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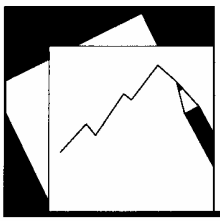

IMF Working Paper

# GDP Growth, Potential Output, and Output Gaps in Mexico

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# GDP Growth, Potential Output, and Output Gaps in Mexico

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## Abstract



This paper analyzes the sources of Mexico's economic growth since the 1960s and compares various decompositions of historical growth into its trend and cyclical components. The role of the implied output gaps in the inflationary process is then assessed. Looking ahead, the paper presents medium-term paths for GDP based on alternative assumptions for productivity growth rates. The results indicate that the most important factor underlying the slowdown in output growth was a decline in trend total factor productivity growth. Economic policy reforms and the introduction of NAFTA may have raised trend productivity growth in recent years. Further increases in productivity growth would appear necessary, however, to raise medium-term growth.

JEL Classification Numbers: E25, E31, E32, E37

Keywords: GDP growth, potential output, output gap, inflation, Mexico

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## I. INTRODUCTION

Mexico has experienced sharply different growth episodes since 1960. GDP increased at an average annual rate of 6½ percent during 1960–79, but growth fell to 2½ percent a year during 1980–2003. More recently, annual GDP growth averaged more than 5 percent from 1996 to 2000, but dropped to less than 1 percent during 2001–03 (growth recovered to 4.4 percent in 2004, outside the period covered by the paper). The shifts in growth performance raise questions about the factors underlying historical GDP growth in Mexico and the implications looking ahead.

This paper reviews Mexico's historical economic growth through 2003, constructs potential output and the implied output gaps, estimates a wage-price model of inflation, and then discusses Mexico's medium-term growth prospects. More specifically, the paper:

- Reviews trends in GDP growth and compares them with the experience of other Latin American, NAFTA, and Asian countries. An aggregate production function is then used to analyze the sources of past growth (using annual data for 1960–2003) and estimate total factor productivity growth in different periods.

- Decomposes growth into its cyclical and trend components using an unobserved components model and quarterly data from 1980:1–2003:4. Estimates of potential output and the implied output gaps are generated.

- Tests the plausibility of the derived estimates of the output gaps in a reduced-form markup model of inflation and then uses the preferred measure to reestimate the staff's model of wage-price dynamics.

- Analyzes Mexico's medium-term growth prospects in terms of the TFP growth and the investment rates that would be needed to generate alternative growth projections.

The analysis shows that swings in growth are mostly accounted for by changes in the contribution of total factor productivity (TFP), as opposed to factor inputs. Various techniques, including univariate and structural methods are used to decompose output into its trend and cyclical components. All measures indicate that underlying TFP growth turned negative after 1980. Some pick-up starting in the mid-1990s can be attributed to NAFTA and other structural reforms. The preferred measure of the output gap has a significant effect on inflation in both the reduced form and the structural models. Looking ahead, three scenarios are considered based on different TFP assumptions. Assuming some fading of the effects of NAFTA and structural reforms, but still positive TFP growth, real GDP would grow at slightly over 3 percent a year over the medium term. If, in contrast, TFP reverted to the post-1980s experience, annual growth would fall to just over 2 percent, while an acceleration in TFP growth (spurred, for example, by recent financial reforms) could allow GDP to grow by about 4½ percent a year.

## II. TRENDS IN GDP GROWTH

### A. Stylized facts

Between 1960 and 1980, the Mexican economy grew at an average annual rate of over 6½ percent, resulting in significant improvements in GDP per capita and living standards. Although economic policies during this period reflected an inward-looking bias and were dominated by a strategy of import substitution, the pursuit of generally sound fiscal policies through the early 1970s, and an absence of significant external shocks, allowed the economy to grow strongly. Economic growth began to slow in the mid-1970s due to the first oil price shock and a slowdown in overall productivity growth, but recovered later in the decade as public expenditure on infrastructure in the energy sector boosted aggregate demand.[2] By 1980, various macroeconomic imbalances that had been building since the mid-1970s led to an external debt crisis and sharp declines in GDP growth. Real GDP grew by less than 1 percent in 1980–87, while GDP per capita declined sharply and total factor productivity growth turned negative.

Mexico recovered from the debt crisis and implemented extensive economic and structural reforms in the latter part of the 1980s. These included reforms to the tax system, liberalization of the trade regime, privatization of public entities, and establishment of full convertibility of the peso. Nevertheless, Mexico did not resume the growth performance of earlier decades. Growth averaged 3¾ percent during 1990–94, but output declined by 6½ percent in 1995, when Mexico was hit with another financial crisis. While the economy was more resilient and bounced back quickly, growth averaged only 3½ percent during 1996–2003, well below the 6½ percent rate reached during the 1960–80 period. Figure 1 illustrates the trend in GDP and GDP per capita, showing the sharp break in GDP growth since 1980.

Table 1 shows a breakdown of GDP by expenditure category. Consistent with the authorities' inward-looking bias during the 1960s and 1970s, investment and public expenditure grew strongly, together increasing from 16.1 percent of GDP in 1950 to 37.2 percent of GDP in 1980. This switch in resource allocation was facilitated by a significant drop in private consumption, which fell by 17 percent of GDP over the same period. Foreign financing also played an important role, as the external current account moved from a surplus to deficit, notwithstanding rising oil revenues. Shares of exports and imports were lower in 1980 than in 1950. Following the 1982 debt crisis, capital inflows dropped significantly and other components of aggregate demand had to be cut to provide room for debt service.

The growth slowdown post-1980 was broadly based. Figure 2 presents average growth rates of primary, industry, and service output in Mexico. A common aspect of the post-1980 data is the striking decline in growth rates across all sectors. The declines in growth in the industrial and service sectors are particularly noteworthy.

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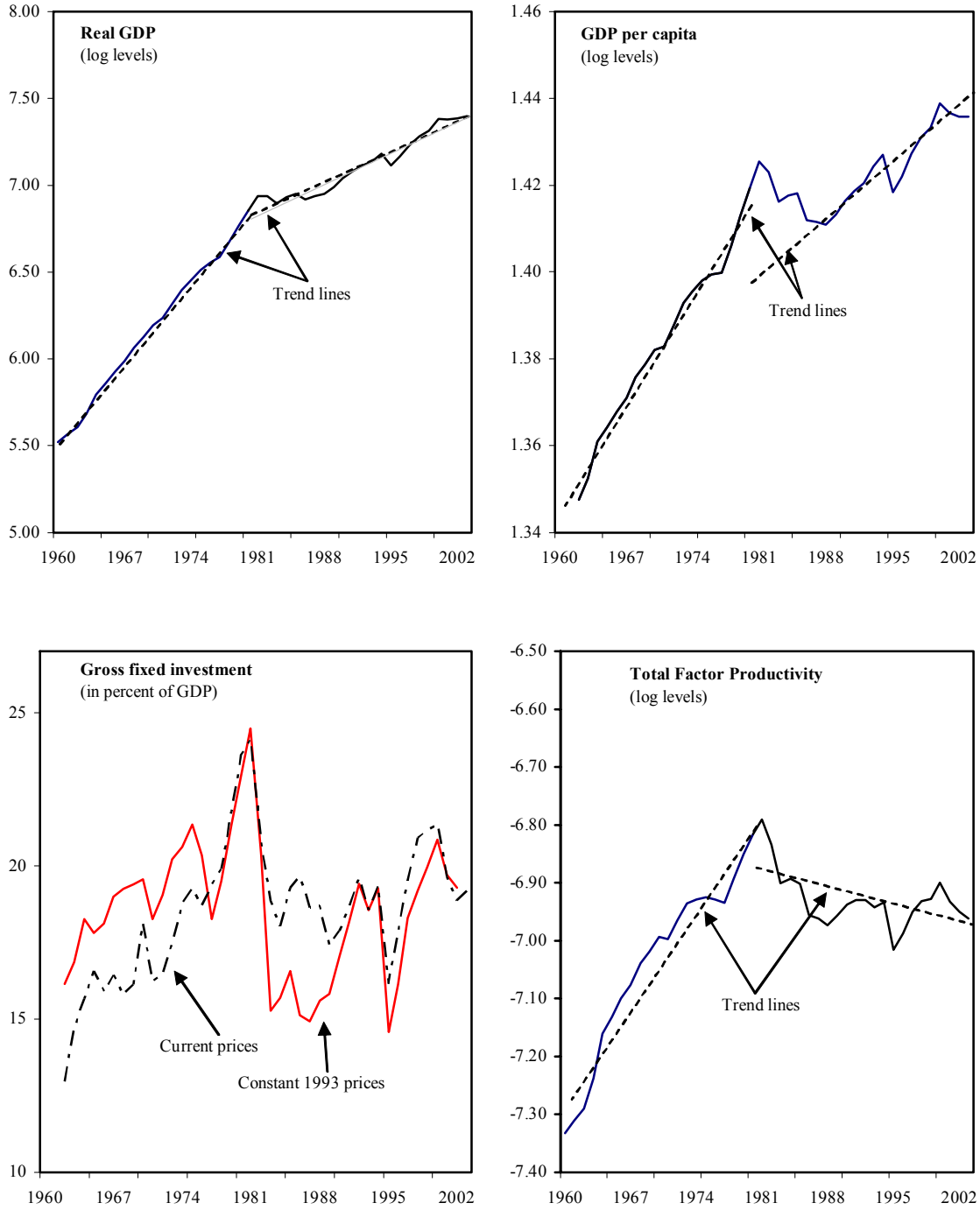
[2] Mexico was a net importer of oil up until the mid-1970s, when large discoveries turned the country into a significant exporter of oil and other petroleum products.

