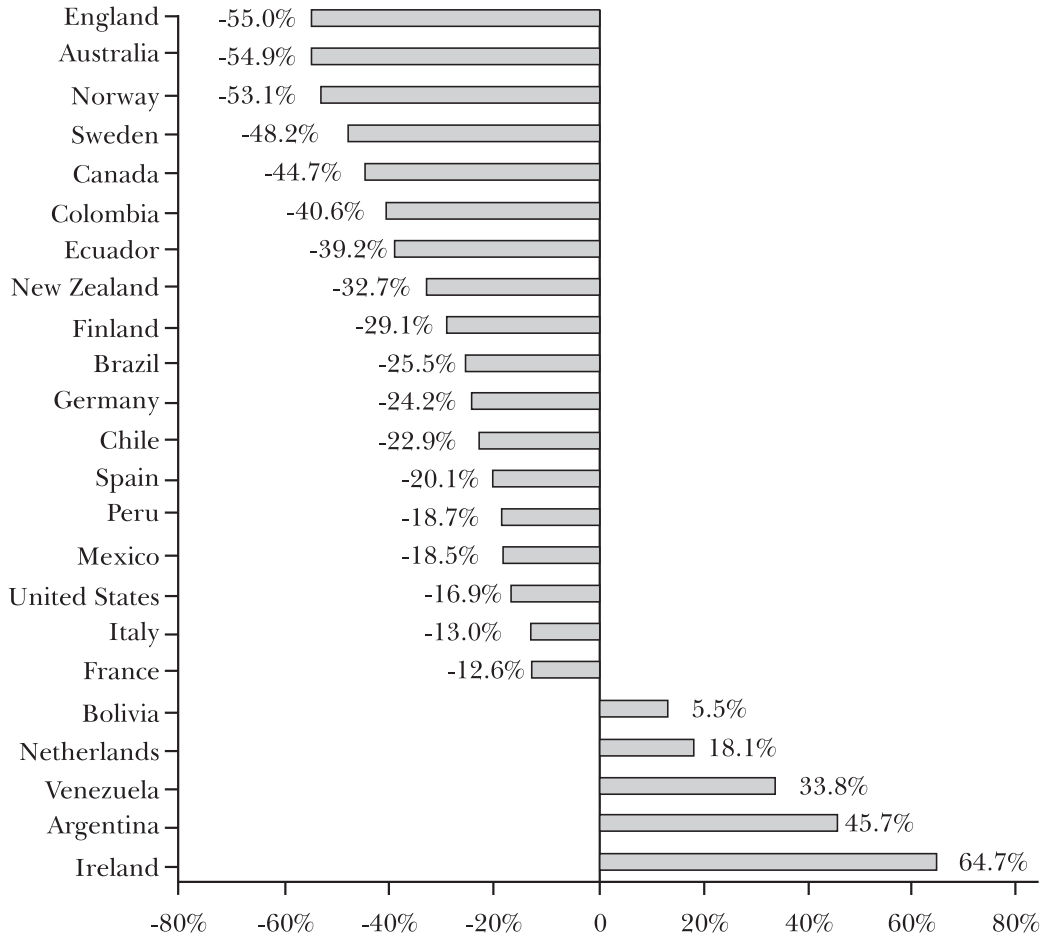
sector's active participation, primarily in functions such as operation of payment systems, currency operations, and banknote printing. In fact, this paper identifies the existence of multiple modalities for the performance of the operative functions in central banks. Strategies differ widely between countries, thus reflecting the role of the private sector, the central bank-government relationship, and historical traditions. Also, it should be taken into account the existence of external factors in some countries, such as a strict regulatory environment, that avoid central banks from delegating part of their activities.

On the other hand, our empirical exercise succeeded in identifying the relevance of operative functions in determining labor demand at central banks. In particular, financial supervision was found to have a large impact on central bank staff, as well as, going from a traditional model to a less interventionist scheme in currency operations. Similarly, low employment-wage elasticity was identified suggesting the existence of a flexible budgetary constrain in central banks. This highlights the efforts made by some central banks to control the growth of their staffs.

We deem that these findings are highly relevant for central banks, governments, and central banking organizations. Likewise, we recognize that this paper could be extended and delve deeply into several other directions. In particular, efficiency measures by functions should be estimated in order to identify the best practices for central banks. With this purpose, part of our research agenda is focused on measuring efficiency by functions, comparing central banks with different efficient-frontier techniques.

Annex 1

PERCENT STAFF VARIATION IN SELECTED CENTRAL BANKS (1993-2004)



SOURCE: Author's calculations based on Central Banks Directory (1993, 2004).

Annex 2

Cultural Activity at the Central Banks

The cultural activity developed by central banks is for the most part related to libraries and museums. The vast majority of central banks only have a small numismatic exhibition, usually inside their premises, and a library specialized in economic and financial matters for their researchers. In advanced economies, for example, only the central banks of Switzerland, Germany and the United States have more than one library open to the public, and these are only of a specialized nature. Similarly, only Finland, Italy, and Belgium have one or two museums larger than the average.

(continue)

Something similar occurs within the group of other developing countries. Only the central banks of Malta, the Philippines and Pakistan have a library open to the general public, and only the library of this latter country contains works on matters other than economics and finances. As to the museums, only the central banks of Morocco, Rumania, Malaysia, and Thailand have a sizable numismatic or thematic museum.

Of the three groups of countries, Latin America is the region where the cultural activity developed by central banks is more notorious due to the historical and political legacy of their governments. Since their establishment, most central banks in the region were given the responsibility of approaching people through cultural activities because of the lack of state policies on this matter. The majority of these central banks have at least one library open to the public, either specialized in economic matters, or of general purpose, that include social, artistic, and historic works.

However, the only central banks in these countries that maintain a significant network of libraries are those from Guatemala, with 53, and Colombia with 19. Likewise, the 6 museums of Ecuador and the 8 museums managed by the central bank in Colombia are worth noting. It is important to say that some central banks, such as those of Guatemala, Bolivia, and Costa Rica, have chosen to assign the administration of their libraries or museums to non-profit organizations to which the central banks only contribute with financial resources

SOURCES: Central Banks Annual Reports (2000-2004) and Jaramillo (2005).

Annex 3

Payment Systems Operation at the Central Banks

Khiaonarong (2003) identified three approaches to how central banks operate payment systems. These approaches differ primarily in the degree of participation of the private sector and the existence of a cost-recovery policy. For a better understanding of this classification, the following table shows some examples of countries that fall within each approach.

Approaches in the Payment Systems Operation

Approach	*Central Bank Participation*	*Cost Recovery Policy*	*Examples*
Minimalist	The central bank owns and operates only large-value payment systems or limits itself to providing account settlement services. The private sector operates low-value systems, generally through commercial banks associations.	There is generally a total cost recovery policy.	England Canada New Zealand Sweden Australia Brazil Mexico

(continue)

Approach	*Central Bank Participation*	*Cost Recovery Policy*	*Examples*
Public	The central banks owns and operates all or most payment systems. When the private sector participates, it does not compete with the central bank	Cost recovery is usually partial	Germany Spain Italy Costa Rica Venezuela
Competitive	The central bank operates most payment systems and competes directly with the private sector.	Cost recovery is total	United States

SOUNCES: Khiaonarong (2003) and Central Banks Annual Reports (2000-2004).

Annex 4

Variables used in the Model by Groups of Countries (2000-2004)				
Variable	*Max.*	*Min.*	*Mean*	*SD*
		Total Sample (n=66)		
L	23,438	105	2,341	3,804
N	293,028	281	30,245	52,713
Y	63,727	316	12,152	12,605
W	127,446	2,984	40,606	29,290
		Advanced Economies (n=29)		
L	23,438	105	3,240	5,331
N	293,028	281	32,059	56,742
Y	63,727	9,276	24,621	9,598
W	127,446	6,435	66,583	24,313
		Latin America (n=12)		
L	4,694	437	1,328	1,116
N	184,101	3,324	26,358	44,521
Y	7,675	435	2,422	1,514
W	73,825	6,025	27,175	14,166
		Other Developing Countries (n=25)		
L	6,375	184	1,865	2,030
N	238,453	390	30,317	52,367
Y	14,988	316	3,137	2,992
W	80,793	2,984	17,994	11,868

L: Number of employees of central banks
N: Population in thousands of inhabitants
Y: GDP per-capita in constant UDS of 2000
W: Annual cost per employee in constant USD of 2000

SOURCES: Author's calculations based on data from Morgan Stanley Central Bank Directory, US Census Bureau, IMF (2005), Annual Reports, and Financial Statements of Central Banks.

Annex 5

OPERATIONAL FUNCTIONS PERFORMED BY CENTRAL BANKS (2000, 2004)[a]

	Financial Supervision		*Currency Operations*		*Banknote Printing*		*RPS Operation*				*LVPS Manual Operation*		*Coin Minting*	
							Automated		*Manual*					
Central Bank / Function	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*
Australia	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Austria	..	..	Yes	..	..	..	..	..	..	..	..	..	..	..
Belgium	..	..	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..
Canada	..	..	Yes	..	..	..	..	..	..	..	..	..	..	..
Cyprus	Yes	Yes	Yes	Yes	..	..	..	..	Yes	Yes	Yes	Yes	..	..
Denmark	..	..	..	..	Yes	Yes	..	..	..	..	..	..	Yes	Yes
England	..	..	..	..	Yes	..	..	..	..	..	..	..	..	..
Finland	..	..	Yes	..	..	..	..	..	..	..	..	..	..	..
France	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		..	..	..	..
Germany	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Greece	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	..	..	Yes	Yes
Hong Kong	Yes	Yes	..	..	..	..	..	..	..	..	..	..	..	..
Iceland	..	..	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Ireland	..	Yes	..	..	Yes	Yes	..	..	..	..	..	..	Yes	Yes
Israel	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Italy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	..	..
Japan	..	..	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Kuwait	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Luxembourg	..	..	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Netherlands	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..	..	..
New Zealand	Yes	Yes	..	..	..	..	..	..	..	..	..	..	..	..
Norway	..	..	Yes	..	Yes	Yes	..	..	..	..	..	..	..	..
Portugal	Yes	Yes	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..

OPERATIONAL FUNCTIONS *(concluded)*

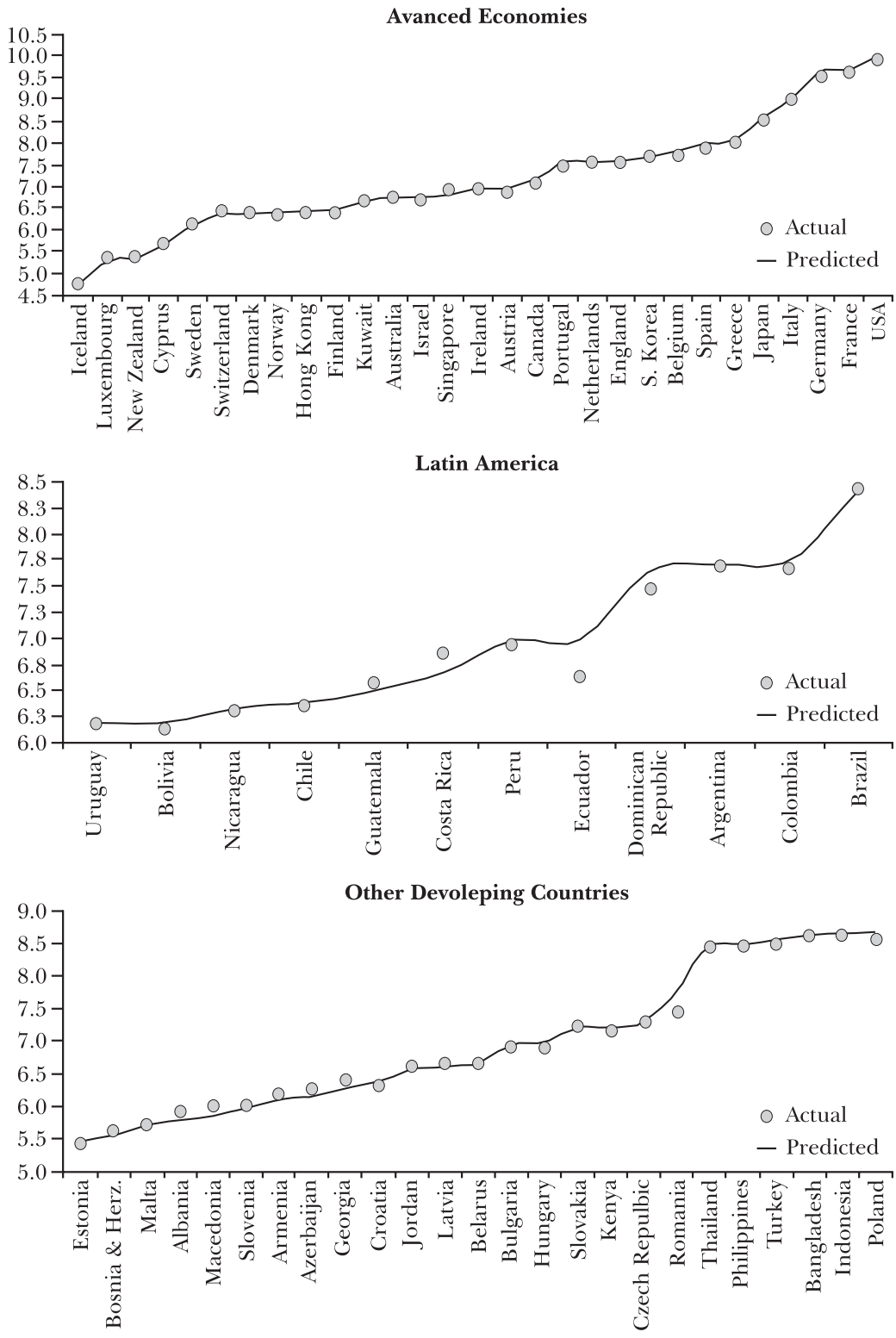
	Financial Supervision		*Currency Operations*		*Banknote Printing*		*RPS Operation*				*LVPS Manual Operation*		*Coin Minting*	
							Automated		*Manual*					
Central Bank / Function	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*	*2000*	*2004*
S. Korea	..	..	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Singapore	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Spain	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Sweden	..	..	..	..	Yes	..	..	..	..	..	..	..	..	..
Switzerland	..	..	Yes	Yes	..	..	..	..	..	..	..	..	..	..
USA	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Total	*14*	*15*	*22*	*18*	*10*	*8*	*7*	*7*	*3*	*2*	*1*	*1*	*3*	*3*
Argentina	Yes	Yes	..	..	..	..	..	..	..	..	..	..	..	..
Bolivia	..	..	Yes	Yes	..	..	..	..	..	..	Yes	..	..	..
Brazil	Yes	Yes	..	..	..	..	..	..	Yes	..	Yes	..	..	..
Chile	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Colombia	..	..	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	Yes	Yes
Costa Rica	..	..	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Ecuador	..	..	Yes	Yes	..	..	..	Yes	Yes	..	Yes	..	..	..
Guatemala	..	..	Yes	Yes	..	..	..	..	Yes	..	Yes	Yes	..	..
Nicaragua	..	..	Yes	Yes	..	..	Yes	Yes	Yes	Yes	..	..	..	..
Peru	..	..	..	..	..	..	..	..	..	..	..	..	Yes	Yes
Dominican Rep.	..	..	Yes	Yes	..	..	..	Yes	Yes	..	..	..	..	..
Uruguay	..	..	..	..	..	..	Yes	Yes	..	..	..	..	..	..
Total	*2*	*2*	*7*	*7*	*1*	*1*	*4*	*6*	*5*	*1*	*4*	*1*	*2*	*2*

Albania	Yes	Yes	Yes	Yes	Yes	Yes	..	..	Yes	Yes	Yes	Yes	Yes	Yes
Armenia	Yes	Yes	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	Yes	Yes
Azerbaijan	Yes	Yes	Yes	Yes	Yes	Yes	..	Yes	Yes	..	Yes	..	..	..
Bangladesh	Yes	Yes	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..
Belarus	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Bosnia & Herz.	..	..	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Bulgaria	Yes	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..	..
Croatia	Yes	Yes	Yes	Yes	Yes	..	Yes	Yes	..	..	..	..	..	..
Slovakia	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Slovenia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	Yes	Yes
Estonia	Yes	..	..	..	..	..	Yes	Yes	..	..	..	..	..	..
Philippines	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	Yes	Yes
Georgia	Yes	Yes	Yes	Yes	..	..	..	Yes	Yes	..	Yes	..	..	..
Hungary	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Indonesia	Yes	Yes	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Jordan	Yes	Yes	Yes	Yes	..	..	Yes	Yes	Yes	..	..	..	..	..
Kenya	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Latvia	..	..	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Macedonia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	..	..
Malta	..	..	Yes	Yes	..	..	Yes	Yes	..	..	..	..	..	..
Poland	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Czech Rep.	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..	..	..	..
Romania	Yes	Yes	Yes	Yes	..	..	..	..	Yes	Yes	Yes	Yes	..	..
Thailand	Yes	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	..	..	..
Turkey	..	..	Yes	Yes	Yes	Yes	Yes	Yes	..	..	..	..	..	..
Total	*21*	*20*	*24*	*24*	*11*	*9*	*15*	*16*	*7*	*4*	*4*	*2*	*4*	*4*

SOURCES: Author's calculations based on data from the Central Banks Annual Reports (2000-2004).
[a] Dummy variables used in the model.