Figure 1. Mexico: GDP, Investment, and Total Factor Productivity, 1960-2003




Sources: INEGI, and IMF staff estimates.

Table 1. Mexico: Shares of Main Expenditure Categories in GDP, Selected Years, 1950-2003

| Period | Private consumption | Public consumption | Gross capital formation | Exports of goods and nonfactor services | Imports of goods and nonfactor services |
|---|---|---|---|---|---|
| 1950 | 81.8 | 4.4 | 11.7 | 17.0 | 14.8 |
| 1960 | 79.5 | 5.1 | 14.9 | 10.6 | 12.0 |
| 1970 | 71.9 | 7.2 | 20.0 | 7.8 | 9.7 |
| 1980 | 65.1 | 10.0 | 27.2 | 10.7 | 13.0 |
| 1990 | 74.0 | 8.9 | 19.0 | 19.8 | 21.0 |
| 1995 | 66.9 | 10.4 | 16.1 | 30.4 | 27.7 |
| 2000 | 67.1 | 11.1 | 21.4 | 31.0 | 33.0 |
| 2001 | 69.6 | 11.8 | 19.6 | 27.4 | 29.7 |
| 2002 | 69.0 | 12.1 | 19.3 | 26.8 | 28.7 |
| 2003 | 69.2 | 12.7 | 19.3 | 28.4 | 30.1 |

Sources: INEGI, IFS, and staff estimates.

## B. International Comparison

Table 2 presents purchasing power-parity based estimates of growth in GDP per capita for Mexico and selected Latin American and Asian countries. Within the region, Mexico's per capita growth rate of about 3½ percent a year during 1960–79 lagged only Brazil, which grew at a rate of around 5 percent a year. All countries, except Chile, experienced a decline in their growth rates in the 1980–2003 period, with Brazil's being the most dramatic, followed by Mexico. The Asian countries and Chile stand out for their ability to sustain high growth rates, and in the case of Chile an increase in growth since 1980.

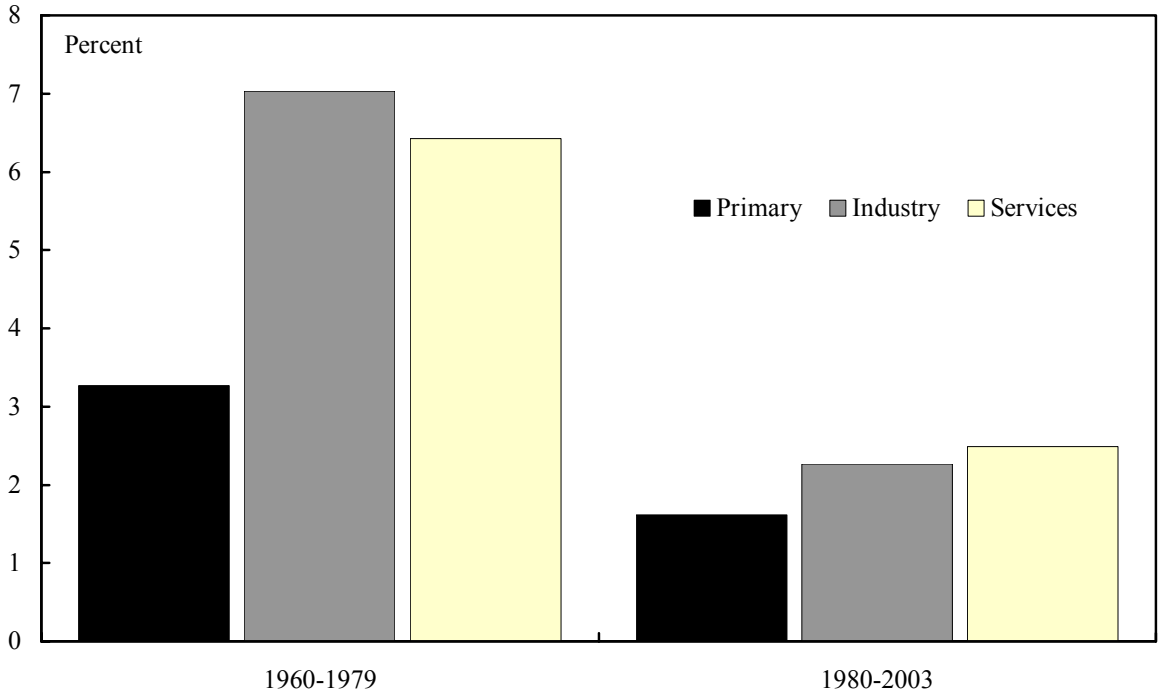
Table 2. Average GDP Per Capita Growth Rates for Selected Countries

(PPP-corrected, in percent)

| | 1960-79 | 1980-2003 | 1995-2003 |
|---|---|---|---|
| **Mexico** | 3.4 | 0.9 | 2.4 |
| **Latin America** | | | |
| Argentina | 2.1 | 0.2 | -0.3 |
| Brazil | 4.9 | 1.0 | 1.4 |
| Chile | 2.1 | 3.2 | 3.7 |
| **NAFTA** | | | |
| United States | 2.9 | 2.1 | 2.7 |
| Canada | 3.1 | 1.8 | 2.8 |
| **Asia** | | | |
| Korea, Rep. of | 6.0 | 5.6 | 4.3 |
| Singapore | 9.0 | 4.2 | 3.0 |
| Thailand | 5.0 | 4.7 | 2.7 |

Sources: Heston, A., Summers, R., and, Aten, R., *Penn World Table Version 6.1* (2002), and WEO.

Figure 2. Mexico: Sectoral Output Growth




Sources: INEGI, and IMF staff estimates.

## III. Growth Accounting and Total Factor Productivity

Total factor productivity provides a measure of the efficiency of a given bundle of factor inputs in generating output. Output is produced by a bundle of capital and labor, and total factor productivity (TFP). Output (*Y*) is measured as deflated value added, while inputs are aggregated into the two primary inputs labor (*L*) and capital services (*K)*. The Solow (1956) growth accounting equation can then be stated as:

$$\frac{d\ln Y}{dt} = s_L \frac{d\ln L}{dt} + s_K \frac{d\ln K}{dt} + \frac{d\ln A}{dt} \qquad \textbf{(1)}$$

Labor and capital contribute to value-added growth with contributions measured as the rate of change of each input times its share in total costs. The change in value added not explained by these contributions is attributed to multi-factor productivity growth, captured by the variable *A*. In practice, the rate of change of *A* is measured as a residual, by subtracting the contributions of labor and capital from the rate of output growth.

An alternative way of presenting the growth accounting equation is in terms of a decomposition of the rate of change of labor productivity (*LP)*, measured as the difference between output growth and labor input growth, such that:

$$\frac{d\ln(LP)}{dt} = \frac{d\ln Y}{dt} - \frac{d\ln L}{dt} \tag{2}$$

Equations (1) and (2) can be rearranged to decompose the change in labor productivity into two parts. The first depicts the change in labor productivity due to capital deepening (labor productivity rises when more capital is used per worker) and the second represents the effect of TFP growth:

$$\frac{d\ln(LP)}{dt} = (1 - s_L)\left\{\frac{d\ln K}{dt} - \frac{d\ln L}{dt}\right\} + \frac{d\ln A}{dt} \tag{3}$$