Annex 6

DEVIATION OF ACTUAL FROM PREDICTED STAFF IN CENTRAL BANKS, 2004 [Ln(L)]



SOURCE: Author's calculations.

Annex 7

The Case of Colombia's Central Bank

Like most central banks, Banco de la República (BR) has made a significant staff reduction in the past few years (40.6% since 1993). During the period 2000-2004 this reduction reached 12%, driven by function restructuring, process automation, and support-functions outsourcing.

As to labor-intensive secondary and operational functions, the BR performs, mostly with its own resources, four out of the five core functions analyzed in this paper. Financial supervision is the only function not under the responsibility of the central bank because since 1923 it is performed by a state-owned entity (Financial Superintendence).

As to currency operations, BR follows primarily a traditional model. However, freelance and sharing models have been implemented in some cities, thus promoting the participation of securities transporting firms. These changes, aimed at increasing efficiency, have resulted in a reduction of the bank's network of branches associated to this function since 1997.

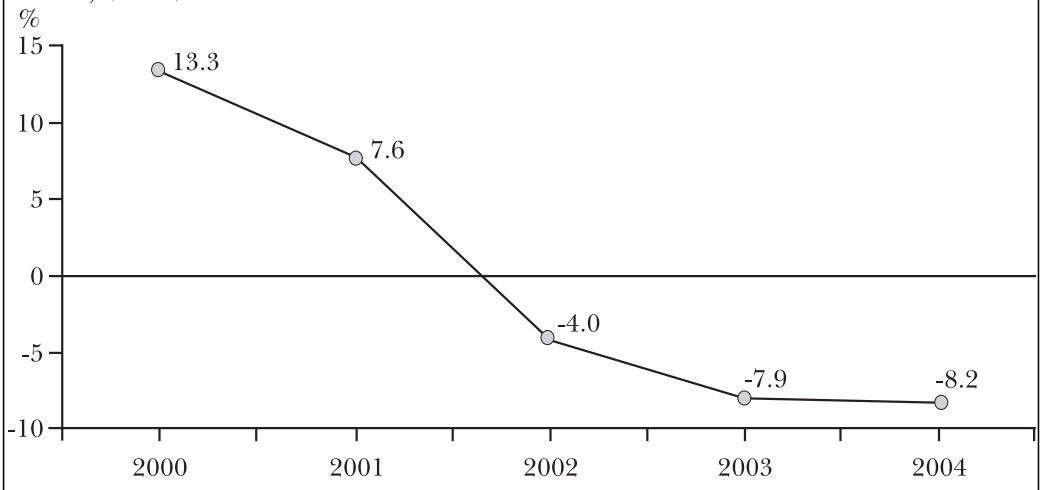
With respect to industrial activities such as coin minting and banknote printing, these are performed directly by BR. Recently, the *Central de Efectivo,* a complex with top facilities for the production of banknotes and currency operations related activities, very similar to Portugal's *Carregado* complex, came into operation. As to coin minting, BR redesigned and enhanced the process in its *Fabrica de Moneda,* which currently operates with a minimal staff (30 employees) and a rotary that has resulted in an improved productivity of this function.

BR manages directly fully automated large-value and retail payment systems, thus being one of the first central banks in Latin America in having automated these processes to date. These changes resulted in significant staff reductions, more particularly in labor-intensive activities such as manual clearing of cheques. Likewise, reforms implemented since the end of the 90's allowed for a deeper capital market and for more efficient and safe payment systems financial management in Colombia (For more details, see Bernal and Merlano, 2005).

On the other hand, cultural promotion is one of BR's major responsibilities toward the community. BR has never had doubts on the continuity of this function due to its high social impact. In fact, BR is the central bank with the widest infrastructure and largest staff devoted to cultural activities in the whole central banks environment. BR operates a network of 18 libraries in the whole national territory, plus a main library located in Bogotá, which has the largest number of books among the libraries of all central banks (1,500,000 books). Additionally, BR operates an ethnographic museum and seven gold museums in the whole country. Similarly, BR organizes a continual program composed of diverse musical and artistic activities distributed in 15 branches and 12 cultural agencies.

In fact, the percentage of employees devoted to these activities as of December 31st 2004 accounted for 15.7% (392 employees) of the total Bank's staff, this being the most numerous staff of all central banks developing some cultural activity. Since the proportion of cultural activities developed by BR is not comparable with other central banks, and since this function is not taken into account within the econometric model, employees devoted to these tasks are excluded from the data on the BR's staff. Model estimates for BR for the years 2000 to 2004 are illustrated in the following figure:

DEVIATIONS FROM ACTUAL TO PREDICTED STAFF AT THE BANCO DE LA REPÚBLICA, 2000-2004



SOURCE: Author's calculations.

As can be seen, in the years 2000 and 2001, BR's was overstaffed. A breakpoint appears the year 2002, and BR's staff goes below the estimate. This is attributed to a 252 staff downsizing during that year. For the year 2004 the percent deviation from the estimate was of -8.2%, value above the average for the region in that year (-4.8%).

In Vaubel (1997) results showed that in 1993 BR had 2,076 employees in excess (45% above the estimate) compared with the observed staff of 4,583 in that year. Later, Banco de la República (2005) estimated a model for the year 2003 finding that BR had a staff 10.9% below the estimate. The panel data model used in this paper allows to identify the structural change that took place in the year 2002, that is, when the BR staff began to appear below the estimate.

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Calista Cheung
Sylvie Morin

The impact of emerging Asia on commodity prices

1. INTRODUCTION

Over the past 5 years, real energy and non-energy commodity prices have trended sharply higher. These relative price movements have had important implications for both inflation and economic activity in Canada and the rest of the world.[1] Dramatic increases have been observed primarily in oil and base metals prices, and can be justified in part by strengthening demand conditions in the industrialized world, the depreciation of the US dollar, and slow supply responses. However, China has accounted for the bulk of incremental demand for oil and many base metals

[1] Since Canada is a net exporter for most commodities, a sustained increase in commodity prices would generate an appreciation in the exchange rate and a shift in productive resources towards commodity-producing sectors. The improved terms of trade would create wealth effects and raise consumption.

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during this period. As rapid economic growth in China has raised the level of world demand, this has placed upward pressure on commodity prices. This effect has been further amplified by increasing resource intensities of China's production in recent years.

This paper discusses the factors driving emerging Asia's demand for commodities and uses an empirical approach to assess the impact of emerging Asia on the real prices of oil and base metals in the Bank of Canada Commodity Price Index (BCPI).[2] Given emerging Asia's growing prominence in the world economy, it is important to understand its impact on commodities markets and its role behind recent price movements. An enhanced understanding of these aspects would allow us to better assess the implications for commodity prices going forward, and improve the accuracy of Bank of Canada projection models for policy analysis. Study of emerging Asia's impact on commodity prices has been limited to date, given that its upsurge in demand has been relatively recent. While Lalonde and Muir (2006) are able to simulate the recent rise in commodity prices within a DSGE framework through combining a permanent productivity increase in emerging Asia with a shock to energy intensity, the literature to date has provided little empirical support for this outcome.

Given the heterogeneity across different commodity markets, two separate single-equation models are estimated for oil and base metals prices. We employ a structural break approach for oil prices, based on previous findings of structural shifts by Lalonde, Zhu, and Demers (2003). For the base metals price index, an error correction model (ECM) is estimated. We find strong evidence that while oil and metals prices have historically moved with the business cycle in developed economies, this relationship broke

[2] Examination of agricultural and forestry product prices is left for future research, as increases observed thus far have been small in real terms and are likely too recent to be captured in estimations. For North American forestry markets, supplies have been heavily influenced by changes in softwood lumber agreements as well as industry restructuring and capacity closures over recent years. In food markets, crop supplies have been highly dependent on weather conditions. More recently, food prices have surged, reflecting pressures from strong demand for bio-fuel, increased demand from emerging markets, and adverse supply shocks.

down around mid-1997. Thereafter, industrial activity in emerging Asia appears to have become a more dominant determinant of oil price movements. While metals price fluctuations have also become increasingly aligned with levels of industrial activity in emerging Asia, rising metals intensities of production may have been a more important factor behind the recent acceleration in prices.

This paper is organized as follows. Section 2 summarizes recent developments in commodity price behaviour and Section 3 discusses the sources of emerging Asia's demand for commodities. A brief literature review is provided in Section 4, followed by a description of the theoretical framework and data in Section 5. The model specifications and results are discussed in Section 6, with concluding remarks in Section 7.

2. RECENT BEHAVIOUR IN REAL COMMODITY PRICES

While real commodity prices had been on a downward trend for much of the past 25 years, they have moved persistently higher since the end of 2001.[3] This is illustrated in Figure 1, which plots the Bank of Canada Non-Energy Commodity Price Index in real terms and the real West Texas Intermediate (*WTI*) benchmark crude oil price. Figure 2 illustrates the evolution of prices of the major non-energy commodity groups from 1980 to the end of 2006.[4] The BCPI is constructed from the US dollar spot or transaction prices of 23 key Canadian commodities produced in Canada and sold in world markets. A list of the commodities and their weights is provided in Table 1.

The real price increases since the end of 2001 have been concentrated primarily in crude oil and base metals, which are now above or close to historical peaks of the last 25 years. The upward trend has been broadly based across different metals, suggesting

[3] The downward trend in real metals prices over history may be largely attributed to productivity gains in this sector and declining metals intensities in major industrialized countries. Meanwhile, advances in technology and agroscience, appear to have played a key role in driving down real agricultural prices.

[4] In Figures 1 and 2, all non-energy commodity price indexes are deflated using the US producer price index for finished goods. The crude oil price is deflated by the US GDP deflator.

FIGURE 1. BANK OF CANADA COMMODITY PRICE INDEX, 1980-2006

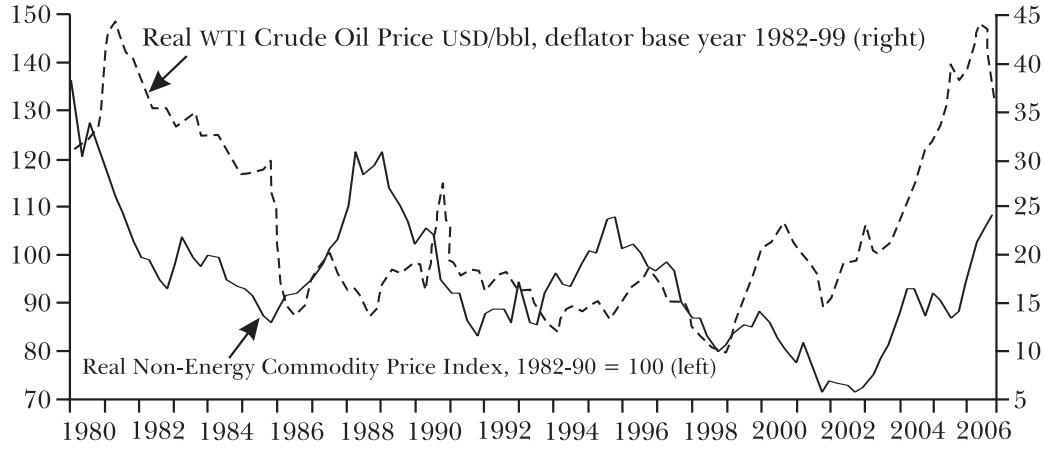


FIGURE 2. BANK OF CANADA NON-ENERGY COMMODITY PRICE INDEX, 1980-2006

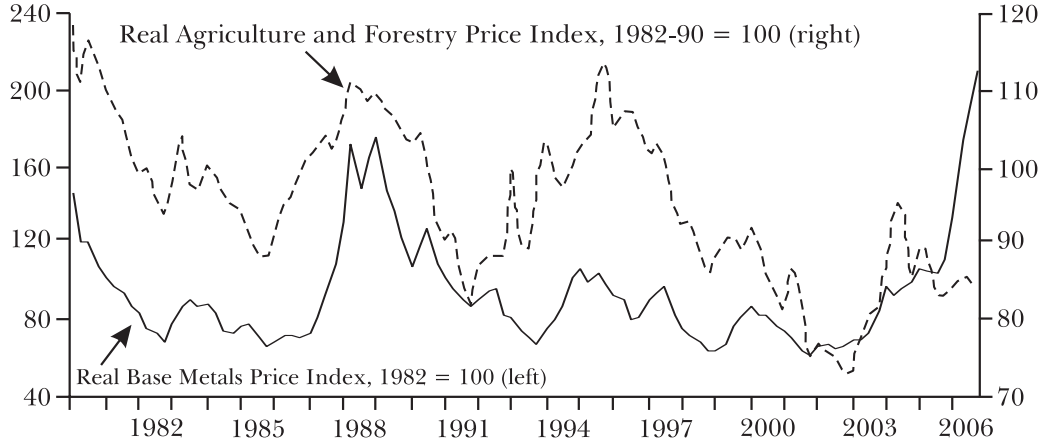
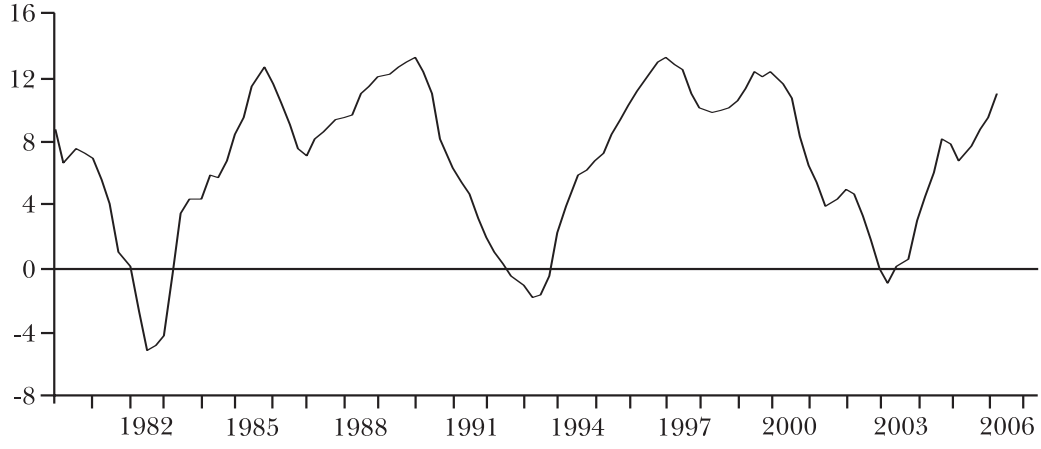


FIGURE 3. OECD INDEX OF INDUSTRIAL PRODUCTION, 1980-2006 (y/y % growth)



that common factors have been responsible. As macroeconomic demand conditions in industrialized countries have traditionally been main determinants of commodity prices, some of the recent

price surges can be explained by robust global economic growth, as illustrated by recent increases in year-over-year growth in OECD industrial production shown in Figure 3. A significant depreciation of the US dollar in recent years, shown in Fig. 4, may have also played a role. However, the expanding share of commodities consumption attributable to emerging Asia suggests that the region has contributed importantly to demand pressures in recent years. Due to declining investment in energy and metals extraction and refining industries since the late 1990s (see Fig. 5), production capacity has been slow to respond. As a result, spare oil production capacity has fallen to historic lows (see Fig. 6), along with many base metals inventories.