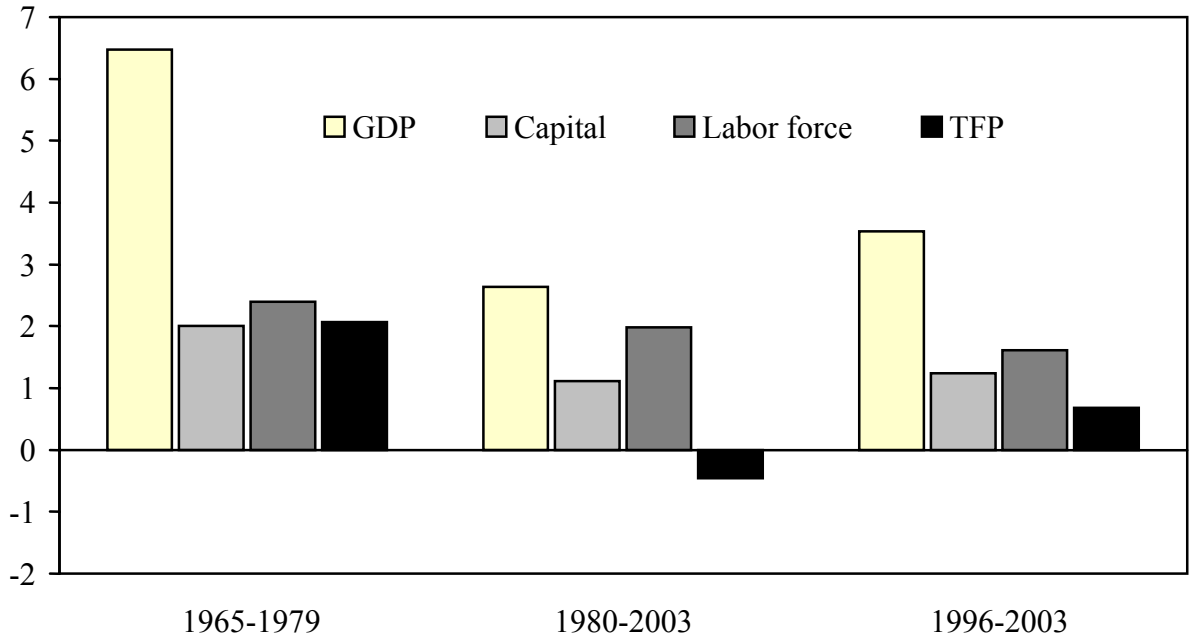
The growth accounting exercise was performed over the 1960–2003 period, assuming a Cobb-Douglas production function with output elasticities of capital and labor of 0.33 and 0.67 respectively.[3] Capital is derived from national accounts data on gross fixed investment using the perpetual inventory method, with an assumed depreciation rate of 10 percent. The labor input is defined as the economically active population aged 15 and over, while TFP is derived as a residual.[4] Due to data limitations, our analysis did not attempt to control for fluctuations in capacity utilization nor in the quality of human capital. Figure 3 describes the evolution of TFP growth in Mexico, and Table 3 shows the resulting estimates of the contributions of the three factor inputs—capital, labor, and TFP—from 1960 to 2003.

The data indicate that TFP accounts for most of the decline in output growth since 1980. From 1960 to 1979, real GDP grew at an average rate of 6.5 percent, while TFP rose by 2.1 percent. From 1980 to 2003, however, real GDP growth slowed to 2.6 percent. About two-thirds of this decline of 3.9 percentage points is explained by lower TFP growth—indeed, the *level* of TFP declined at an average rate of 0.5 percent over this period. The sharp decline in TFP in the 1980s (the so called "lost decade") is not surprising when one considers the impact of the debt crisis on financial activity and investment. What is surprising is that, while the performance during the more recent 1996–2003 subperiod is more favorable, the outturn seems

[3] The assumption of fixed weights of 0.67 for labor and 0.33 for capital is consistent with those of other researchers. See; for example Bosworth (1998), Santaella (1998), World Bank (1998), Loayza, Fajnzylber, and Calderon (2002), Bergoeing et al. (2002), and Blazquez and Santiso (2004). United Nations (1986) estimated the factor share for labor to be 0.42. This does not include, however, compensation of the self-employed.

[4] The national accounts include an estimate of output of the informal sector, but the official "formal sector" employment measure excludes the self-employed, family workers, and jobs in the informal sector. We use the more comprehensive measure—the economically active labor force—in our analysis to try to capture the contribution of workers in the latter categories.

Figure 3. Growth Accounting, 1960-2003
(Contribution to GDP growth in percent)




Sources: INEGI, and staff estimates.

Table 3. Mexico: Sources of Growth, 1960-2003

| | 1965-79 | 1980-2003 | 1996-2003 |
|---|---|---|---|
| **Real GDP growth** | **6.5** | **2.6** | **3.5** |
| Factor growth rates (in percent) | | | |
| Capital | 6.1 | 3.4 | 3.8 |
| Labor | 3.6 | 3.0 | 2.4 |
| TFP | 2.1 | -0.5 | 0.7 |
| Factor contributions (in percentage points) | | | |
| Capital | 2.0 | 1.1 | 1.2 |
| Labor | 2.4 | 2.0 | 1.6 |
| TFP | 2.1 | -0.5 | 0.7 |
| **Memorandum items:** | | | |
| Potential output growth | 6.4 | 2.7 | 3.5 |
| Trend TFP growth | 2.0 | -0.4 | 0.6 |

Sources: INEGI, and staff estimates.

modest relative to the structural changes that were implemented, including significant trade and financial liberalization.[5]

These findings are qualitatively similar with the findings of other studies on Mexico. Elias (1992), Santaella (1998), Bosworth (1998), World Bank (2000), and Bergoeing et al. (2002) also found that TFP growth, in general, consistently declined between 1980 and the mid-1990s. Santaella (1998) estimates TFP growth of about 2 percent during1950–79, and -0.6 percent during 1980–94. Similarly, both Bosworth and the World Bank found that TFP growth declined at an average annual rate of 0.8 percent in 1981–94.

## IV. Explaining Mexico's Output and Productivity Decline

The growth accounting exercise raises some important questions. First, while the magnitude of the 1982 debt crisis may explain the initial collapse of output and TFP growth, it is less clear why these have not recovered to pre-1982 levels after 2½ decades.[6] Second, why have output and TFP growth remained modest since the 1990s, even after implementing an extensive structural reforms beginning in the late 1980s? Of course, explaining why Mexico's productivity and real GDP growth was modest relative to pre-1980 even after significant trade, financial sector, and public sector reforms is complicated. Nevertheless, it is useful to consider some of the factors that may have contributed to the weak performance of output and TFP[7] Nevertheless, it is useful to consider some of the factors that may have contributed to the weak performance of output and TFP.

### A. Role of Structural Reforms

Mexico has implemented a wide range of structural reforms since the late 1980s. Public sector reforms were implemented to open markets to private initiative, capital, and technology. The deregulation process included elimination of regulations that inhibit competition, create monopolies or oligopolies, prevent private-sector participation and/or generate unnecessary transaction costs. In terms of trade reform, Mexico opened up its economy and eliminated most quantitative restrictions on foreign trade. The process was complemented by membership in GATT/WTO, NAFTA, as well as other bilateral and multilateral agreements. As a result, average tariff rates on NAFTA imports have been reduced from 12 percent in 1993 to under

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[5] The analysis in this paper did not exclude the sharp contraction in real GDP in 1995 since the subsequent recovery in 1996 equally large, suggesting no permanent output loss, and partly because the financial crisis was endogenous. Abstracting from the effects of the crisis on output in 1995 would, however, cause a higher level deterioration in TFP growth during 1983–88, reflecting the debt crisis, and a smaller but still negative level of TFP for the period 1989–94.

[6] Chile offers an interesting contrast in this respect. For a detailed comparison see Bergeonig et al. (2002).

[7] For a recent discussion of possible factors see Ortiz (2004), World Bank (2000), Lora (1997), and Loayza and Palacios (1997).

2 percent in 2001, while rates of effective protection have also declined and are projected to continue to decline with further integration with the North American and regional markets. Trade as a percent of GDP increased sharply from about 27 percent of GDP in 1980 to about 65 percent in 2003.

It appears, however, that the pace of reform and liberalization, other than in the financial sector, slowed in the latter half of the 1990s. It proved difficult to maintain the pace of reforms as they moved into politically sensitive areas—including tax policy, energy, labor markets, and the judicial system. Studies by Lora (1997), Loayza and Palacios (1997), Loayza, Fajnzylber, and Calderón (2002) have analyzed the issues relating to structural reforms and growth in Latin America. Their analyses indicate Mexico is lagging in a number of reform areas, both by regional standards and relative to other emerging economies in Asia. The regional comparison is reflected in the aggregate index of structural reforms constructed by Lora (1997) (Figure 4). Other observers (see, for example, Ortiz (2004)) have also alluded to the role that incomplete reforms have played in the growth slowdown.

Of course, the weak performance of TFP since 1980 reflected both supply and demand factors, as the government was mostly constrained by the ongoing nature of the debt crisis, which cut off Mexico's access to capital markets (Bosworth (1998)). The financial crisis in 1994–95 again caused a sharp contraction in aggregate demand. But the demand-side effects of these episodes of financial turmoil would be expected to fade in recent years. In this context, Chile provides an interesting contrast to Mexico. Chile suffered an output decline even larger than Mexico in the early 1980s, with GDP per worker falling by 18 percent between 1981–83, compared with 12 percent in Mexico (World Bank (1998)). Bergoeing et al. (2002) have argued that Chile recovered faster from the collapse than Mexico, and was able to subsequently maintain high growth rates. One argument for the different recovery of growth in the two countries may have been the timing of economic reforms, which were largely completed before the crisis in Chile, but were pursued later in Mexico (Bergoeing et al. (2002)).