TABLE 1. COMPONENT WEIGHTS IN BANK OF CANADA COMMODITY PRICE INDEX

Weights	*Canadian production shares, 1988-99 (%)*
ENERGY:	33.9
Oil	21.4
Natural Gas	10.7
Coal	1.8
NON-ENERGY:	66.1
Metals	14.3
Base Metals:	11.7
Aluminium	5.0
Copper	2.0
Nickel	2.4
Zinc	2.2
Precious Metals:	2.6
Gold	2.3
Silver	0.3
Minerals	2.3
Potash	1.7
Forestry	33.4
Lumber	13.6
Pulp	12.1
Newsprint	7.7
Food	16.8
Grains & Oilseeds:	5.9
Wheat	3.4
Canola	1.2
Barley	0.7
Corn	0.5
Livestock:	9.7
Cattle	7.9
Hogs	1.8
Fish	1.2

SOURCE: Bank of Canada.

FIGURE 4. U.S. REAL EFFECTIVE EXCHANGE RATE, 1980-2006

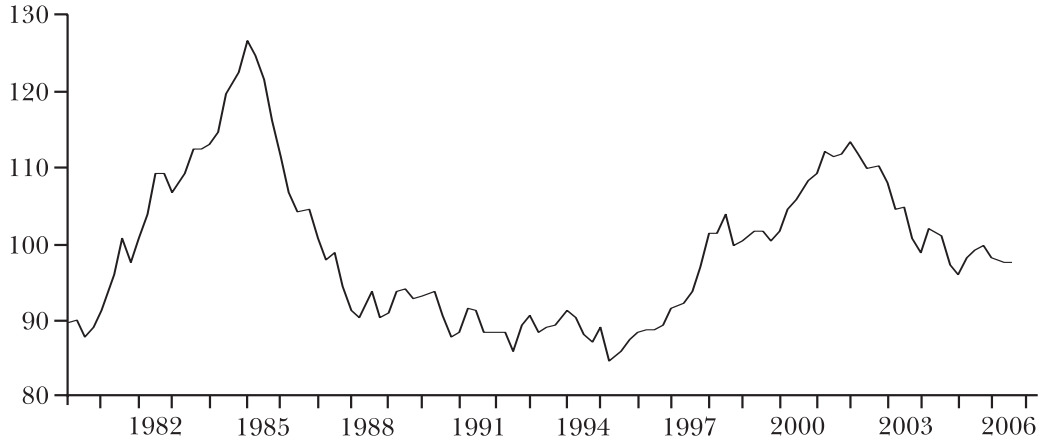
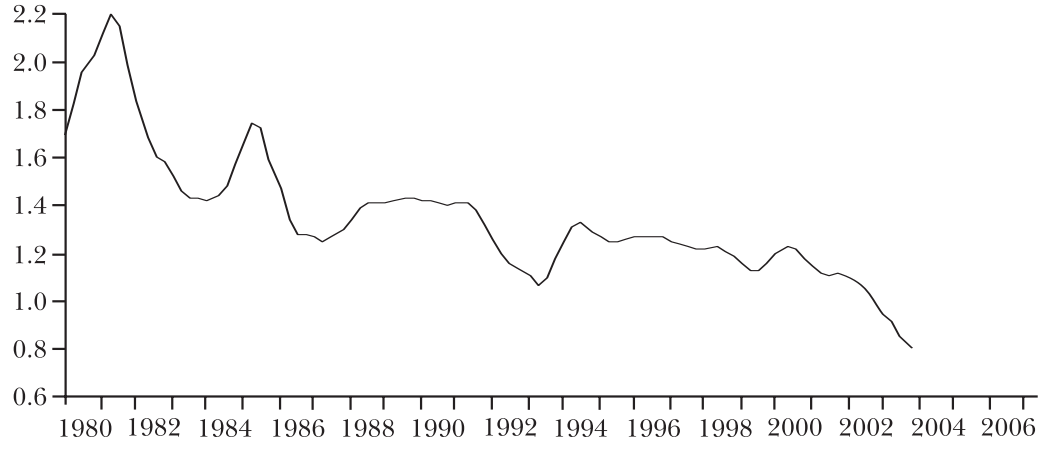
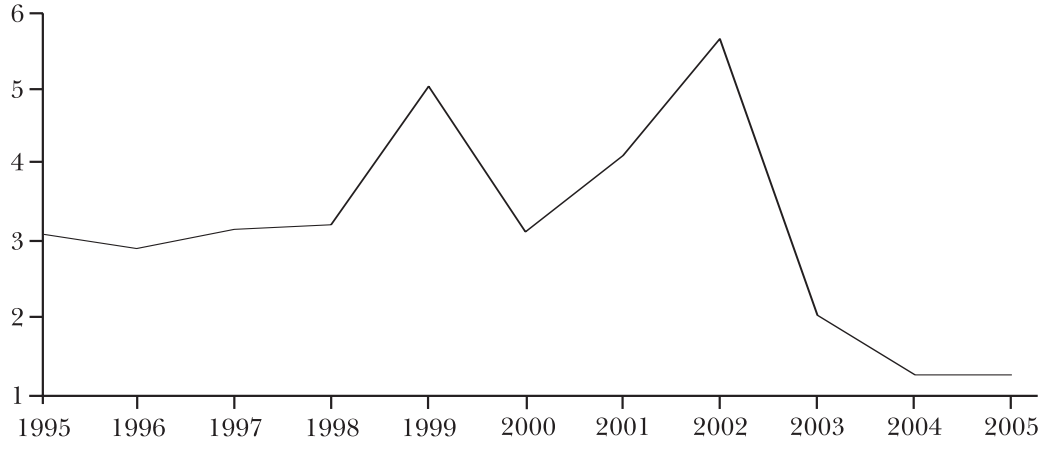


FIGURE 5. OECD REAL INVESTMENT IN METALS AND MINING INDUSTRIES RELATIVE TO OECD INDUSTRIAL PRODUCTION INDEX, 1980-2006 (Millions of USD)



SOURCE: OECD STAN Database.

FIGURE 6. WORLD SPARE OIL PRODUCTION CAPACITY, 1995-2005 (mb/d)

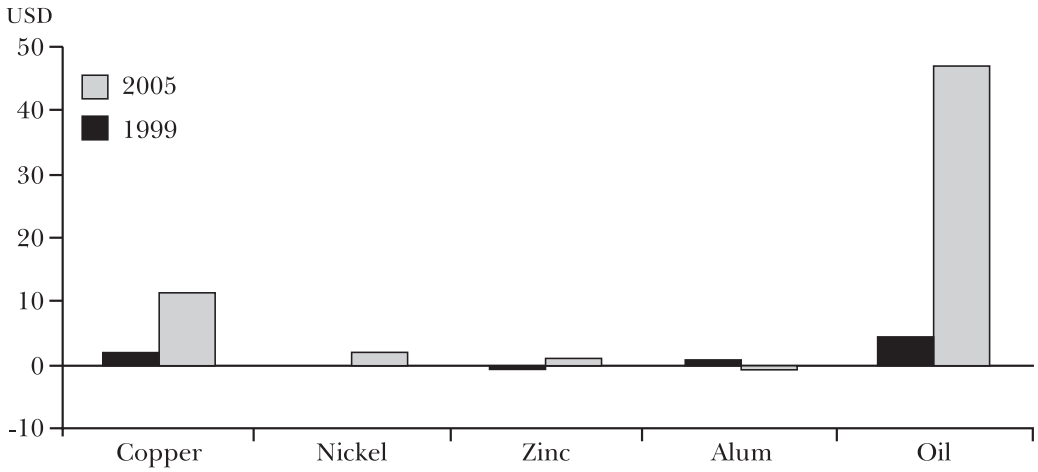


SOURCE: IMF.

3. A DECOMPOSITION OF ASIA'S DEMAND FOR COMMODITIES

Over the past 5 years, China has accounted for the majority of incremental demand for copper, nickel, and zinc, as well as a substantial portion of oil demand growth. The first two columns of Table 2 depict China's expanding share of world demand growth for oil and the four base metals contained in the BCPI. Because China has a low domestic endowment of natural resources relative to its needs, it has become a net importer of most commodities, as shown in Figure 7.[5]

FIGURE 7. NET IMPORTS - CHINA (Billions of USD)



SOURCE: UN COMTRADE.

China's expanding appetite for industrial materials can be decomposed into two sources: *i)* its rapid industrialization and infrastructure investment to meet the needs of an expanding urban population, and *ii)* its growing industrial integration with other East Asian countries to become a major world exporter of manufactured goods. Of course, these two factors are highly interrelated, since China's thriving export industry has been a major catalyst for rising domestic investment and urban migration in

[5] While China is the sixth largest crude oil producer in the world, it has been a net importer of oil since 1993. China has also recently emerged as a top producer and net exporter of aluminum. However, China's net imports of alumina (the main input for aluminum production) have surged since 2001, accompanied by steep increases in alumina prices. This suggests that China has likely impacted aluminum prices indirectly through driving up the input costs of production.

TABLE 2. SHARES OF WORLD DEMAND GROWTH, 1996-2005

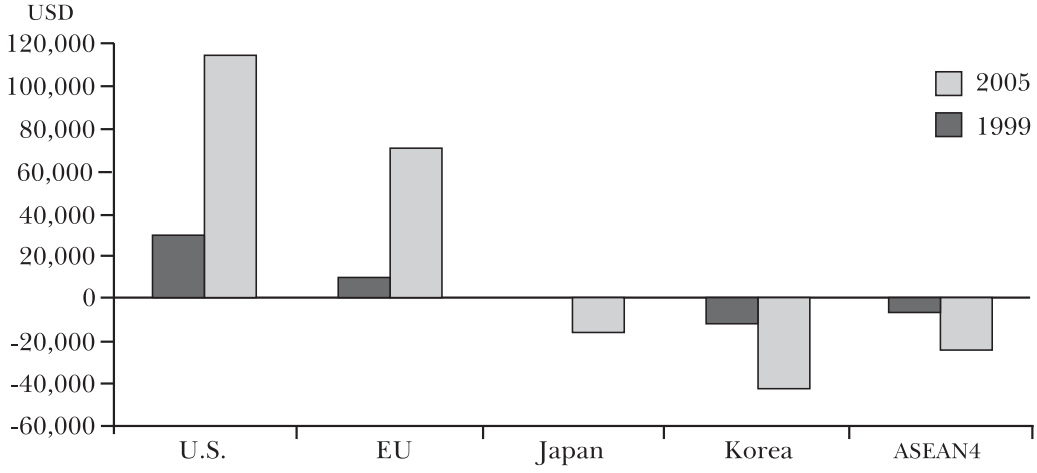
	China (%)		*Asian NIEs*[a] *(%)*		*Japan (%)*		*ASEAN-4*[b] *(%)*		*India (%)*	
	1996-2000	*2001-2005*	*1996-2000*	*2001-2005*	*1996-2000*	*2001-2005*	*1996-2000*	*2001-2005*	*1996-2000*	*2001-2005*
Oil	23	35	6	5	0	0	3	5	12	3
Aluminium	32	46	7	6	0	3	0	3	0	4
Copper	26	62	12	5	0	4	8	13	4	5
Nickel	4	63	37	28	2	0	0	4	2	0
Zinc	32	88	13	4	0	0	2	4	2	5

SOURCES: BP Statistical Review 2006, World Bureau of Metal Statistics. Demand growth is calculated as the change in units consumed over the stated period.

[a] Asian NIEs include Hong Kong, Singapore, South Korea, and Taiwan. [b] ASEAN-4 countries include Indonesia, Malaysia, Philippines, and Thailand.

recent years. Nevertheless, it is worth distinguishing between these two sources of demand for commodities. This is because the first channel is driven by final domestic demand in China and is expected to be a persistent source of commodities demand going forward, whereas the second is more dependent on external demand conditions, and is expected to eventually diminish in importance as growth rotates towards domestic demand. Henceforth, we refer to the first source as the *domestic demand channel*, and the second as the *export channel*.

FIGURE 8. CHINA'S NET BILATERAL TRADE POSITION BY REGION (Millions of USD)



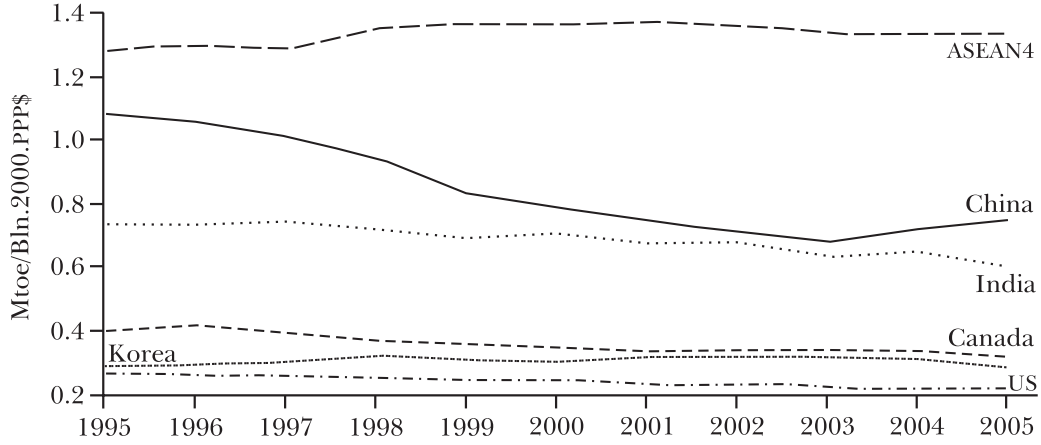
SOURCE: IMF, Direction of Trade Statistics.