Other reasons have been advanced for why the structural reform process has not provided a more robust boost to the supply-side performance of the economy:

- **Incomplete reforms.** Several observers have argued that, while the earlier reforms of the 1980s and 1990s led to a recovery in investment and growth, the reform process remains largely incomplete (see Ortiz (2004)). In general, Mexico's reform process was more advanced in liberalizing external trade, but slower in terms of domestic deregulation and the promotion of labor market flexibility, in particular, in the electricity and petroleum sectors.

- **Financial sector repression.** Even though the financial system was progressively liberalized after 1988, it was slow to recover from previous "repression." The banking system, where domestic banks were protected from foreign competition, had limited experience in identifying and financing profitable investments and devoted most loanable funds to unproductive consumer and real estate loans. Furthermore,

development of alternative financial instruments stagnated due to legal restrictions, and did not become an important source of investment finance.

- **Labor market distortions.** Loayza and Palacios (1997) characterized the Mexican labor market as one of the most distorted in Latin America and the Caribbean. In their view, the legal framework creates significant distortions as it protects workers, while making it costly for firms to introduce technological change; it also inhibits the mobility of resources from one sector to another. The visible and rapid expansion of informal sector activity since 1980 suggests that increases in nonwage labor costs, including severance costs, depressed the demand for labor in the formal sector and encouraged a shift to informal labor arrangements.[8] Since the informal sector is often characterized by lower wages and productivity, the expansion of the informal sector acts as a drag on overall productivity growth.

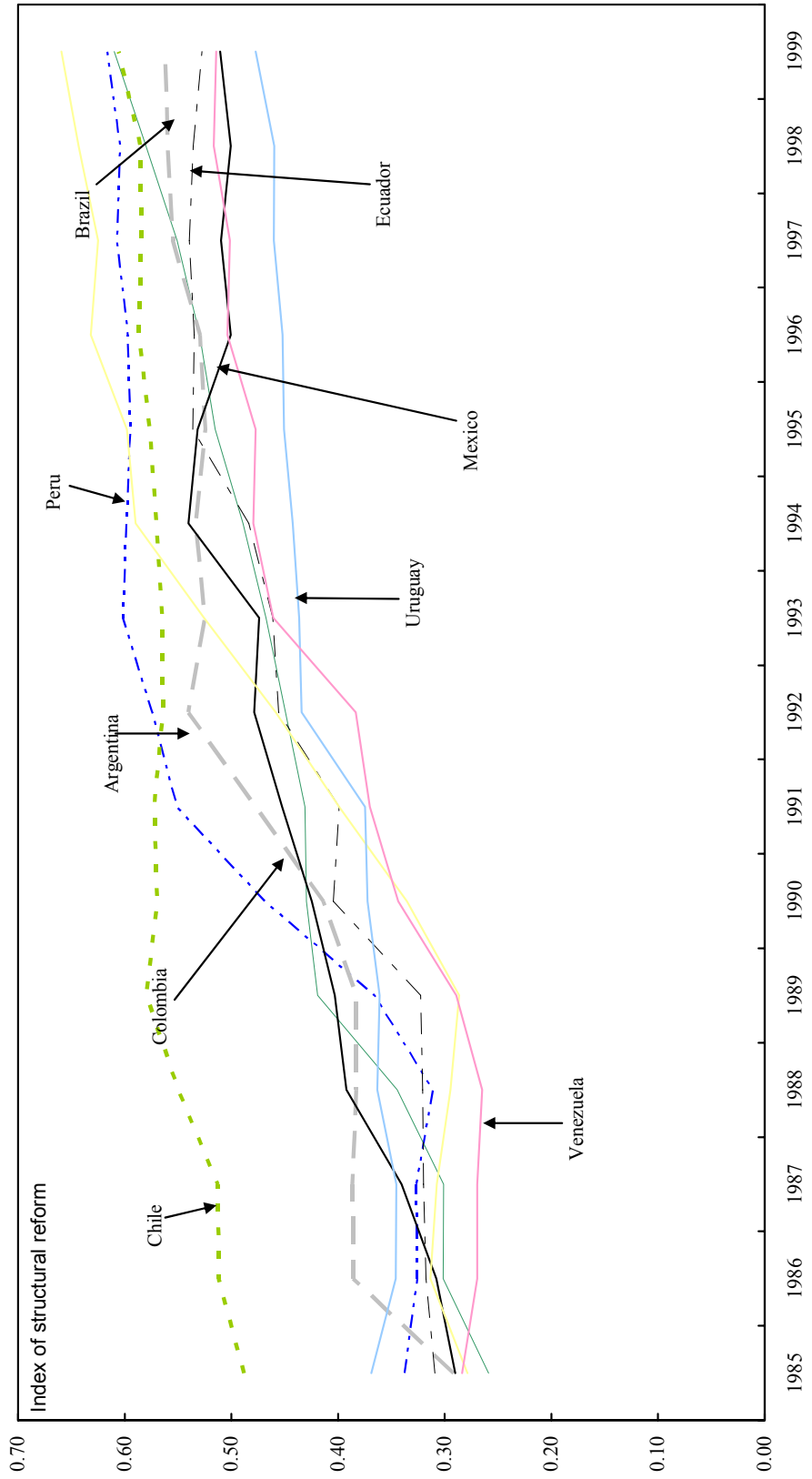
## V. Estimates of Potential Output

This section compares various approaches for decomposing real GDP growth into its cyclical and trend components, and derives estimates of potential output growth and the implied output gaps. In general, strategies to estimate these unobserved variables may be classified as univariate (atheoretical), structural, or a multivariate (mixed) approach. The univariate approach views the problem as a statistical exercise in which actual data on output are used to construct an estimate of potential output. Therefore, it requires less information and relies solely on historical GDP data. Examples of this approach are the Beveridge-Nelson (1981) and the unobserved components (UC) time-series approaches proposed by Watson (1986) and Clark (1989), and the Hodrick-Prescott filter (1997). An important shortcoming of these approaches is that they disregard other information, such as inflation, unemployment, and capacity utilization. Structural approaches exploit economic theory to estimate potential output. In general, data on employment and estimates of the capital stock are used to fit a production function, and estimates of potential output are then derived given "normal" levels of employment, productivity, and capital utilization.

The multivariate approach combines the time series elements of the univariate model with aspects of a structural model. Several researchers have used inflation and real output to obtain measures of potential outputs—Laxton and Tetlow (1992) for Canada, Kuttner (1994) for the United States, Gerlach and Smets (1999) for the EMU-area, and Benes and N'diaye (2001) for the Czech Republic. An important shortcoming, however, is the assumption that the relationship between the output gap and inflation is stable. This assumption is debatable for economies like Mexico, which have experienced sharp structural changes.

[8] World Bank (1998) estimates that the informal sector has absorbed over 50 percent of the increase in the total labor force since 1981 (p. 34).

Figure 4. Structural Reform Policy Indices for Selected Latin American Countries, 1985-99




Sources: Eduardo Lora (1997) and updated calculations for 1998–99.

We use the UC approach and the Kalman Filter to decompose real GDP into trend and cycle (plus an erratic component) within a univariate framework such as Watson (1986) and Clark (1987). This essentially requires assumptions on the functional form of these components and the structure of the error processes, including cross correlation properties. We then compare the results from these approaches to the Hodrick-Prescott (H-P) filter. These techniques were also applied in a structural context by filtering the TFP residual. Inserting the trend value of TFP in equation (1) then provides an alternative measure of potential output.

## A. Model

The model used to decompose real GDP into a permanent and cyclical component is as follows: [1]

$$y_t = y_t^p + z_t \quad (4)$$

$$y_t^p = \mu_t + y_{t-1}^p + \varepsilon_t^y \quad (5)$$

$$\mu_t = \mu_{t-1} + \varepsilon_t^\mu \quad (6)$$

$$z_t = \phi_1 z_{t-1} + \phi_2 z_{t-1} + \varepsilon_t^z \quad (7)$$

In equation (4), actual output ($y_t$) is decomposed into a "permanent" component ( $y_t^p$ ) and a "transitory" component ( $z_t$ ). The permanent and transitory components can be thought of as corresponding to potential output and the output gap terms, respectively. In equation (5), permanent output is assumed to follow a random walk with drift $\mu_t$, while $\varepsilon_t^y$ is a white noise disturbance with variance $\sigma_y^2$. If $\sigma_y^2$ is zero, then potential growth is constant. In equation (6), we allow the drift term to follow a random walk, since our estimation covers the period 1980-2003, and thus includes periods of important changes in macroeconomic conditions. To close the model, equation (7) assumes that the output gap follows a second-order autoregressive (AR(2)) process, where $\varepsilon_t^z$ is a white noise disturbance with variance $\sigma_z^2$, which is uncorrelated with $\varepsilon_t$ and the stationarity conditions hold (Kim and Nelson (1999), Morley (2002)).[2]

[1] The model follows closely Clark (1989), Kim and Nelson (1999a, b), Kim and Murray (2002), Morley (2002), and Morley, Nelson and Zivot (2001).

[2] Harvey (1985) and Clark (1987) suggest specificfying $\rho$=2. Depending on the estimates of the AR(2) processes, $z_t$ may have complex roots and thus obey a cyclical process.

### B. State Space Representation of the Unobserved Components

Given the characteristics of output and TFP, equations (6) and (7) are transformed into state-space form.[3] The observation equation linking the current level of output to the four state variables is defined as follows:

$$y_t = [1 \;\; 1 \;\; 0 \;\; 0] \begin{bmatrix} y_t^p \\ z_t \\ z_{t-1} \\ \mu_t \end{bmatrix} \tag{8}$$

The state variables evolve according to the system of transition equations below:

$$\begin{bmatrix} y_t \\ z_t \\ z_{t-1} \\ \mu_t \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & \phi_1 & \phi_2 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} y_{t-1} \\ z_{t-1} \\ z_{t-2} \\ \mu_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^z \\ 0 \\ \varepsilon_t^\mu \end{bmatrix} \tag{9}$$

We assume above that the covariance matrix of the disturbances is diagonal such that the variance-covariance matrix of the residuals of the errors is zero. This implies that shocks to the output gap are uncorrelated to the growth rate of potential.[4]

$$Q = \begin{bmatrix} \sigma_y^2 & 0 & 0 & 0 \\ 0 & \sigma_\mu^2 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \sigma_z^2 \end{bmatrix} \tag{10}$$

For a given set of the parameters, initial values of the state variables and the corresponding variance-covariance matrix, optimal estimates of the unobserved components based on

[3] See Harvey (1989) and Hamilton (1994) for a discussion of state-space models and the Kalman filter.

[4] It is possible that large output gaps could have lasting effects on the growth rate of potential, but there are no a priori reasons for this to be the case.

information at time t observations can be obtained by obtained using the Kalman filter and maximum likelihood estimation as described below:

$$\log L = -\frac{T}{2}\log(2\partial) - \frac{1}{2}\sum_{1}^{T}\log|F_t| - \frac{1}{2}\sum_{1}^{T} v_t^T F_t^{-1} v_t \qquad (11)$$

In equation (4), T is the sample size, $v_t$ is the prediction error matrix and $F_t$ is the mean square error matrix of the prediction errors.

### C. Characteristics of the model

The relative size of the standard deviations of $\varepsilon_t^{\mu}$ and $\varepsilon_t^{z}$, together with the coefficients on the autoregressive terms $\varphi_1$ and $\varphi_2$, determine the behavior of permanent output and thus the gap between actual and permanent series. The standard deviation of the cyclical component, $\sigma_z$, measures the contributions of cycles. There are no cycles if the standard deviation of $\sigma_z$ is equal to zero. If the standard deviation of the growth rate, $\sigma_\mu$, is zero, then potential growth collapses to a constant. The default assumption in the model is that trend and cycle innovations are uncorrelated. This setup remains the standard treatment of trend-cycle decompositions in state-space framework, as in Kim and Nelson (1998) and Proietti (2002). We denote this zero covariance constrained UC-model as "restricted" and the model with a freely estimated covariance between the trend and cycle as "unrestricted."

## VI. Empirical Results—Potential Output and Output Gaps

The estimation results are reported in Table 4 for the restricted and unrestricted models estimated using GDP, whereas Table 5 presents the estimates for TFP. The results show that the sums of the coefficients for $\varphi_1$ and $\varphi_2$ are less than 1, implying stationary cycles for both models.[5] This implies that positive shocks to the output gap, $\varepsilon_t^{z}$, will cause it to increase for several quarters before returning to the steady-state level of zero. The estimates of trend output growth are also broadly similar in the two cases, averaging about 0.57 percent quarterly, or 2.3 percent annually for this period. The innovations in the trend process are at least twice as large in the unrestricted model as in the restricted model. By contrast, the cyclical innovations are significantly larger in the restricted model than in the unrestricted model. This implies that a greater proportion of the variance in output is explained by the cycle under the restricted model, and the period of the cycle is also longer.

[5] In this section, trend GDP is generated using the Kalman Filter. Trend TFP is then derived as the difference between actual and trend GDP.

Table 4. GDP: Estimates of the Restricted Unobserved Components Model 1/
(1980:1 - 2003:4)

| | Restricted | | Unrestricted | |
|---|---|---|---|---|
| | Parameter | Standard error | Parameter | Standard error |
| **Trend process** | | | | |
| Drift: $\mu$ | 0.599 | 0.090 | 0.551 | 0.194 |
| Innovation: $\sigma_\mu$ | 0.709 | 0.012 | 1.802 | 0.220 |
| **Cycle process** | | | | |
| Coefficient: $\varphi 1$ | 1.358 | 0.086 | 0.055 | 0.028 |
| Coefficient: $\varphi 2$ | -0.427 | 0.059 | -0.472 | 0.128 |
| Innovation: $\sigma_z$ | 1.120 | 0.118 | 0.466 | 0.171 |
| Log likelihood | -150.266 | | -148.642 | |

Sources: INEGI, and staff estimates.
1/ Seasonally adjusted quarterly data.

Table 5. TFP: Estimates of the Restricted Unobserved Components Model 1/
(1980:1 - 2003:4)

| | Restricted | | Unrestricted | |
|---|---|---|---|---|
| | Parameter | Standard error | Parameter | Standard error |
| **Trend process** | | | | |
| Drift: $\mu$ | -0.145 | 0.254 | -0.154 | 0.182 |
| Innovation: $\sigma_\mu$ | 0.005 | 0.081 | 1.709 | 0.168 |
| **Cycle process** | | | | |
| Coefficient: $\varphi 1$ | 1.136 | 0.041 | 0.100 | 0.070 |
| Coefficient: $\varphi 2$ | -0.186 | 0.094 | -0.878 | 0.030 |
| Innovation: $\sigma_z$ | 1.651 | 0.157 | 0.317 | 0.080 |
| Log likelihood | -167.643 | | -160.727 | |

Sources: INEGI, and staff estimates.

1/ Seasonally adjusted quarterly data.

Figure 5 shows that HP filter estimates of the trend components of GDP and TFP are "smoother" than either of the UC estimates.[6] Smoother trends can be obtained from the

[6] We assumed the conventional 1,600 smoothing parameter for the quarterly data under the HP filter.

unrestricted unobserved component model by imposing a higher variance on the level disturbances. However, the resulting cycles are still smaller in amplitude and less persistent compared to the HP or the restricted models. Estimates of potential GDP growth follow similar patterns, with the unrestricted UC trend growth estimates showing significantly more volatility than the HP or the restricted UC models (Figure 6).

### A. Assessing the Implied Output Gaps [7]

Estimates of the output gaps are generated as the difference between the value of the series and the estimated trend. As can be seen from Figure 7, and based on the relative variances of the gap measures, the HP filter gap estimates are "noisier" than those based on the UC models. The relative variance of the HP gap is 57 percentage points, compared with 33 and 53 percentage points for the for the restricted and unrestricted gaps, respectively. Also evident from Figure 7, however, is the similarity of the output gap profiles. Indeed, the correlation coefficients between the various GDP gap measures range between 0.79 and 0.98, while those of the TFP measures range between 0.74 to 0.96. Nevertheless, these approaches give conflicting answers about the output gap at particular points in time, underscoring the uncertainty about its absolute size. But the result that the profiles of the gap are broadly similar indicates that it is sensible to assess the relative size of the output gap at a particular point in time by comparing the current estimate of the gap to its recent history and to past peaks and troughs.