3. 1. Domestic demand channel

Although China has continuously developed its urban infrastructure and domestic industry for quite some time, its energy and metals intensities have only advanced noticeably in recent years. As Figures 9 to 13 show, China's per GDP consumption has accelerated since 2003 for energy and zinc, and since the late 1990s for aluminum, copper and nickel. As discussed in Rosen and Houser (2007), much of this is attributable to the substantive growth in energy-intensive and capital-intensive industries - such as steel, aluminum, cement, and glass – used for road and building construction.[6]

[6] China's energy elasticity of GDP growth averaged a modest 0.6 over the 1980s-1990s, leading to a substantial reduction in the amount of energy required to produce each unit of GDP. This may have been related to gains in en-

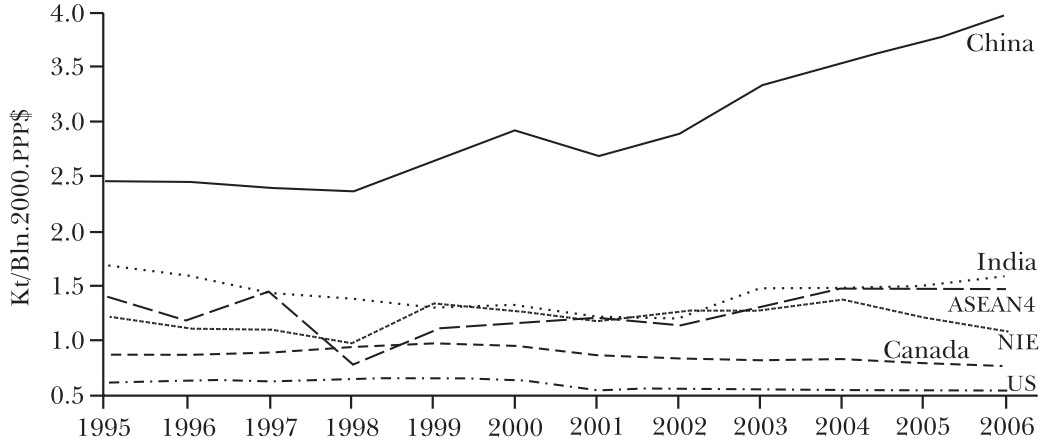
FIGURE 9. PRIMARY ENERGY CONSUMPTION PER GDP, 1995-2005



SOURCE: *BP Statistical Review 2006,* World Bank, IMF.

Studies show that resource demands in developing countries typically begin to climb during the early phase of industrialization, and eventually stabilize and then decline as income levels advance, creating an inverted *U*-curve.[7] For example, Figure 14 plots the per capita consumption of zinc against real GDP per capita

FIGURE 10. ALUMINIUM CONSUMPTION PER GDP, 1995-2006

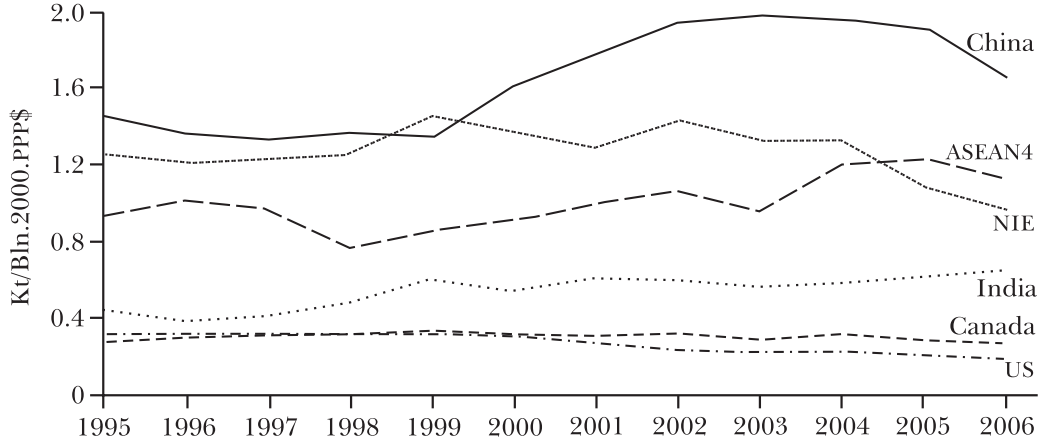


SOURCE: World Bureau of Metals Statistical, UN Commodity Yearbook, World Bank, IMF.

ergy efficiencies and market reforms that encouraged structural shifts away from heavy industry (e.g. steel and cement) towards labour-intensive light manufacturing (e.g. textiles). This trend has reversed in recent years, as economic incentives have favoured energy-intensive industries. Since 2001, it is estimated that this energy elasticity has almost doubled. For more details, see Lardy (2006).

[7] For example, see Cleveland and Ruth (1999), Park and Zhai (2006), and Garnaut and Song (2006).

FIGURE 11. COPPER CONSUMPTION PER GDP, 1995-2006

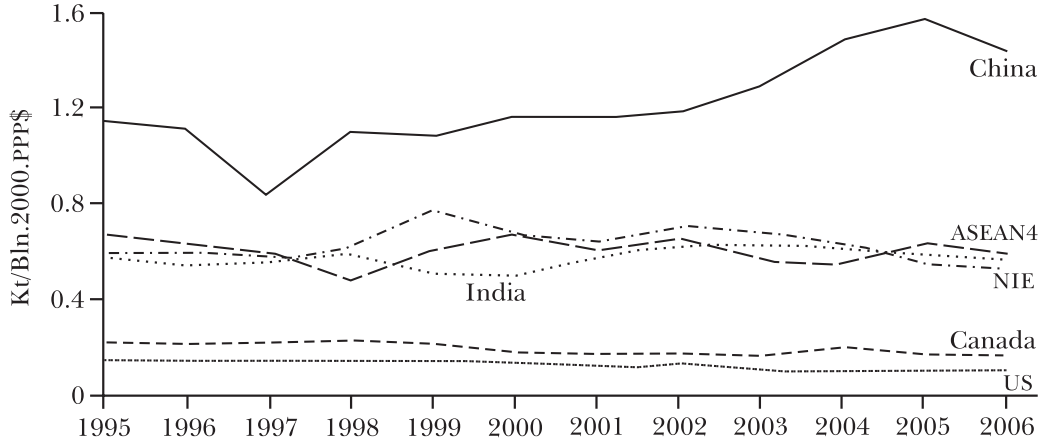


SOURCE: World Bureau of Metals Statistical, UN Commodity Yearbook, World Bank, IMF.

FIGURE 12. NICKEL CONSUMPTION PER GDP, 1995-2006

SOURCE: World Bureau of Metals Statistical, UN Commodity Yearbook, World Bank, IMF.

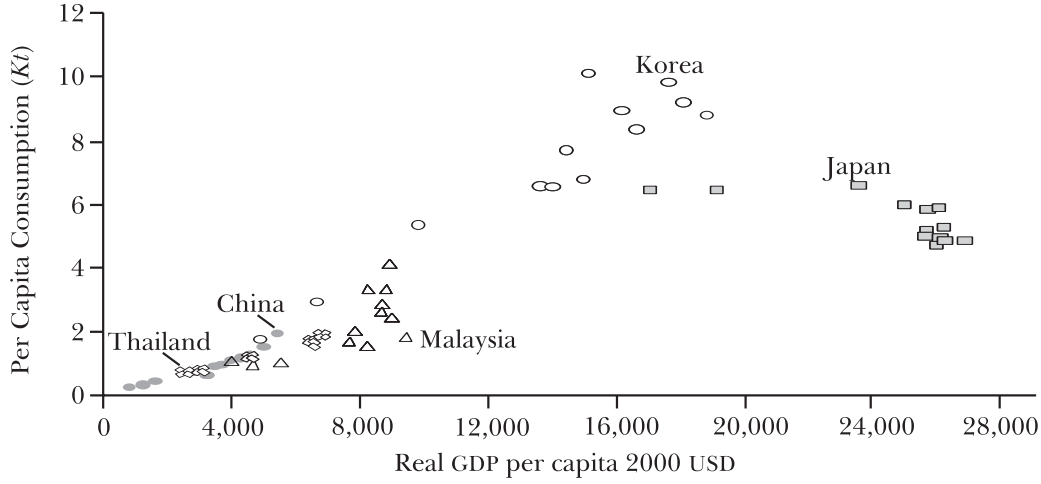
FIGURE 13. ZINC CONSUMPTION PER GDP, 1995-2006



SOURCE: World Bureau of Metals Statistical, UN Commodity Yearbook, World Bank, IMF.

(2000 USD dollar terms) for China, Japan, South Korea, Malaysia, and Thailand. Similar graphs for energy and other base metals show comparable patterns, and are thus not shown. Based on the experiences of Japan in the 1960s and Korea in the 1980s, emerging Asia's energy and metals intensities could be expected to gain momentum at income levels between $5,000-$10,000 per capita, and continue to grow rapidly before slowing at income levels of about $15,000-$20,000 per capita.[8] Indeed, for countries whose per capita income levels range between $5,000-$10,000 (China, Thailand, and Malaysia), resource intensities have accelerated in recent years. In contrast, little change has been observed thus far in India, Indonesia, and the Philippines, where per capita income levels remain below $5,000.

FIGURE 14. ZINC CONSUMPTION PER CAPITA



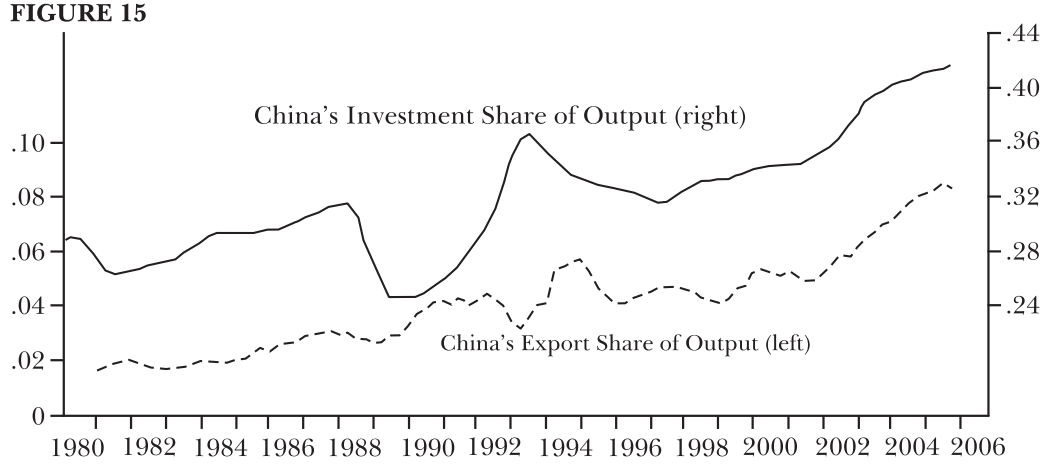
SOURCE: World Bureau of Metals Statistical, UN Commodity Yearbook, World Bank, IMF.

Garnaut and Song (2006) propose three key variables that drive a country's energy and metals use: investment share of output, export share of production, and rate of urbanization (defined as the fraction of population that is urban). So far, China's resource intensities have been bolstered primarily by advancing investment and export shares of output in recent years, displayed in Figure 15.[9] Looking ahead, consumption is expected to become

[8] A slowing in China's resource intensities would be dependent on its industry moving away from manufacturing towards a service sector orientation.

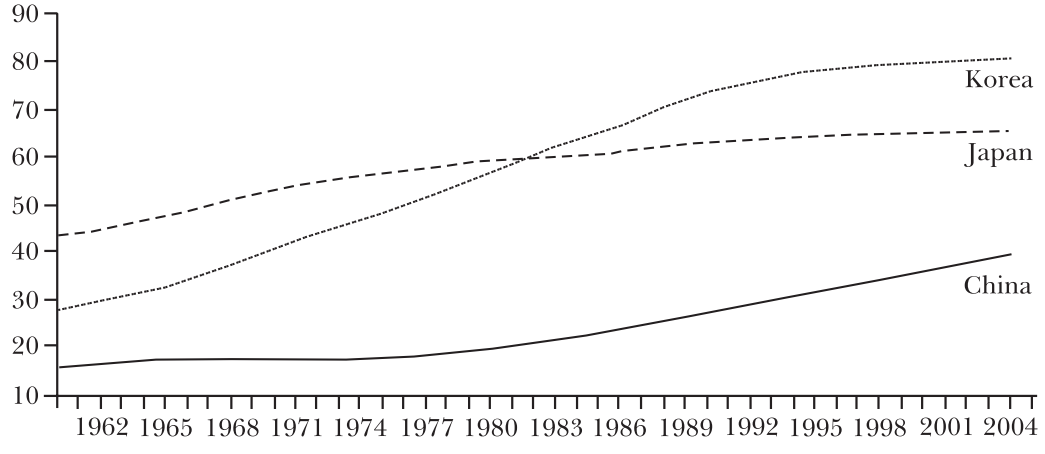
[9] The transportation sector has also become increasingly important. The number of motor vehicles on the road has doubled in the last 5 years, and trans-

FIGURE 15



SOURCE: IMF, *International Financial Statistics*.

FIGURE 16. URBAN POPULATION PERCENTAGE, 1960-2004



SOURCE: World Bank.

the leading driver of energy and metals demand, as rising incomes of urban workers generates growing automobile ownership and consumption of household durables. The proportion of China's population living in cities - currently at 40%, compared with Japan at 66% and Korea at 81% (see Fig. 16) - should also continue to progress for some time. Together, these factors suggest that the domestic demand channel should be a persistent source of demand for commodities going forward.

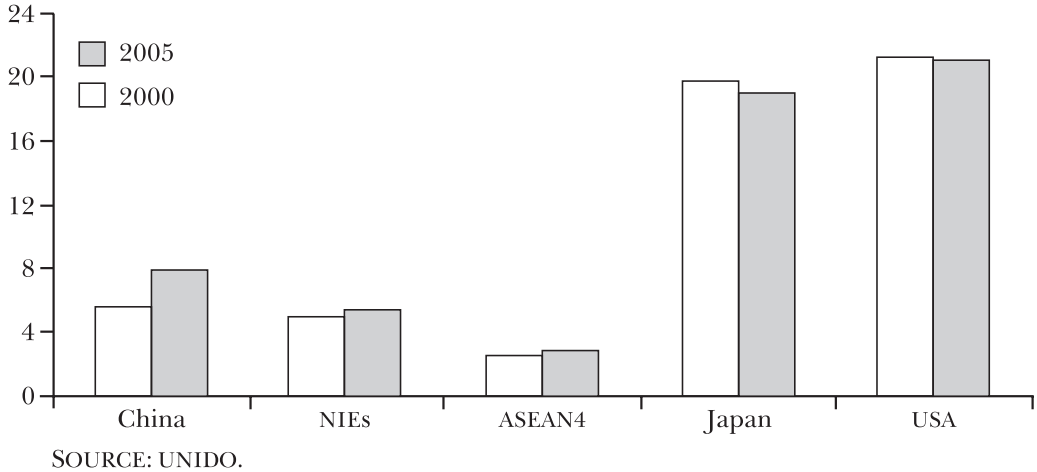
3.2. Export channel

China's expanding international trade, following its accession

portation has accounted for 42% of China's growth in oil consumption since 1995.

to the WTO in 2001, has been an important factor behind its escalating demand for industrial materials. Much of this trade growth has been associated with China's integration into the cross-border processing chain as a low-cost final assembler of manufactured goods. Adopting this role has generated a surge in China's exports of manufactured goods and increased raw material needs. Li and Song (2006) suggest that increasing bilateral trade and similar export structures between China and ASEAN countries reflect regional fragmentation of production by multinational corporations seeking economies of scale. It is estimated that a large portion of China's exports originate from Japanese and other Asian countries, for final destination in US and European markets. Consequently, while China has fostered a swelling trade surplus with the West, it has also built trade deficits with Japan, Korea, and the ASEAN-4 countries, as shown in Figure 8. Furthermore, Li and Song (2006) find that the composition of Asian exports has shifted from goods that are agricultural-intensive and labour-intensive towards goods that are more capital-intensive over the last decade. This change has likely boosted the metals and energy content of the region's manufacturing activity.

FIGURE 17. SHARE OF WORLD MANUFACTURING ACTIVITY



SOURCE: UNIDO.