Table 6 shows a comparison of results from this study and those reported in IMF Country Report 01/191 for the same sub-periods. In general, estimates of potential GDP growth and the output gap were broadly similar. Estimates obtained from for the period 1983:2–2001:1 indicate potential GDP growth of 2¼ percent in the current study, compared with 2½ percent in the 2001 report. Estimates of potential GDP growth, however, differ by as much as 1 percentage point in the quarterly estimates for the sub-periods 1983:2–1995:4 and 1996:1-2001:1. The corresponding output gaps are also higher in the 2001 report for the latter period. The two approaches to estimating the output gap illustrate the difficulty of identifying, with a reasonable degree of confidence, the permanent and cyclical components of the business cycle. Different techniques can point to the economy being at varied stages of the business cycle, despite being based on the same information set. As one means of assessing which estimates of potential output and the output gap are most plausible, we estimate a simple "accelerationist" model of inflation. The model in equation (8) relates current inflation ($\pi$) to a lagged four-quarters moving average gap (*gap*), lagged

[7] The gap is defined as follows:

$$Outputgap = \frac{actual\ output - potential\ output}{potential\ output} * 100 .$$

Table 6. Mexico: Comparison with Results from IMF Country Report No. 01/191.

| | Current study | Country report | Current study | Country report | Current study | Country report |
|---|---|---|---|---|---|---|
| | Quarterly data 1/ | | | | | |
| | 1983:2-2001:1 | | 1983:2-1995:4 | | 1996:1-2001:1 | |
| Actual output | 2.3 | 2.6 | 1.5 | 1.6 | 5.0 | 4.9 |
| Potential output | 2.3 | 2.5 | 1.6 | 2.0 | 4.8 | 3.9 |
| Output gap | 0.0 | 0.1 | -0.1 | -0.4 | 0.2 | 1.0 |

Sources: IMF Country Report 01/191 data and results, and staff estimates.

1/ The estimation strategy for potential output in IMF Country Report No. 01/191 is the Hodrick-Prescott Filter. The current study uses a univariate unobserved components model.

As one means of assessing which estimates of potential output and the output gap are most plausible, we estimate a simple "accelerationist" model of inflation. The model in equation (8) relates current inflation ($\pi$) to a lagged four-quarters moving average gap (*gap*), lagged inflation, and a moving average error term to account for overlapping observations.[8] Current inflation is defined as the four-quarter change in the overall CPI.

$$\pi_t = \alpha + \beta\pi_{t-4} + \lambda gap_{t_{-1}-t_{-4}} \qquad (8)$$

The results, shown in Table 7, indicate that the only measure that is significantly and positively related to inflation is that derived from the restricted UC model. None of the other estimates are significant, and typically have the "wrong" sign.

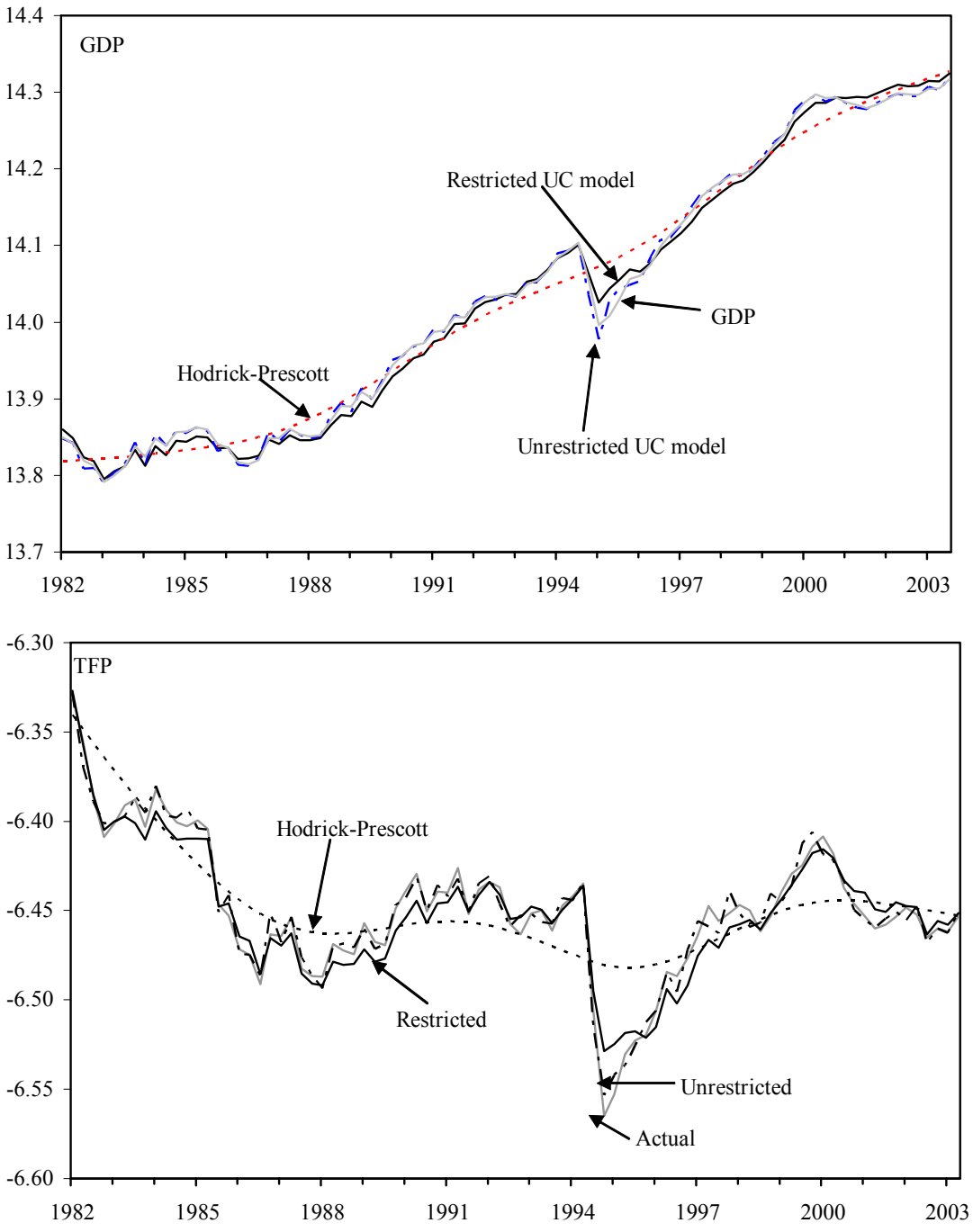
Table 7. Mexico: Inflation and Output Gaps, 1983:2-2003:4

| | GDP Gaps | | | TFP Gaps | | |
|---|---|---|---|---|---|---|
| | H-P filter | ***Restricted*** | Unrestricted | H-P filter | Restricted | Unrestricted |
| **Inflation** | | | | | | |
| β-hat | 0.21 | ***10.51*** | -0.73 | -0.70 | -2.97 | -12.42 |
| t-statistic | 0.25 | ***1.85*** * | -0.45 | -0.77 | -1.52 | -1.70 |
| P-value | 0.80 | ***0.05*** | 0.67 | 0.44 | 0.13 | 0.09 |
| Adjusted R-squared | 0.96 | ***0.97*** | 0.96 | 0.96 | 0.96 | 0.96 |
| Durbin-Watson | 1.88 | ***1.92*** | 1.88 | 1.87 | 1.92 | 1.96 |

Indicates significance at the 5 percent level.

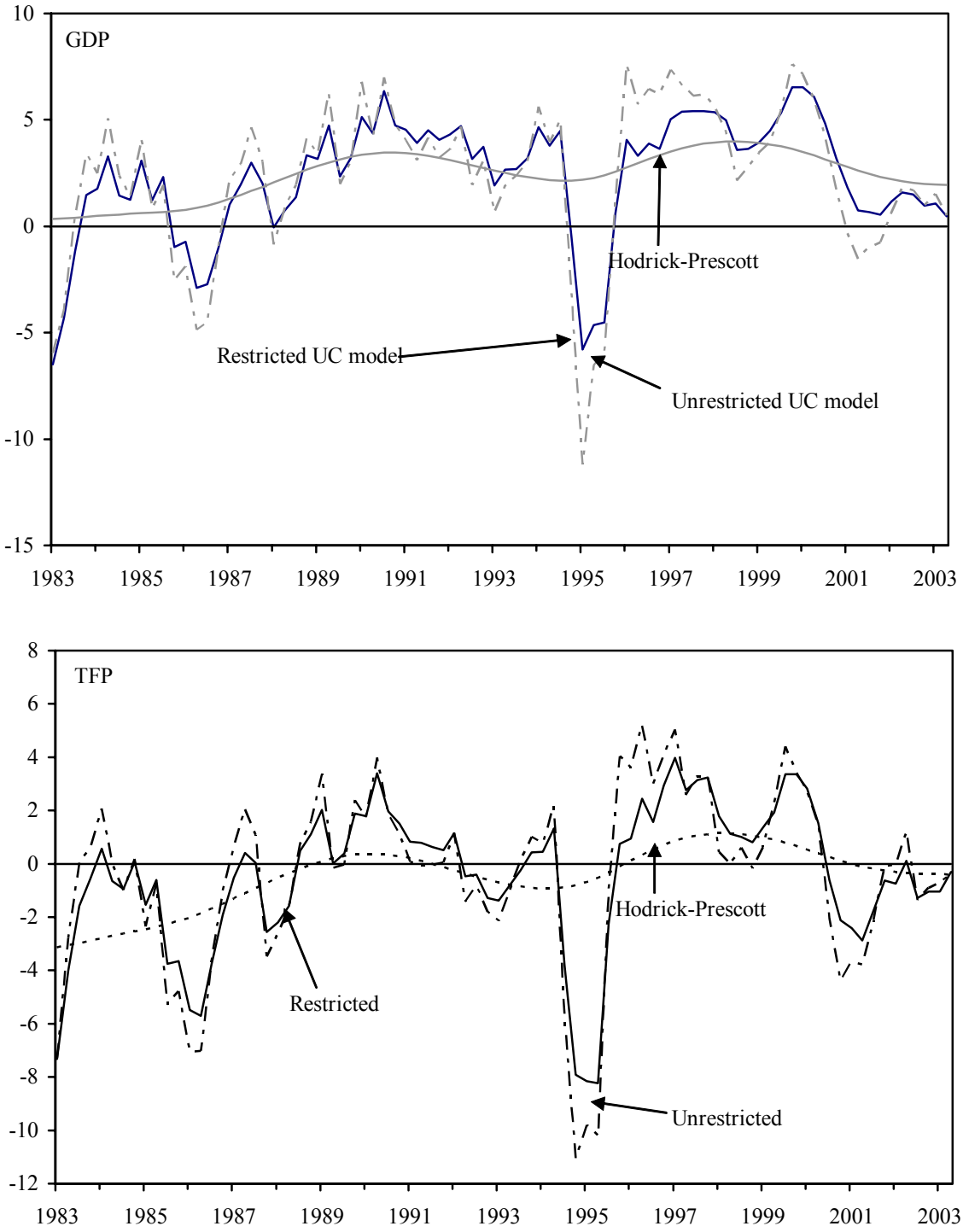
[8] A more complete model incorporating supply-side factors and expectations is analyzed in the next section.

Figure 5. Mexico: HP and UC Trend Estimates of GDP and TFP, 1982-2003
(in log levels)



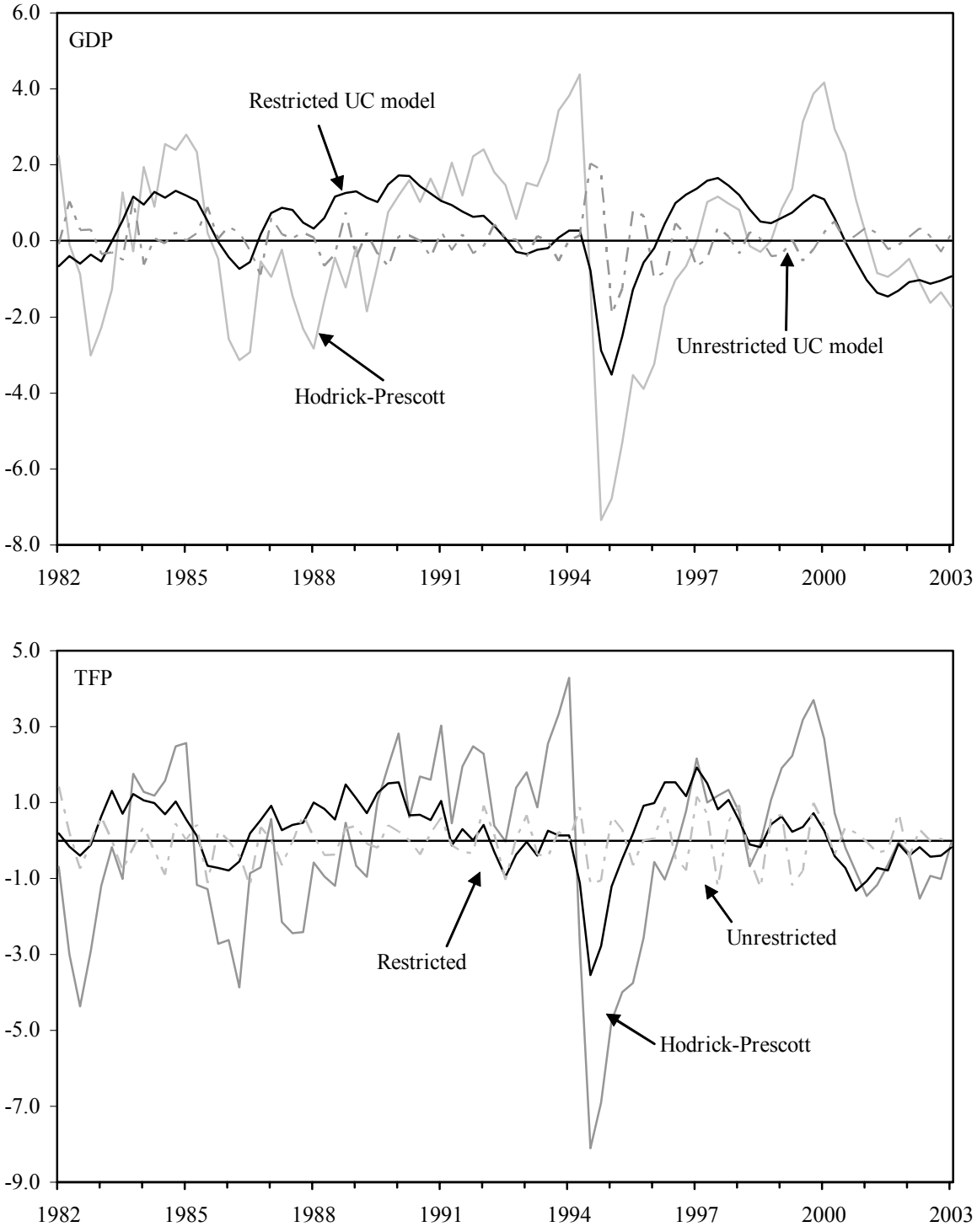

Sources: INEGI, and Fund staff estimates

Figure 6. Mexico: HP and UC Estimates of Trend Output Growth, 1983-2003
(4-quarter change, in percent)




Sources: INEGI, and Fund staff estimates

Figure 7. Mexico: HP and UC Estimates of GDP Output Gaps, 1982-2003
(in percent of potential output)




Sources: INEGI, and Fund staff estimates

## B. Estimating a Wage-Price Model for Mexico

We use the restricted UC model to reestimate inflation model in IMF Country Report No. 04/250. The model analyzes the inflation process in terms of a two-equation model consisting of an expectations-augmented Phillips curve for wages and a mark-up equation for prices. It incorporates both backward- and forward-looking elements in the inflation process derived from the following two equations.[9] All variables are in logs, *w* stands for wages, *p* for the domestic price level, *p** for foreign export prices, $y_{gap}$ for the output gap, π is inflation and *E* is the expectations operator.

$$\Delta w_t = \theta E_{t-1}\pi_t + (1-\theta)\pi_{t-1} + \phi ygap_{t-1} \tag{9}$$

$$\pi_t = \alpha + \beta_1(L)\Delta w_t + \beta_2(L)(\Delta p^* - \pi_{t-1}) + \beta_3(L)\Delta y_{gap} + \beta_4(L)(\Delta admp - \pi_{t-1}) \tag{10}$$

We estimate wage dynamics and price inflation by ordinary least squares following a general-to-specific approach. To abstract from the noise in the inflation data following the financial crisis, the estimation period covers the period 1998:09–2003:12. Monthly GDP data and the corresponding gap estimates were generated as a linear interpolation of the quarterly series of actual and potential GDP. Wage growth is measured as the increase implied by contractual wage settlements; overall inflation and the change in foreign prices are measured as the 12-month log changes in the respective variable, while inflation expectations are the Bank of Mexico (BOM) survey measure of inflation expectations for the following 12 months. All parameters are expected to be positive. The overlapping observations in our measurement of the dependent variables induce moving-average processes in the residuals—these are accounted for by explicitly introducing moving-average terms in the estimation process. The estimation results for the wage equation exhibit the expected properties. Table 8 shows that the weights on both forward and backward-looking inflation are about 50 percent. The fact that the coefficients on backward- and forward-looking inflation sum to roughly one is consistent with a vertical long-run Phillips curve—i.e., that there is no long-run trade off between activity and inflation.[10] The intercept term is positive and significant, proxying for the effect of productivity growth on real wage gains, while the output gap is highly significant.[11] The regressors explain most of the movements in contractual wages, with an adjusted R-squared of about 0.98. In addition, diagnostic tests indicate normality in the

[9] See Chadha, Masson, and Meredith (1992) for a discussion of the rationale for including both forward- and backward-looking components of the inflation process.

[10] This restriction easily passes a Wald test.

[11] In IMF Country Report 04/250, the coefficient on the output gap of 0.13 was insignificant at the 5 percent level. This compares with an estimate of 0.06 in the current study. The latter estimate is significant at the 1 percent level.

residuals and allow rejection of the presence of heteroskedasticity and autocorrelation, respectively.