Because China is only one part of the manufacturing process for Asia's exported goods, it is important to also examine the role of other Asian economies in boosting commodities demand. Figure 17 illustrates that since 2000, larger shares of world manufacturing activity have been accumulated by China, the NIEs, and

ASEAN-4.[10] Table 2 compares the shares of commodities demand growth of China with those of other Asian countries. These statistics indicate that the contributions of ASEAN-4 to demand growth in oil and base metals have increased significantly in recent years, but remain modest compared to China. India and Japan have seen little increase in their shares of world demand growth for these commodities, while the portion attributable to Asian NIE countries has diminished for all commodities examined.[11]

To the extent that emerging Asia is boosting the global supply of manufactured goods, higher production levels would generate a higher level of world demand for raw materials. It is worth emphasizing that it is the incremental *world* demand attributable to emerging Asia that moves commodity prices. This amount is generally difficult to isolate, as part of the observed increase in Asia's production levels could reflect manufacturing activity that has simply been outsourced from higher-cost countries, for re-export to those countries.[12] The declines observed in Japanese and US shares of world manufacturing activity since 2000 (shown in Fig. 17) suggest that mounting exports from emerging Asia may be displacing production in the rest of the world.[13] Therefore, the increase in *world* demand for commodities is likely to be smaller than the incremental demand suggested by observed increases in Asia's production levels. At the same time, the migration of

[10] In particular, China's shares of global production have more than doubled since 2000 to 28% for aluminum, 35% for steel, and 48% for cement.

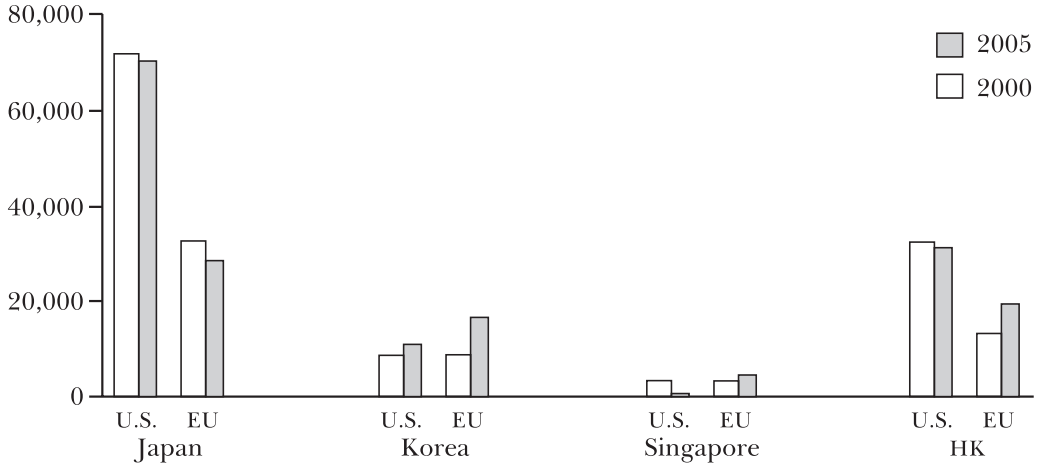
[11] Although this suggests little role for the NIEs in driving recent commodity price increases, South Korea's contribution to world nickel demand growth over 2001-2005 more than doubled to 33%, from 15% in the previous 5 years. This increase has been more than offset by a significant decline in Taiwan's share.

[12] Another reason emerging Asia's influence on commodity prices may be difficult to identify is that a significant portion of the region's manufactured goods are exported to the Americas and Europe. Consequently, one could arguably attribute the related raw materials usage to external demand. As concluded in a study by the Asian Development Bank (2007) on Asian intra-industry trade, growth in manufactures exports from emerging Asia remains heavily reliant on final demand from outside the region. Accordingly, the region's demand for commodities for its production of manufactures exports is arguably more driven by the business cycle in the industrialized world than in emerging Asia itself.

[13] The observed declines in net exports to the US from Japan, Singapore, and Hong Kong since 2000 (shown in Fig. 18) may also indicate that some of the expanding Chinese exports to the US have simply displaced Japanese and Asian NIE exports.

manufacturing activity to Asia may also generate net gains in world commodities demand. This is particularly the case for oil, since emerging Asia tends to consume considerably more energy per unit of production than in the developed economies. According to some estimates (see Rosen and Houser, 2007), Chinese firms use 20% to 40% more energy for the same level of output compared to their OECD counterparts.[14]

FIGURE 18. INDUSTRIALIZED ASIA: NET BILATERAL TRADE POSITIONS



SOURCE: IMF, Direction of Trade.

4. REVIEW OF LITERATURE

Research on structural models for commodity prices have traditionally found that price movements tend to be driven by world industrial activity and the US exchange rate. For examples of these studies, see Hua (1998) and Lalonde, Zhu, and Demers (2003). Hua (1998) and Borensztein and Reinhart (1994) further find that oil price shocks play an important role in driving non-oil prices.

More recently, an empirical study by Pain, Koske, and Sollie (2006) suggests that emerging economies have become a more important influence on commodity price movements over the last 5 years. The authors represent growth in emerging markets using non-OECD shares of world output and trade, and find that relative strength in these economies exhibited significant and

[14] This may be due to economic incentives that have favoured energy-intensive industries in China.

permanent effects on real oil prices, while only temporary effects on the level of real metals prices, and no effect on agricultural prices. However, specific analysis of emerging Asia's impact on commodity prices has been limited to date, given that its upsurge in demand has been relatively recent. Given that many major emerging markets actually lowered their shares of world demand growth in commodities over the 2002-2005 period (see IMF, 2006), such as Brazil, India, Mexico and Russia, a focus on emerging Asia could lead to different results from the Pain et al. (2006) study. Within a DSGE framework, Lalonde and Muir (2006) are able to explain the recent rise in oil prices through simulating a permanent increase in productivity in emerging Asia, combined with a further shock to energy intensity. However, empirical support for this outcome has been limited thus far in the literature.

Since commodity prices respond to both demand and supply movements, it is also important to consider supply conditions. Borensztein and Reinhart (1994) argue that traditional "demand-driven" structural models that ignore supply have tended to persistently over-predict real commodity prices by wide margins from the latter half of the 1980s into the early 1990s.[15] In practice, data on world commodity supply, demand, and inventories face limitations in terms of low quality, timeliness, and prohibitive cost.[16] Consequently, lack of data availability is a standard restriction in much of the commodity price literature, and price predictions are commonly derived from statistical inference based solely on the observed prices.

The specification of the commodity price equation also depends to a great extent on whether the series are stationary.

[15] The authors suggest that this was due to the sharp increase in commodities exports from economies in transition in the former Soviet Union, which were not accounted for in most models.

[16] Frequency and units of measure also vary markedly across different countries and different types of commodities, making aggregation difficult. Furthermore, even if reliable production data can be obtained for a given commodity, it is arguably productive *capacity* which drives longer-term price behaviour. While supply capacity can be estimated from indicators such as reserves and investment in mining and resource sectors, such data remains difficult to obtain globally. Yet more difficult to capture are *expected* supply shortages, which can be important in influencing prices even in the absence of actual disruptions.

While many commodity prices do not appear to be stationary over history, there is no clear consensus in the literature on whether this arises from deterministic trends, stochastic trends, or structural breaks. While earlier studies commonly assumed commodity prices to follow a random walk, much of the recent financial literature has argued in favour of modelling them as mean-reverting processes (see for example, Pindyck [2001], Schwartz and Smith [2000]). Intuitively, if a positive demand shock pushes the price of a commodity above its equilibrium level, producers would respond by increasing supply, thus pressuring prices down towards equilibrium. Non-stationarity can nonetheless arise because demand and supply adjustments are often slow, and shocks to commodity prices tend to be long-lasting, as shown by Cashin et al. (2000). The equilibrium price could also shift in response to changing expectations of the reserve base, political and regulatory climates, or production technologies.

Perron (1990) demonstrated that the existence of structural shifts in the mean of a series may also give rise to the appearance of an integrated process, when in fact the series may be stationary within each regime. Lalonde et al. (2003) find this behaviour is consistent with real oil prices between 1974 and 2001. Using the methodology of Bai and Perron (1998), the authors find evidence of two structural breaks over this sample period, each coinciding with a major exogenous shock that dramatically shifted supply expectations: the Iran-Iraq war in 1980 and the collapse of OPEC discipline in the mid-1980s. Upon accounting for these structural shifts, real oil prices are found to be stationary within each regime.

5. THEORETICAL FRAMEWORK

The approach used to estimate the impact of emerging Asia on commodity prices begins with a simple partial equilibrium framework of price formation in a storable commodity market. The market comprises of consumption demand, inventory demand, and supply:

$$D_t = D\{(L)P_t, (L)Y_t, (L)X_t\}$$

$$Q_t = Q\{(L)P_t, P^e_t, (L)Z_t\}$$

$$I_t = I\ \{(P^e_{t+1} - P_t), r_t\}$$

With *(L)* denoting the lag operator, commodities demand (D_t) is a function of current and past levels of the price (P_t), income (Y_t), and other exogenous variables (X_t). Supply (Q_t) is also determined by current and past commodity prices, expected future prices, and some exogenous variables (Z_t). Inventory demand (I_t) is dependent on the cost of storage as defined by the interest rate (r_t), and the expected profit from holding the stock, as defined by the expected change in price. Because commodities are storable, expectations about future market conditions can have immediate impacts on the demand for storage, and thus affect current prices. Finally, the market clearing price is that which equates consumption demand and inventory demand with supply:

$$Q_t = D_t + \Delta I_t$$

The lack of data precludes estimating this system of equations for world commodities supply, demand, and inventories. Consequently, the commodity price is typically represented by a reduced-form single-equation model, and is a function of income, lagged prices, price expectations, interest rates, and other exogenous variables:

$$P_t = P\{(L)Y_t, (L)P_{t-1}, (L)X_t, \Delta P^e_{t-1}, (L)r_t\} \qquad (5.1)$$

From this equation, it would not be possible to identify the parameters in the structural system, nor disentangle effects of supply and demand adjustments. Variables such as expected future prices are also unobservable. The dependent and independent variables considered for equation (5.1) are described in the following section. To estimate the impact of emerging Asia on commodity prices, we consider a number of different variables to represent the region's growth in demand and intensity of resource use from both domestic demand and export channels. While it would be interesting to identify and distinguish between effects from domestic demand and export demand as described in Section 3, this is difficult in practice given that the two channels are highly correlated.

5.1. Data

All data series are quarterly and expressed as logarithms, with

the exception of real world interest rates and variables in ratio form. More detailed sources and definitions of the data used are given in the Appendix. The commodity price series used are the benchmark *WTI* crude oil price and the base metals price index of the BCPI. To obtain real prices, the oil price is deflated using the US GDP deflator, while the metals price index is deflated with the US producer price index for finished goods.

To represent demand from industrialized countries, the income variables considered are the OECD index of industrial production and the OECD output gap. These variables are expected to bear a positive relationship with prices, as increased production in major industrialized countries would raise input demand for commodities. Other important determinants of commodities demand are the US real effective exchange rate and real world interest rates. Since most commodities are traded and priced in US dollars, a depreciation of the US dollar would allow other countries to purchase commodities more cheaply, and would thus be expected to generate higher demand levels and higher prices. The exchange rate variable is represented as the price of foreign currency, with an increase signifying a real depreciation of the US dollar. The relationship between commodity prices and real interest rates, however, is less clear. An increase in interest rates could lower commodity demand by raising the costs of storage as well as slowing future aggregate demand, putting downward pressure on prices. Conversely, rising interest rates could discourage investment activity by producers, thus lowering expected future supplies and driving commodity prices higher. Since commodities are also considered a financial asset class whose price can be influenced by investment demand, we also consider the Standard and Poors 500 stock index as a substitute good price.

On the supply side, variables considered for the oil equation include data on world oil production capacity. For metals, an investment indicator was constructed from data on OECD real investment in metals and mining industries. This data provides a fairly rough measure of investment since it is only available to 2003, it is missing data for many of the OECD countries, and it also excludes many major metals producing countries such as Mexico, Chile, and China. Real oil prices are also considered in the equation for metals prices to represent costs of extraction and production.

Various variables are considered to represent demand growth in emerging Asia and rising resource intensities in the region. Emerging Asia is defined to include the 10 countries of China, India, ASEAN-4, and the Asian NIEs. A major limitation faced is the availability and reliability of Chinese data, with many of the desired series available only since the mid-1990s, or else only at annual frequencies, or in nominal or growth rate form. Given these constraints, we construct an emerging Asia industrial production index using time-varying GDP weights on the individual industrial production indexes of the 10 emerging Asia countries.[17]

FIGURE 19. INDUSTRIAL PRODUCTION CYCLES: OECD VS. EMERGING ASIA, 1980-2006

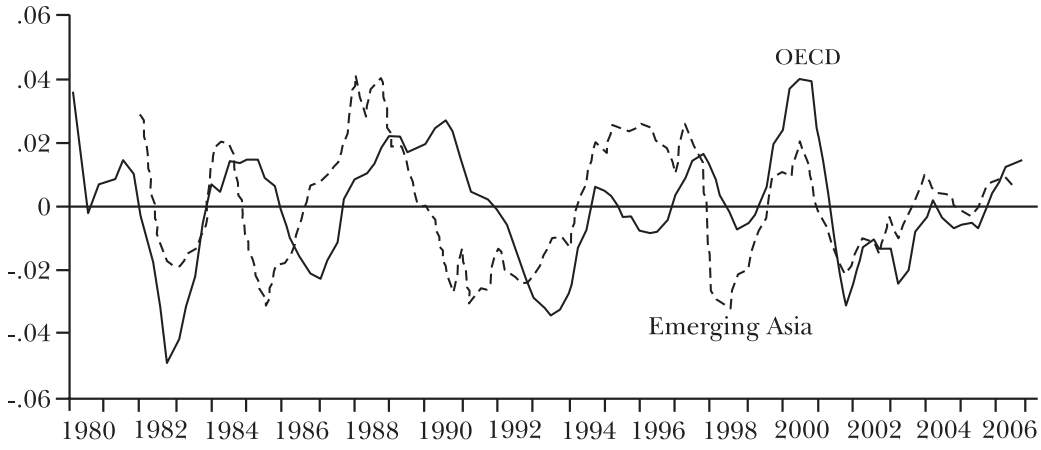
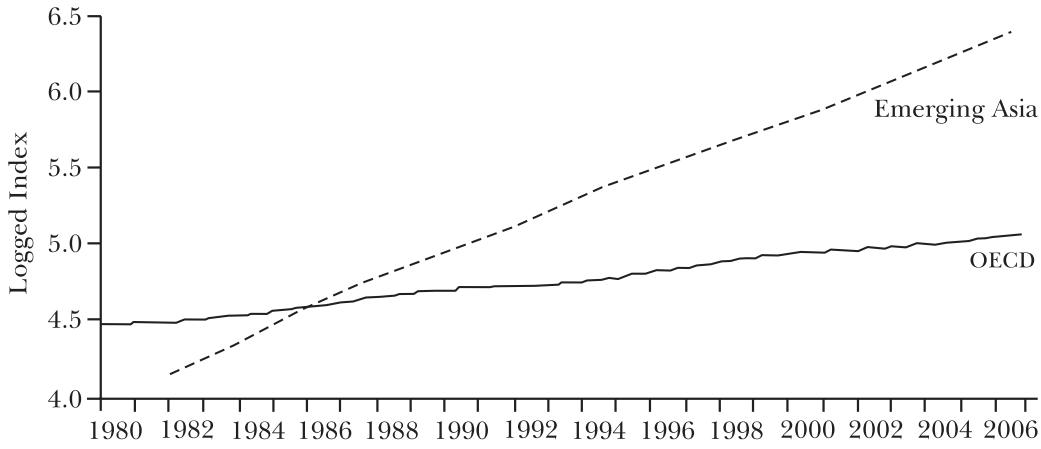


Figure 19 shows the resulting de-trended emerging Asia industrial production index, compared with the similarly de-trended OECD industrial production index. Both series are de-trended using a Hodrick-Prescott (HP) filter, and Figure 20 illustrates the estimated trends in both series. Several observations are worth noting in these graphs. The first is that the trend in emerging Asia's industrial production has increased considerably more rapidly than that of the OECD over time. The second is that the production cycle in emerging Asia has become more closely correlated with that in the OECD since about 1997. The correlation coefficient between the two series from 1997Q3-2006Q2 is 0.58, compared with 0.29 from 1982Q1-1997Q2. This may be a reflection of either increasing globalization that has led to converging business

[17] While this measure overlaps somewhat with the OECD industrial production index, with South Korea included in both, the implications are expected to be minor given that its weight in OECD output is relatively small.