Table 8. Mexico: Estimation Results for Wages, 1998:09-2004:05

| Variable | Coefficient | T-Statistic | P-value |
|---|---|---|---|
| Constant | 0.01 | 3.18 | 0.00 * |
| Output gap(-1) | 0.06 | 3.33 | 0.01 * |
| Inflation expectations | 0.51 | 5.01 | 0.00 * |
| Lagged inflation | 0.47 | 4.35 | 0.00 * |
| Adjusted R-squared | 0.98 | ... | ... |
| **Diagnostic tests** | | | |
| Jarque Bera test for normality of the residuals | 1.30 | | 0.05 |
| Serial correlation First order-Durbin Watson | 2.20 | | |
| Serial correlation:-Higher order-Breusch-Godfrey LM Test | 5.49 | | 0.01 |
| **Homogeneity** | | | |
| Wald F-Test | 1.02 | | 0.61 |
| Normalized restriction | 0.03 | 1.03 | |

Source: Staff estimates.

* Significant at the 1 and 5 percent levels.

P-values give the probability that the null hypothesis is accepted.

The estimation results for the inflation equation are also as anticipated (Table 9). The restriction that the sum of the coefficients on wage growth is unity is easily accepted, consistent with dynamic homogeneity of the wage-price process. The change in the output gap also helps to explain inflation, presumably capturing cyclical changes in markups.[12] Foreign prices affect domestic inflation with a "passthrough" coefficient of about 0.073 (about 8 percent in nominal terms), suggesting an impact that is typical of other economies with trade shares similar to Mexico that have enjoyed an extended period of low and stable inflation. Changes in administered prices also have a significant impact. The overall fit of the equation is high, with an adjusted $R^2$ of 0.99.

[12] In IMF Country Report 04/250, potential output and the output gap were estimated by applying the Hodrick-Prescott filter to the monthly global economic activity index (IGAE) for Mexico obtained from *INEGI*. The coefficient on the change in the output gap of 0.09, compares with 0.02 in the current study. Both coefficients are significant in explaining inflation at the 1 percent level.

Table 9. Mexico: Estimation Results for Inflation in Mexico, 1998:09-2004:05

| Variable | Coefficient | T-Statistic | P-value | |
|---|---|---|---|---|
| Constant | -0.01 | -2.47 | 0.02 | * |
| Change in output gap | 0.02 | 1.85 | 0.05 | * |
| Wages | 0.35 | 17.92 | 0.00 | * |
| Wages (-1) | 0.31 | 19.72 | 0.00 | * |
| Wages (-2) | 0.34 | 18.52 | 0.00 | * |
| Foreign prices (-1) | 0.06 | 2.24 | 0.03 | * |
| Admiistered prices (-1) | 0.10 | 7.77 | 0.02 | * |
| MA (1) | 1.60 | 11.73 | 0.00 | * |
| MA (2) | 1.56 | 9.47 | 0.00 | * |
| MA(3) | 0.53 | 4.34 | 0.00 | * |
| **Adjusted R-squared** | **0.99** | **...** | **...** | |
| **Diagnostic tests** | | | | |
| Jarque Bera test for normality of the residuals | 2.04 | | 0.48 | |
| Serial correlation First order-Durbin Watson | 1.54 | | | |
| Serial correlation: Higher order-Breusch-Godfrey LM Test | 7.93 | | 0.00 | |
| **Homogeneity** | | | | |
| Wald F-Test | 0.01 | | 0.94 | |
| Normalized restriction | 0.00 | 0.07 | | |

Source: Staff estimates.

Significant at the 5 percent level.
P-values give the probability that the null hypothesis is accepted.

## VII. MEDIUM-TERM GROWTH PROJECTIONS

The production function and associated growth accounting exercise discussed in section (C) provides a useful framework for discussing Mexico's medium-term growth potential (Table 10). Our medium-term projections assume that growth in the capital stock is consistent with keeping the capital-output ratio constant at 1.5. As a result, the capital contribution is higher as we move from a low to a higher growth scenario because more investment is needed to maintain the fixed capital-ratio with faster growth. The labor force grows by 2.4 percent. A baseline scenario assuming trend TFP growth at 0.3 percent. The latter is above the average pace since 1980, but below that in the 1960s and 1970s. It is also below the 0.7 percent rate experienced in1996–2003, based on the assumption that growth was temporarily boosted by the effects of NAFTA and other structural reforms. We derive potential output as the sum of trend TFP and the contributions of the capital and labor inputs. Based on these assumptions, projected GDP would grow at an average rate of 3.2 percent during 2005–09, while potential output grows by 2.9 percent. The difference reflects the unwinding of the output gap that is estimated to exist in 2004.

The alternative "high" scenario shows the TFP growth that would be needed to support GDP growth of 4.5 percent—about 2 percentage points higher than actual growth over 1999-2003 and close to the growth rate experienced in 2004 as the economy recovered. The implied trend TFP growth rate of 1¼ percent may appear optimistic given the historical experience. However, it could be plausible if the significant reforms and restructuring that have already

taken place in the financial sector lead to significantly higher levels of intermediation and real private investment, and other key reforms are implemented. The "low" scenario extrapolates the experience over the entire period from 1980–2003 of declining TFP, resulting in GDP growth of just over 2 percent. Of course, future developments will depend importantly on progress with structural reforms. But the difficult political environment for advancing reforms underscores the need for caution.

The assessment in the paper suggests that looking ahead, there are benefits to be gained from further structural reforms to increase investment and enhance TFP. For instance, a target of 5 percent growth over the medium to long term, assuming depreciation of capital stock of 10 percent, would imply that the minimum gross rate of investment needed for sustained growth would be 22.2 percent of GDP. Similarly, a 6.5 percent target would require an investment ratio of 24.5 percent of GDP. In contrast, the actual rate of investment has averaged 18.5 percent since 1985.

Table 10. Mexico: Alternative Medium-Term Growth Projections, 2005-09

| | Low scenario | Baseline | High scenario |
|---|---|---|---|
| **Real GDP growth** | **2.1** | **3.2** | **4.5** |
| Factor contributions ( in percentage points) | | | |
| Capital | 0.8 | 1.1 | 1.5 |
| Labor | 1.5 | 1.5 | 1.5 |
| **TFP** | **-0.2** | **0.6** | **1.5** |
| **Memorandum items:** | | | |
| Potential GDP growth | 1.8 | 2.9 | 4.2 |
| Trend TFP | -0.5 | 0.3 | 1.2 |

Source: IMF staff estimates.

## VIII. CONCLUSIONS

Mexico recorded remarkable growth between 1960–1979. After the 1982 debt crisis, however, there was a dramatic slowdown in the rate of output and TFP growth. Structural reforms in the late 1980s and 1990s provided some impetus for a recovery in TFP growth, but this has been relatively modest in relation to the structural reforms that were implemented. Looking ahead, the implementation of the authorities' structural reform agenda in the energy, tax, labor market, and telecommunication areas would be crucial to raising investment rates. Capital formation, spurred by the reforms of the energy sector in Mexico, could provide the impetus that is needed to boost investment. Similarly, reform of the labor markets would be crucial to acceleration of growth over the medium term. One area where reforms have taken place is in the financial sector, and these may now begin to pay off in terms of faster growth. But the difficult political environment for advancing broader reforms underscores the need for caution in constructing medium-term forecasts.

The second part of the paper estimated potential output and output gaps using various versions of the univariate UC model in which we let the data "speak" by just using the time series properties of the actual output data. The estimates of trend output growth are also broadly similar in the restricted and unrestricted UC models, averaging about 0.57 percent quarterly, or 2.3 percent annually for this period. The innovations in the trend process are at least twice as large in the unrestricted model as in the restricted model. This implies that a greater proportion of the variance in output is explained by the cycle under the restricted model, and the period of the cycle is also longer. The analysis suggests that the gap measure that explains inflation best is derived from the estimation of the restricted UC model. The results of our estimation of the wage and price equations confirm the significance of gaps in the inflation process.

The paper also presents medium-term paths for GDP based on alternative productivity growth rates and investment levels. Assuming some fading of the effects of NAFTA and structural reforms, but still positive TFP growth, real GDP would grow at slightly over 3 percent a year over the medium term. If TFP reverted to the post-1980s experience, annual output growth would fall to just over 2 percent, while an acceleration in TFP growth (spurred, for example, by recent financial reforms) could allow GDP to grow by about 4 percent a year. In terms of investment, a target of 5 percent a year growth over the medium to long term, assuming depreciation of capital stock of 10 percent a year would imply that the investment rate needed for sustained growth would be 22.2 percent of GDP. Similarly, a 6.5 percent growth target would require an investment ratio of 24.5 percent of GDP. In contrast, the actual rate of investment has averaged 18.5 percent of GDP since 1985.

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