FIGURE 20. INDUSTRIAL PRODUCTION TRENDS: OECD VS. EMERGING ASIA, 1980-2006

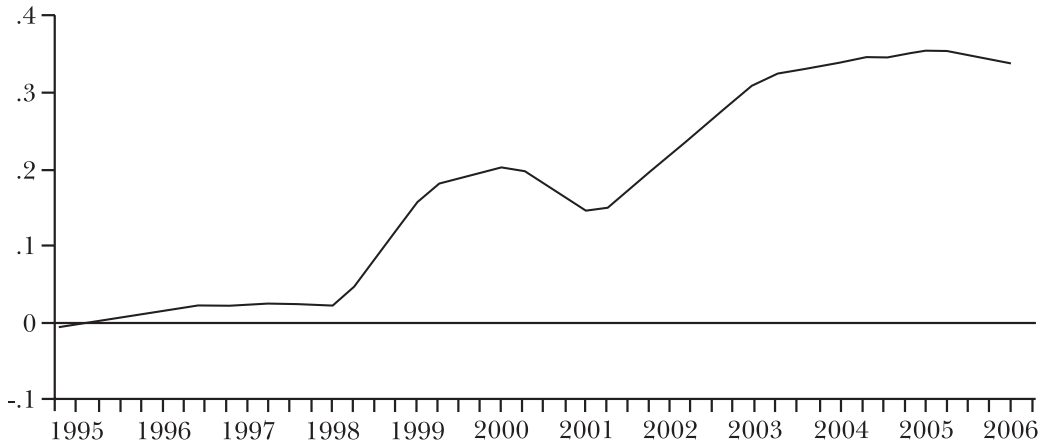


cycles worldwide, or that the economies of emerging Asia have become more linked to those in the developed world via export demand. Another notable item in Figure 19 is that the increase in emerging Asia's industrial cycle since 2001 looks fairly modest relative to evidence of strong demand growth in the region for commodities over the last 5 years, and relative to increases in industrial production observed in the early 1990s. This observation could be a sign that the variable does not convey the rising resource intensities of production associated with expanding urban infrastructure and recent shifts in Chinese manufacturing from labour-intensive goods towards more capital-intensive goods.

Other variables are used to capture the increasing resource intensities in emerging Asia through the domestic demand channel, including China's urbanization rate, China's investment share of output, as well as a constructed metals intensity index for emerging Asia (displayed in Fig. 21). No energy intensity measure was constructed, since increases observed thus far have been modest (as shown in Fig. 9) and likely too recent to be captured in any estimations. To reflect rising resource intensities through the export channel, variables used include emerging Asia's share of world trade, China's net exports of manufactured goods, China's exports of manufactured goods as a share of the country's GDP, Chinese exports of manufactured goods to the US, and Chinese exports of machinery and equipment to the US.[18]

[18] Data on Chinese exports to Europe of manufactured goods and machinery and equipment were not available.

FIGURE 21. EMERGING ASIA LOGGED METALS INTENSITY INDEX, 1995-2006



6. EQUATION SPECIFICATIONS

As our interest in commodity prices stems primarily from their importance for the Canadian economy, our analysis is centred on the commodities in the BCPI basket. Since the most pronounced increases have been observed in the real prices for oil and base metals over recent years, we focus on these commodities. Two separate equations are estimated for the real oil price and the real base metals price index from the BCPI, given the heterogeneity across different commodity markets.[19] In particular, Lalonde et al. (2003) find that past oil price movements have been characterized by deterministic shifts that can be linked to specific events, which render prices to be nonstationary over history, but stationary within each estimated regime. This presence of stationarity in real oil prices may be the result of a tendency for supply and demand to grow at roughly the same pace over time, or to adjust fairly rapidly to shocks. Meanwhile, real metals prices have exhibited a fairly cyclical nature over history (see Figure 2), but unit root test results are not able to reject nonstationarity. In the absence of any structural shift, this nonstationarity may indicate that metals demand and supply have typically adjusted more slowly to shocks over time.

[19] For example, oil prices tend to be subject to idiosyncratic shocks related to geopolitical conflicts, because of the fact that the majority of world oil supplies are located in regions with political instability.

6.1. Real oil prices

Based on the findings of Lalonde et al. (2003), we begin with an examination of the behaviour of real oil prices since the authors' last estimated break point of 1985Q3. It can be seen that the series no longer appears stationary once the sample is extended to the end of 2006. Indeed, an ADF test on real oil prices over the 1985Q4-2006Q4 interval yields a t-statistic of -1.66, confirming a failure to reject the presence of a unit root. This suggests the influence of some factors that may have generated yet another structural change, or else a stochastic shift in oil prices.[20] Since it is difficult to know the cause of such a change, we first test for the presence of a structural shift.

We begin by estimating the same equation as Lalonde et al. (2003) for the level of oil prices using the Bai-Perron (BP) methodology for the 1985Q4-2006Q2 sample. Given the relatively short sample size, we allow for a maximum of one unknown break point, with all parameters free to shift at the point. As described in Lalonde et al. (2003), real oil prices are characterized by the following equation in each regime i:[21]

$$RWTI_t = C_i + \beta_{1i} RWTI_{t-1} + \beta_{2i} RWTI_{t-2} + \beta_{3i} WLYGAP_{t-1} + \beta_{4i} \Delta USREER_{t-2} \quad (6.1)$$

where *WLYGAP* is a world output gap (in logged form) and *USREER* is the logged US real effective exchange rate.[22]

The test detects the presence of a structural break in 1997Q2 at a 1% significance level. The resulting parameter estimates over each regime are shown under the column labelled *Y*1 of Table 3, which indicate that the *WLYGAP* variable is not statistically significant in either of the estimated regimes. Consequently, we modified equation (6.1) by replacing the world output gap variable with the OECD output gap, *OECD_GAP*. This moved the

[20] The breakdown in stationarity over the extended sample may also indicate a divergence in the pace of demand growth relative to supply growth in recent years, or increasing marginal costs of oil production.

[21] This equation uses the first difference of the US exchange rate, whereas Lalonde et al. (2003) had employed an exchange rate "gap" variable constructed using a HP filter. This does not affect the results materially.

[22] The world output gap is a production-weighted average of the gaps of the US, Canada, Mexico, the UK, Europe, and Asia.

estimated break date slightly to 1997Q3, while improving the fit of the equation. The results from this estimation are shown in the column entitled *Y*2 of Table 3.[23] While the OECD output gap was found to bear a significant, positive impact on oil prices in the first regime of 1985Q4-1997Q3, it appears to have lost its statistical significance since mid-1997. Meanwhile, the US exchange rate is only significant with the correct sign in the second regime.

The estimated break date in mid-1997 coincides well with the Asian currency crisis, which had considerably reduced demand for commodities from this region over this period. The fact that the OECD output gap became insignificant in the period after 1997Q3 may suggest that oil prices became dominated by developments in emerging Asia's demand around that time. To test this hypothesis, we included the emerging Asia industrial production index (*ASIA_IPdt)*, de-trended using a HP filter, into the modified equation (2) along with the OECD output gap. As shown in column *Y*3 of Table 3, including the emerging Asia variable contemporaneously into the equation generated roughly the same break date (1997Q4) as specification *Y*2, and improved the adjusted R^2. While the variable was found to be insignificant in the first regime, since 1998Q1 it has produced a significant and positive impact on oil prices. These results point to a larger influence from emerging Asia on oil prices since 1997.[24] Alternative variables were also considered to capture the effect of emerging Asia on oil prices through both domestic demand and export channels, but these variables were found to either worsen the overall fit of the equation, or to be statistically insignificant.[25]

[23] Alternative specifications were also tested with varying lag lengths and additional variables suspected to influence oil prices, such as the real world interest rate and oil production capacity. These variables were found either to be insignificant or to worsen the fit of the equation.

[24] Of course, emerging Asia may have also been a key source of demand for commodities even over the early 1990s (see Novin and Stuber, 1999). However, it is likely that its importance became more apparent when oil prices dropped in the wake of the Asian crisis, without any major change in the OECD output gap.

[25] Alternative variables include China's investment share of output, China's urbanization rate, emerging Asia's share of world trade, China's net exports of manufactured goods, China's exports of manufactured goods as a share of GDP, Chinese exports of manufactured goods to the US, and Chinese exports of machinery and equipment to US.

TABLE 3. REAL OIL PRICES: BAI-PERRON ESTIMATION RESULTS, 1985-2006

Regime 1:	*Y1* *1985Q4-1997Q2*	*Y2* *1985Q4-1997Q3*	*Y3* *1985Q4-1997Q4*
C	1.291[a] (6.53)	1.386[a] (7.18)	1.620[a] (3.13)
$RWTI_{t-1}$	0.715[a] (7.37)	0.698[a] (8.22)	0.678[a] (5.89)
$RWTI_{t-2}$	-0.168[c] (-1.86)	-0.186[a] (-2.45)	-0.246[b] (-2.03)
$WLYGAP_{t-1}$	4.796 (1.63)		
$OECD\_GAP_{t-1}$		0.033[a] (2.54)	0.034[a] (2.57)
$\Delta\, USREER_{t-2}$	0.663 (1.15)	0.637 (1.22)	0.453 (0.75)
$ASIA\_IPdt_t$			-1.550 (-1.35)
Regime 2:	*1997Q3-2006Q2*	*1997Q4-2006Q2*	*1998Q1-2006Q2*
C	0.240[c] (1.70)	0.156 (1.13)	0.589[a] (3.67)
$RWTI_{t-1}$	1.199[a] (10.12)	1.200[a] (9.62)	0.825[a] (5.66)
$RWTI_{t-2}$	-0.271[b] (-2.22)	-0.245[c] (-1.86)	-0.005 (-0.04)
$WLYGAP_{t-1}$	-0.034 (-0.01)		
$OECD\_GAP_{t-1}$		0.010 (0.45)	-0.042[b] (-2.11)
$\Delta\, USREER_{t-2}$	-2.449[a] (-3.13)	-2.662[a] (-3.04)	-1.257[c] (-1.74)
$ASIA\_IPdt_t$			7.855[a] (5.00)
Adj-R^2	0.850	0.856	0.874

NOTE: *T*-statistics in parentheses.
[a] Denote significance at the 1%. [b] Denote significance at the 5%. [c] Denote significance at the 10%.

In order to account for possible endogeneity between the contemporaneous emerging Asia variable and oil prices, we also estimated the equation over the second regime using generalized

method of moments (GMM), with four lags of each regressor used as instruments and the standard errors adjusted using a five-lag Newey-West correction. The resulting parameter estimates were not significantly different from those produced by the BP methodology.

While the OECD gap variable remains significant and positive in the earlier regime, Table 2 shows that the inclusion of the emerging Asia industrial production variable now produces a significantly negative coefficient on the OECD gap since 1998Q1. This may reflect some multicollinearity associated with increasing correlation that has emerged between the business cycles of the developed economies with emerging Asia since mid-1997, discussed in section 5.1. Nevertheless, given that the OECD output gap was found to be insignificant since 1997 in the absence of the emerging Asia variable (equation *Y*2), it is desirable to remove it from the estimation when the emerging Asia variable is included. In order to do so, we estimate the oil equation using ordinary least squares (OLS) only over the latter 1998Q1-2006Q2 period, while removing the OECD output gap variable. The resulting estimates are (with t-statistics in parentheses):

$$RWTI_t = \underset{(2.81)}{0.481} + \underset{(5.34)}{0.904}\,RWTI_{t-1} - \underset{(-0.28)}{0.045}\,RWTI_{t-2} - \underset{(-2.35)}{1.930}\,\Delta US\_REER_{t-2} + \underset{(3.18)}{5.807}\,ASIA\_IPdt_t$$

which shows a lower coefficient on the emerging Asia variable. The cumulative AR coefficient of 0.859 on the above equation implies less persistence in oil prices when we account for emerging Asia, compared to the *Y*2 specification which does not. Ljung-Box Q-statistics also show no evidence of serial correlation in the residuals for up to 8 lags. These estimates imply a conditional mean price of oil that has increased in the 1998Q1-2006Q2 regime to USD 30.31 per barrel in real terms, compared to USD 17.32 per barrel over the 1985Q4-1997Q4 regime. The results also suggest that over the current regime, a 1 percent increase in Asian industrial production above trend is associated with a 5.8 percent increase in real oil prices.

The use of the de-trended industrial production index for emerging Asia in the above analysis effectively attributes oil price movements to only temporary shocks in the region's industrial activity. However, it is recognized that it may not be emerging

Asia's increase in output relative to trend that is driving recent oil price increases, but rather a permanent increase in its levels of economic activity or trend output, resulting from higher productivity growth in recent years. If so, the above analysis would not capture this channel. Given that oil prices are characterized by stationarity within regimes over most of history (Lalonde et al. [2003] estimate the last regime to span 1986Q1-2001Q4), the need to use stationary variables in the equation is a limitation of this analysis. At the same time, HP-filter estimates of the trend in Asian industrial production over the extended sample (1985Q4-2006Q2) do not reveal any visible shift relative to the trend estimated over shorter samples (neither 1985Q4-1997Q3 nor 1985Q4-2001Q4).

The fact that the emerging Asia variable seems to have dominated the positive influence from OECD demand since 1997 may indicate that the increasing share of world manufacturing activity that has migrated to emerging Asia in recent years has caused oil prices to be driven more by industrial activity in this region than in the developed economies. If this is the case, then the impact captured in the estimated parameter of the emerging Asia variable may partly reflect oil demand that has simply shifted from one part of the world to another (i.e. the export channel), in addition to any incremental demand that the region may have added to world demand. Nonetheless, this shift has likely generated net gains in world oil demand, as greater shares of world manufacturing activity have moved to a region with relatively higher trend output growth (shown in Fig. 20), and which uses more energy per unit of output, relative to the developed world.

The results point to two main findings. The first is the presence of a break detected in the equilibrium price for oil in the last half of 1997. The second is that the cyclical behaviour of oil prices since that break point appears to be linked to emerging Asia's industrial activity. Although no conclusive evidence exists to explain the cause for the break, it appears to have possibly arisen from the increasing influence of emerging Asia. This would pose an additional challenge, as it would signify that the shift is more stochastic in nature, unlike previous breaks that were related to exogenous supply shocks or changes in OPEC behaviour.[26] However,

[26] While there was a 10% increase in OPEC production quotas that took place

the number of observations available is insufficient to capture such a stochastic equilibrium shift. In this context, the emerging Asia variable may be picking up the effects on oil prices possibly coming from any other trending factors not included in the equation, such as increased globalization or geopolitical factors. Such a case would create upward bias to the impact suggested by the estimated coefficient of emerging Asia. Since the oil production capacity variable was found to be insignificant over the sample, our estimated model for oil prices does not take into account developments in supply. As shown in Figure 6, the sharp decline in OPEC spare production capacity since 2002 points to an insufficient supply response to recent demand pressures, which may have contributed in part to the recent acceleration in price. The omission of this supply effect would imply an additional upward bias on emerging Asia's estimated coefficient.

6.2. Real base metals prices

The approach used to model real base metals prices is different from that for real oil prices. Unlike the case for oil, no specific events can be identified with metals prices to justify the presence of deterministic breaks. As ADF test results on the real metals price index were not able to reject the presence of a unit root, we employ a stochastic approach to model them. Consistent with the idea that real commodity prices should revert to some equilibrium level, we therefore test for the possibility that real metals prices possess a stable long-run cointegrating relationship with some other macroeconomic activity variable or combination of variables. This was conducted using Engle and Granger (1987) residual-based tests on the estimated cointegrating equation, using the dynamic least squares method of Saikkonen (1991) to correct for endogeneity and serial correlation:

$$RMTLS_t = \beta' x_t + \sum_{j=-k}^{k} b'_j \Delta x_{t-j} + v_t \qquad (6.2)$$

where x_t is a vector of $I(1)$ variables cointegrated with the $I(1)$

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in November 1997, no remarkable shifts in behaviour are visible from the production data around that time.

variable $RMTLS_t$, the logged real metals price index. The estimated long-run relationship between the variables is defined by the vector β. Given evidence of a long-run equilibrium, a dynamic error correction equation (ECM) can be estimated using OLS, to model the short-term dynamics of metals prices:

$$\Delta RMTLS_t = \lambda(RMTLS_{t-1} - \beta' x_{t-1}) + \sum_{j=0}^{m} \delta_j Z_{t-j} + \mu_t \qquad (6.3)$$

where Z_t is a vector of $I(0)$ exogenous variables, and λ is the estimated speed at which metals prices adjust back to their long-run level following a shock that pushes them away from equilibrium.

Given the commonly found relationship between commodity prices and macroeconomic activity in developed countries, cointegration was first tested between real metals prices and various combinations of the following variables: OECD industrial production, the US real effective exchange rate, the real world interest rate, real oil prices, and real OECD investment in metals and mining industries.

Estimation results

The empirical analysis is conducted using a sample beginning from the earliest available data point in 1975Q3. Results from the cointegration tests reveal the strongest support for a long-run relationship between metals prices and OECD industrial production (*OECD_IP)*, with allowance for a deterministic trend. This cointegration, however, only exists for the sample up to 1997Q3.[27] The column (1) of Table 4a displays the results from this estimated cointegrated system. As shown by the ADF test statistic from the Engle-Granger test, the null hypothesis of no cointegration can be rejected at a 5% significance level for the sample up to 1997Q3.[28] It was also found that including emerging Asia variables (such as industrial production or trade share) in the long-run

[27] Tests were conducted beginning with the longest sample 1975Q3-2006Q4, with observations removed from the endpoint recursively until cointegration was found.

[28] This result was not altered significantly when the exchange rate, interest rate, oil price, or investment variables were included in the cointegrating equation.

TABLE 4a. REAL METALS PRICES: COINTEGRATION TEST RESULTS

Sample: 1975Q3-1997Q3	*(1)*	*(2)*
C	-20.198	-24.105
	(-7.40)	(-5.38)
Trend	-0.033	-0.083
	(-9.37)	(-3.90)
$OECD\_IP_t$	5.791	4.870
	(9.09)	(4.03)
$ASIA\_IP_t$		2.417
		(2.35)
No. Leads & Lags (*k*)	1	1
ADF *t*-stat:	-3.940	-3.547
(*p*-value)[a]	(0.044)	(0.218)

4b. Real Metals Prices: Estimated ECM (1975Q3-1997Q3)

	Z1
Long-Run Parameters	
C	-20.198[b]
	(-7.40)
Trend	-0.033[b]
	(-9.37)
$OECD\_IP_{t-1}$	5.791[b]
	(9.09)
Equilibrium Adjustment Parameter (λ)[d]	-0.202[c]
	(-3.91)
Dynamic Parameters	
C	-0.021[c]
	(-2.13)
$\Delta RMTLS_{t-1}$	0.194[c]
	(2.05)
$\Delta RMTLS_{t-3}$	0.220[b]
	(2.37)
$\Delta OECD\_IP_t$	4.307[b]
	(4.80)
Adj-R^2	0.319
Jarque-Bera	1.835

NOTES: *T*-statistics are given in parenthesis, unless otherwise stated.

[a] Denotes MacKinnon (1996) critical values used. [b] Denote significance at the 1%. [c] Denote significance at the 5%. [d] Denotes Ericsson and MacKinnon (2002) critical values used.

equation for the sample to 1997Q3 actually weakened the support for cointegration. This is demonstrated in column (2) of Table 4a, which shows results of the equation estimated over the same sample when emerging Asia industrial production (*ASIA_IP)* is included. Incorporating this variable lowers the ADF test statistic from the Engle-Granger test to a level that no longer supports the existence of cointegration, suggesting that emerging Asia did not influence long-run metals prices over this period.

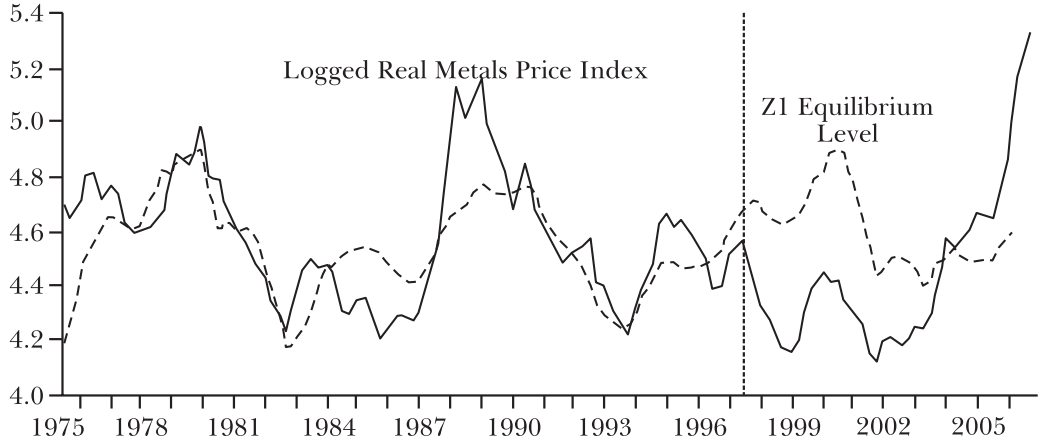
Table 4b displays the estimated cointegrated system with *OECD_IP* (labelled Z1) over the period 1975Q3-1997Q3, along with the dynamic parameter estimates from the ECM. The adjustment parameter is statistically significant at the 5% level, lending further support to the existence of an equilibrium relationship between metals prices and *OECD_IP*. The results suggest that a 1 percent increase in OECD industrial production leads to a long-term increase of 5.8 percent in real metals prices. The negative long-run coefficient on the time trend may be representative of improving supply conditions, as productivity gains in metals extraction and refining may have contributed to the downward trend in prices over this period. Variables found to significantly influence the short-run dynamics of metals price movements were growth in *OECD_IP* as well as the first and third lag of first-differenced metals prices. Estimation of the dynamic ECM equation was performed using OLS. Parameter estimates from a GMM estimation did not differ significantly, suggesting that endogeneity is not an issue.[29] Ljung-Box Q-statistics on the residuals also do not detect any serial correlation up to 8 lags out, and the Jarque-Bera statistic suggests they are normal with zero mean.

Interestingly, the long-run relationship found between metals prices and OECD industrial activity appears to break down once the sample is extended beyond 1997Q3. When the same long-run equation is estimated over the full sample 1975Q3-2006Q4, the ADF test statistic of -1.766 fails to find evidence of cointegration over this period.[30] Figure 22 compares the estimated long-run

[29] Four lags of each regressor were used as instruments for the estimation, with robust standard errors of the estimated parameters calculated using Newey-West correction with 8 lags.

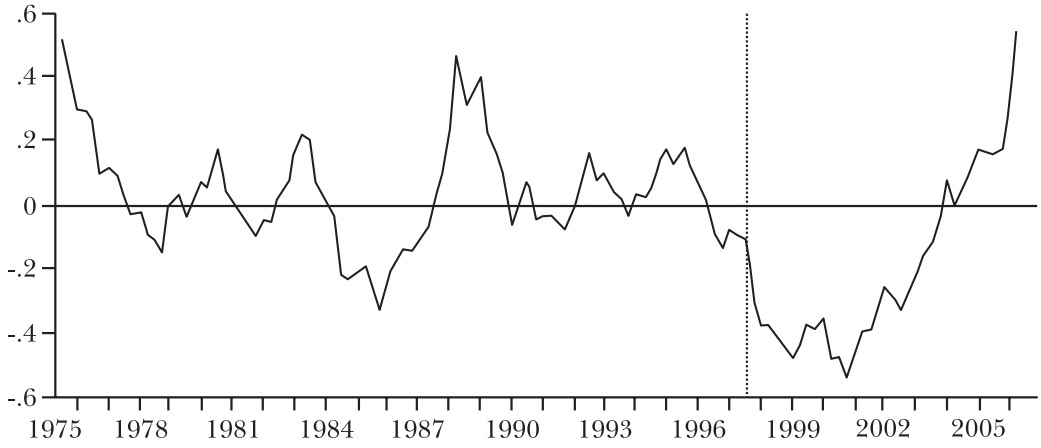
[30] Tests for cointegration with a structural shift were also conducted using the Gregory-Hansen (1996) methodology. Test results did not provide strong evidence of cointegration with a regime shift.

FIGURE 22. REAL METALS PRICE INDEX VS. ESTIMATED EQUILIBRIUM, 1975-2006



equilibrium from the cointegrated system in Z1 against actual metals prices, while Figure 23 plots the gap between metals prices and this equilibrium. Upon examination of the gap, it appears that the failure to find cointegration between the two variables beyond 1997Q3 stems from the fact that metals prices remained persistently below equilibrium levels suggested by OECD industrial production for several years after this point. Similar to our findings for oil prices, this may have been caused by the Asian currency crisis, which significantly reduced world demand for commodities around that time. Since 2003, however, metals prices have surged well above equilibrium levels defined by OECD activity.

FIGURE 23. ESTIMATED EQUILIBRIUM GAP (Z1), 1975-2006



Assessing the impact of emerging Asia

The previous results suggest that since the end of 1997, metals

prices have been driven primarily by factors other than industrial activity in the developed world. Determining whether this factor is emerging Asia poses a challenge, however, given the relatively recent period since the region's role would have likely become significant. This makes finding any long-term relationship between metals prices and emerging Asia particularly difficult within the "cointegration" framework. We thus conduct a series of experiments in order to assess whether the collapse of the long-run relationship between real metals prices and OECD industrial production is related to a greater influence from emerging Asia on world demand for metals. This exercise consists of testing whether including various emerging Asia variables into the long-run equation (6.2) over the extended sample can explain the discrepancy between metals prices and their equilibrium since the end of 1997. The emerging Asia variables tested are listed and described in the Data Appendix.

FIGURE 24. REAL METALS PRICE INDEX VS. ESTIMATED EQUILIBRIUM, 1982-2004

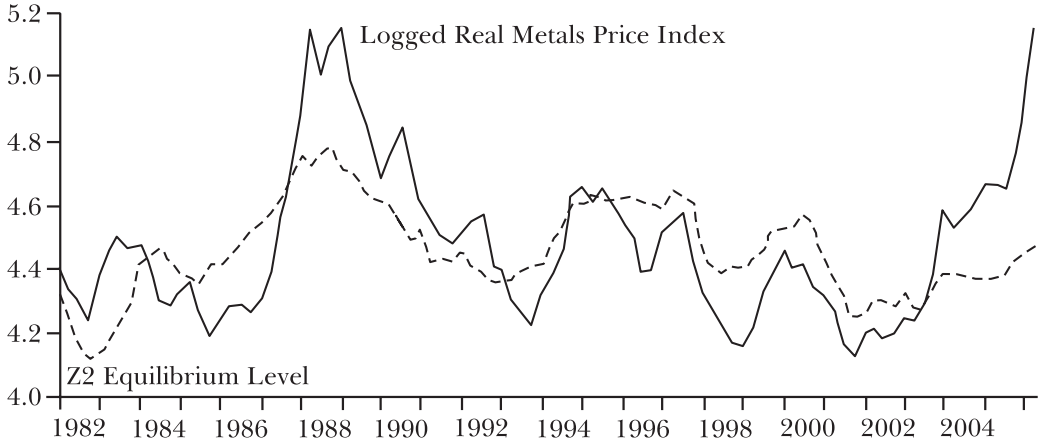
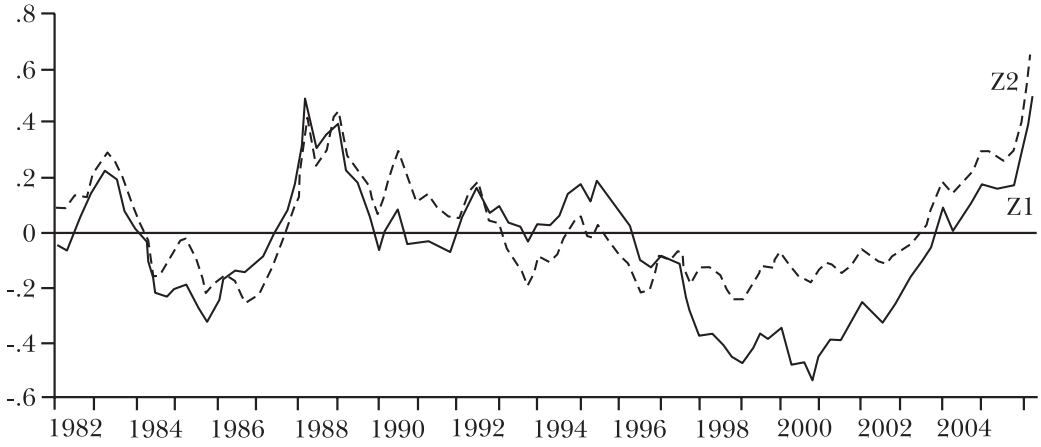


Figure 24 compares the estimated metals price equilibrium when the emerging Asia industrial production index is included into the long-run equation along with the OECD industrial production index, a specification labelled Z2. Figure 25 compares the disequilibrium gap from Z2 with that from the original Z1 equation. The full sample now becomes 1982Q1-2006Q2, based on the data available for emerging Asia. It can be seen that accounting for *ASIA_IP* considerably reduces the negative disequilibrium gap created by the original Z1 equation over the 1997 to 2003 interval. This could signify that weakness in emerging Asia was a

factor pulling metals prices below equilibrium levels suggested by OECD industrial activity over this period.

FIGURE 25. ESTIMATED EQUILIBRIUM GAPS, 1982-2004



It is useful to compare the fit of this alternative specification with the original one. The first column of Table 5 reports the results from GMM estimations of the dynamic ECM for Z1e, the original specification re-estimated over the sample 1982Q1-2006Q2.[31] The short-run dynamics of the equation are also modified to include $\Delta USREER_t$, $\Delta OECD\_IP_t$, and $\Delta ASIA\_IP_{t-1}$. Results from similar estimations of scenario Z2 are shown in the second column of Table 5.[32] As mentioned earlier, the long-run relationship between metals prices and *OECD_IP* no longer holds over this longer sample. Because the impact from emerging Asia has likely been too recent, including the *ASIA_IP* variable into the equation (Z2) still does not lead to cointegration.[33] As a result, the

[31] GMM estimates are reported in Table 5 because they yielded significantly different parameter estimates for $\Delta ASIA\_IP_{t-1}$ than those from OLS estimations, suggesting the existence of endogeneity issues.

[32] The results shown are from a two-stage estimation of the equations. In the first stage, the long-run equation was estimated using the dynamic OLS method of Saikkonen (1991). The long-run parameter estimates were then imposed in the GMM estimation of the dynamic equation. One-step estimations of the full system were also performed using nonlinear least squares, but these did not change the results significantly and are thus not reported.

[33] A weighted "world" industrial production index was also constructed using a GDP-weighted aggregate of OECD and emerging Asia industrial production series. This variable was also not found to be cointegrated with metals prices, and also generated a negative coefficient (while causing the coefficient on the time trend to switch signs).

TABLE 5. REAL METALS PRICES: ESTIMATED ECM WITH EMERGING ASIA (1982Q1-2006Q2)

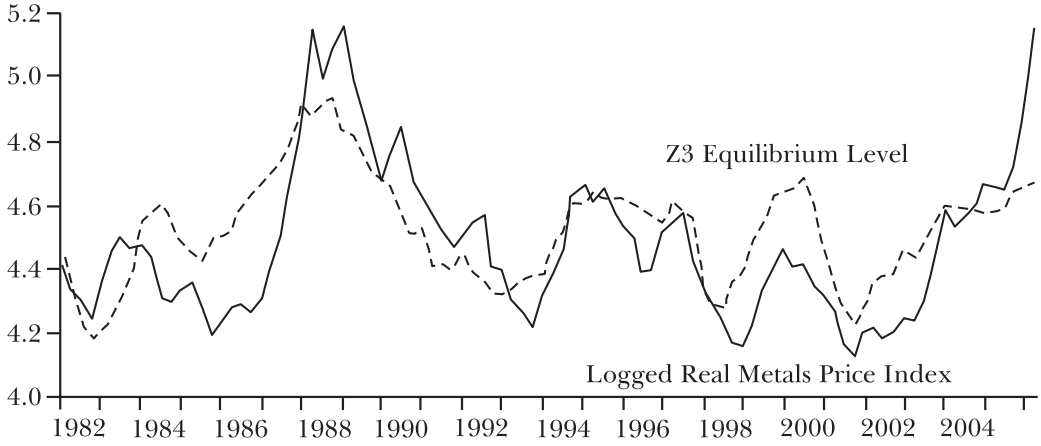
Variable	*Z1e*	*Z2*	*Z3*
Long-Run Parameters			
C	-8.26	-14.848	-19.263
	(-2.02)	(-3.41)	(-5.20)
Trend	-0.018	-0.090	-0.126
	(-3.17)	(-5.72)	(-7.11)
$OECD\_IP_{t-1}$	2.997	1.763	1.818
	(3.11)	(1.79)	(2.19)
$ASIA\_IP_{t-1}$		3.580	4.960
		(4.94)	(6.20)
$Dum^* INTENS_{t-1}$			1.369
			(4.40)
ADF *t*-stat:	-0.736	-1.458	-2.427
(*p*-value)[a]	(0.99)	(0.97)	(0.86)
Equilibrium Adjustment	-0.039	-0.057	-0.098
Parameter (λ)[b]	(-2.24)	(-2.26)	(-3.99)
Dynamic Parameters			
C	-0.061	-0.060	-0.058
	(-4.78)	(-4.90)	(-4.88)
$\Delta\, RMTLS_{t-1}$	0.224	0.232	0.247
	(3.16)	(3.17)	(2.99)
$\Delta\, OECD\_IP_t$	3.424	3.271	2.957
	(3.90)	(3.76)	(3.35)
$\Delta\, USREER_t$	-0.712	-0.629	-0.457
	(-1.91)	(-1.67)	(-1.07)
$\Delta\, ASIA\_IP_{t-1}$	2.056	1.964	1.709
	(3.82)	(3.72)	(3.42)
Adj-R^2	0.274	0.276	0.298
Jarque-Bera	0.063	0.048	0.319

NOTES: *T*-statistics are given in parenthesis, unless otherwise stated.
[a] Denotes MacKinnon (1996) critical values used. [b] Denotes Ericsson and MacKinnon (2002) critical values used.

long-run parameter estimates shown in Table 5 cannot be interpreted as an equilibrium relationship. Nonetheless, it is interesting to note that incorporating *ASIA_IP* over this sample now increases (in absolute terms) the ADF test statistic from the cointegration test relative to Z1– this contrasts with the findings from the shorter sample ending in 1997Q3, shown in Table 4a. Interestingly,

if we sum the long-run coefficients from the Z2 estimation, the total implied effects of the *OECD_IP* and *ASIA_IP* variables on metals prices roughly equals the estimated long-run impact from OECD industrial production in the shorter sample up to 1997Q3 (Z1). As discussed in section 6.1, this may reflect the shift in metals demand from the developed world to emerging Asia as multinational firms have outsourced manufacturing activity there. The relatively larger coefficient on *ASIA_IP* also supports the notion that industrial activity in emerging Asia has been more important in driving world metals demand since 1997.

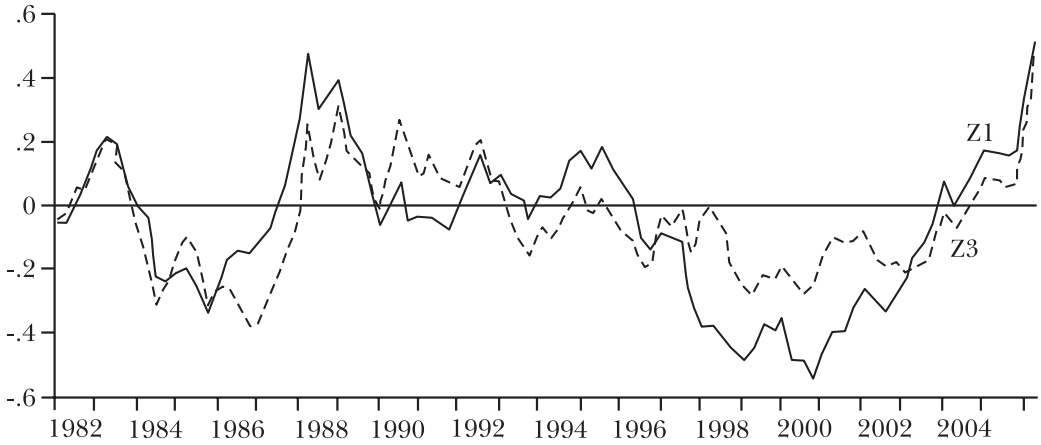
FIGURE 26. REAL METALS PRICE INDEX VS. ESTIMATED EQUILIBRIUM, 1982-2004



While industrial activity in emerging Asia may have contributed to the metals price weakness relative to equilibrium in the period after 1997, Figure 25 illustrates that it does not explain well the relative strength observed in metals prices since the end of 2003. A possible reason for this is that the *ASIA_IP* variable does not capture well the rising metals intensities in Asian manufacturing sectors, as discussed in Section 5.1. To account for this possibility, we further add the metals intensity index (*INTENS)* in the equation along with *ASIA_IP*. Since metals intensity data was only available from 1995 onwards, the index was interacted with a dummy variable (*Dum)* which assumes a value of zero up to 1997Q3, and a value of one afterwards. This specification is labelled Z3. Figure 27 compares the disequilibrium gap from this scenario with that from equation Z1. We can see that accounting for rising metals intensities in emerging Asia appears to explain the strength in metals prices quite well up to the end of 2005.

Where the specifications falls short, however, is over the last two quarters of the sample, 2006Q1-2006Q2. Over this period, metals prices surged despite that emerging Asia's metals intensities appear to have declined (see Fig. 21). While the reason for this decline is not clear, it is possible that the intensity data for 2006 is less reliable, given that metals consumption data tends to undergo frequent revisions. It is also possible that increased speculative investment activity has been a larger influence on metals price behaviour in 2006.

FIGURE 27. ESTIMATED EQUILIBRIUM GAPS, 1982-2004



Despite that the need for a dummy variable makes it inappropriate to evaluate the equation Z3 within a cointegration framework, it is useful to consider the estimation results in column 3 of Table 5. The positive and significant coefficient on *INTENS* suggests that the increase in metals prices above levels that would be predicted by both OECD and Asian industrial activity since 2003 may be explained by rising metals intensities in emerging Asia This is further supported by the observation that the adjustment parameter is larger and more significant when both *ASIA_IP* and *INTENS* are incorporated into the defined "equilibrium", relative to when it is characterized only by OECD activity in Z1e.

7. CONCLUDING REMARKS

The purpose of this paper was to assess the impact of emerging Asia on the real prices of oil and base metals in the Bank of Canada Commodity Price Index (BCPI). Although we find strong

evidence that oil and metals prices have historically moved with the business cycle in developed economies, this relationship has broken down since mid-1997. Thereafter, results suggest that industrial activity in emerging Asia has become a more dominant driver of oil price movements. This may be related to the increased outsourcing of production to Asia from the developed economies, which would generate higher levels of energy demand as relatively energy-inefficient Asian firms take on greater shares of world manufacturing activity. For metals, price fluctuations also appear to have become increasingly aligned with emerging Asia's industrial activity since mid-1997. Unlike the case for oil, incorporating Asian industrial production is not sufficient to explain the surge in metals prices since 2002, and it appears that rising metals intensities in the region have provided the additional boost to prices over recent years. Because these influences began so recently, it remains too soon to obtain precise estimates of their long-run impact. The fact that an increasing share of world manufacturing activity has relocated to emerging Asia in recent years suggests that the estimated parameter on emerging Asia industrial production may reflect not only the incremental commodities demand from the region, but also the demand that has simply relocated from the industrialized world. There may also be some upward bias on this parameter estimate coming other excluded factors that may have been at play, such as supply shortfalls, speculative investment demand, increasing globalization, or geopolitical unrest (in the case of oil).

Rising intensities *within* emerging Asia may also play a larger role going forward, as expanding urban infrastructure and shifts in Chinese manufacturing from labour-intensive goods towards capital-intensive goods are expected to push metals and energy intensities higher going forward. Resource-intensive consumption may also become more important in the future, as rising incomes generate greater motor vehicle ownership and consumption of household durables. Our analysis suggests that emerging Asia's impact on commodity prices will likely persist for many years as rising urbanization rates continue to push up resource intensities.

Appendix

Data sources and definitions

Commodity prices: Real oil price used is the West Texas Intermediate crude oil price deflated by the US GDP deflator. Real metals price used is the base metals price index from the Bank of Canada Commodity Price Index (BCPI), deflated by the US producer price index for finished goods. The BCPI has a base of 1982-90 =100 and is expressed in US dollars.

Commodities Consumption (Volumes): Oil and energy consumption data are from the *BP Statistical Review 2006*. Consumption data for the metals (zinc, aluminum, nickel and copper) are from the *World Bureau of Metal Statistics* and *UN Commodity Yearbook 2003*, at an annual frequency. Metals per capita consumption data is constructed with *World Bank Development Indicators* annual population data.

Output measures:

OECD Industrial Production Index: Quarterly, from *OECD Main Economic Indicators* database.

World output gap: Quarterly production-weighted average of the gaps of US, Canada, Mexico, UK, Europe, and Asia, constructed by the Bank of Canada.

OECD output gap:. Quarterly, from the *OECD Economic Outlook* database, in which potential output is estimated from a production function approach.

US effective exchange rate: Foreign exchange value of the US dollar, US Federal Reserve Board of Governors broad index, 1973=100.

Real world interest rate: a trade-weighted average of interest rates of Japan, UK, the Euro zone, and US, deflated by trade-weighted GDP deflator.

Supply side variables:

Oil Production Capacity: constructed by summing data on world oil production with data on world spare production capacity. World oil production data is quarterly from the US

Department of Energy's *Energy Information Administration*, while spare capacity data is annual from the *IMF World Economic Outlook* (August 2006), with quarterly values interpolated.

Real OECD Investment in Metals and Mining industries: Annual data to 2003 from the *OECD STAN* database, with quarterly values interpolated.

Emerging Asia variables:

Country coverage: Emerging Asia includes the following ten countries: China, India, Hong Kong, Singapore, South Korea, Taiwan, Indonesia, Malaysia, Philippines and Thailand.

Emerging Asia Industrial Production Index: constructed from the 10 individual country indexes of industrial production in the manufacturing sector where available, and total industrial production otherwise. Individual country quarterly indexes are first seasonally adjusted using the X11 method and then aggregated using GDP weights, 1990=100. China's industrial production index is constructed from National Accounts data from the Chinese Statistical Yearbook on real production in the secondary industry. Prior to 1992, this series is only available at an annual frequency, with quarterly values interpolated. Taiwan's industrial production index is constructed from National Accounts data on GDP for the manufacturing sector. For the remaining Asian countries, quarterly industrial production indexes are obtained from the *OECD Main Economic Indicators* database for Indonesia, *IMF International Financial Statistics* (*IFS)* for Malaysia, Philippines, Singapore, Hong Kong, Korea, and India, and the *Bank of International Settlements* for Thailand.

Metals intensity index: The emerging Asia metals intensity index is constructed by first summing the units consumed of a given metal across the 10 countries and dividing by the sum of the region's real GDP to obtain an emerging Asia intensity measure for each metal. Intensity idexes are constructed for each metal with base year 1995. Each of the four intensity indexes are then weighted according to their weight in the BCPI to form the overall metals intensity index. The series begins in 1995, based on availability of consumption data for

the full set of metals across all 10 countries. Since all data are annual, a quarterly index is then constructed through interpolation.

China's urbanization rate: annual from the *World Bank Development Indicators*, with quarterly values interpolated. Defined as the percentage of the population living in cities.

China's investment share: Annual data on nominal investment from the *IMF IFS,* with quarterly values interpolated.

Chinese exports of manufactured goods to the US and *Chinese exports of machinery and equipment to the US:* monthly data from 1997-2006 from *Datastream*. Prior to 1997, levels are constructed assuming the same growth rate as Chinese total exports of manufactured goods (an annual series from *Datastream*, with quarterly values interpolated).

Emerging Asia trade share: An aggregate of 10 countries' total trade (exports and imports) as a ratio to total world trade. Quarterly nominal export and import data is obtained from the *IMF IFS*, deflated using different price indexes and seasonally adjusted using X11 methodology. For Singapore, Hong Kong and South Korea, the country's export and import price indexes from the *IFS* are used as deflators, and Taiwan trade data is deflated using an average of these countries' deflators. For the remaining emerging Asia countries, exports and imports are deflated using the Asia export and import prices from the *IFS*.

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"Rodrigo Gómez" Central Bank Award: 2008 call for papers

In order to honour the memory of Don Rodrigo Gómez (1897-1970), Director General of Banco de Mexico (1952-1970), the governors of the Latin American central banks established an annual prize to stimulate the production of papers, studies or analyses of interest to central banks.

The following are the rules governing the call for papers for the prize to be awarded in 2008:

1. The author(s) of the papers submitted to the contest must be nationals of the countries of the central banks in the region.[1] No staff member from the Centro de Estudios Monetarios Latinoamericanos (CEMLA) may participate.

2. The topics of the papers must bear upon the functions and aspects of direct interest to regional central banks. Among other topics, papers on monetary policy, macroeconomic stability, financial stability, central bank operations, financial cooperation between Latin American and Caribbean countries or the repercussions of international financial events on the region may be submitted.

3. The papers that are submitted must be original and unedited, and must be final versions. In other words, they must not have been published in print or electronically, either

[1] Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Eastern Caribbean (Anguilla, Antigua and Barbuda, Dominica, Grenada, Montserrat, St. Kitts and Nevis, Saint Lucia, and St. Vincent and the Grenadines), Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay y Venezuela.

individually or in a journal, book or compilation. Papers that have been circulated in printed or electronic form (on restricted access websites) for expert consultation during their preparatory stages, may be submitted to the Award. University degree theses and papers submitted to the annual meetings of the Central Bank Researchers´ Network of the American Continent may also be submitted to the Award, so long as they comply with the above requirements.

4. The papers may be submitted in Spanish, French, English or Portuguese, accompanied if possible by an English or Spanish translation, in order to facilitate the work of the panel of judges. The papers may not exceed 20 000 words or 50 pages (whichever comes first), including the cover, abstract, introduction, development, conclusions and appendices or annexes.

5. No papers that have participated in previous editions of the Rodrigo Gomez Award may be submitted. Likewise, submitted papers may not compete for other awards or be under consideration by other publications such as specialized journals, books or compilations.

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