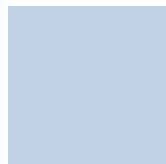
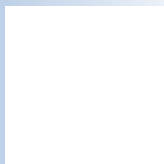


**Federal Reserve Bank of St. Louis**

# REVIEW

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# Currency Design in the United States and Abroad: Counterfeit Deterrence and Visual Accessibility

Marcela M. Williams and Richard G. Anderson

Despite the increasing use of electronic payments, currency retains an important role in the payment system of every country. In this article, the authors compare and contrast trade-offs among currency design features, including those primarily intended to deter counterfeiting and those to improve usability by the visually impaired. The authors conclude that periodic changes in the design of currency are an important aspect of counterfeit deterrence and that currency designers worldwide generally have been successful in efforts to deter counterfeiting. At the same time, currency designers have sought to be sensitive to the needs of the visually impaired. Although trade-offs among goals sometimes have forced compromises, new technologies promise banknotes that are both more difficult to counterfeit and more accessible to the visually impaired. Among the world's currencies, U.S. banknotes are the notes most widely used outside their country of issue and thus require special consideration. (JEL E42, E51)

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An efficient and sustainable payment system development process ought to be built around the current and foreseeable payment needs of the users in the economy, such as consumers, government and financial and non-financial businesses. These needs should be weighed against the current economic and technical capabilities of the economy to supply the required payment instruments and services in a cost-effective manner.

*Guideline 4, Committee on Payment and Settlement Systems, Bank for International Settlements (2006)*

**D**espite the increasing popularity of electronic payments, currency remains an integral part of all nations' payment systems and the most familiar medium for daily face-to-face payments. In most nations, the bulk of the circulating currency is that issued by that nation's monetary authority; in a few cases, the

currency of a foreign nation, such as the United States, is widely used. Regardless of the specific currencies in circulation, each nation's payment system has a large number of participants, including consumers, retail businesses, financial institutions, the central bank or other monetary authority, armored car companies and others who transport currency, and third-party currency processors. Everyone who touches currency in a nation's payment system has a stake in recognizing the authenticity of currency ("authenticating"), readily determining its denomination ("denominating"), and—subject to these constraints—minimizing the cost of its handling.

To sustain public confidence in a circulating currency, banknotes must contain features that the public can use to readily judge their authenticity and determine the notes' denominations.

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Marcela M. Williams is a senior research associate and Richard G. Anderson is a vice president and economist at the Federal Reserve Bank of St. Louis. Views expressed herein are solely those of the authors and are not necessarily those of the Federal Reserve Bank of St. Louis, the Board of Governors of the Federal Reserve System, the U.S. Treasury, or the Department of Homeland Security. The authors thank numerous colleagues for comments. They also thank, for their cooperation and assistance, the Reserve Bank of Australia, the Bank of Canada, the Bank of Japan, the Sveriges Riksbank, the European Central Bank, the Monetary Authority of Hong Kong, the Hongkong and Shanghai Banking Corporation Limited, the Monetary Authority of Singapore, the Swiss National Bank, the Bank of England, and the United States Bureau of Engraving and Printing. All currency images used within are the property of the respective currency issuers and are used with permission. Responsibility for errors remains with the authors.

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Currency design is driven by these considerations, subject to constraints imposed by the desire to minimize the notes' cost and maximize their ease of handling by third parties. Monetary authorities, quite naturally, prefer banknotes that are relatively inexpensive to produce and, other things equal, have a long life in circulation. These considerations make banknote design a mixture of art, science, and economics.<sup>1</sup> Generally, monetary authorities worldwide recognize that improved public understanding and awareness of the features of their currency assist them in meeting these goals. Yet, studies of public awareness of currency features suggest that often many members of the public are not aware of even a single security feature in their nation's banknotes.<sup>2</sup>

In this article, we compare and contrast design features in banknotes issued by monetary authorities in a number of countries, including the United States. Our focus is on two primary design issues: counterfeit deterrence and high visual accessibility (for both the normal-sighted and visually impaired).<sup>3</sup> We discuss both those fea-

tures that are readily visible to consumers and businesses, and machine-readable features not accessible without machine assistance. Our emphasis is on design features that the public might use to determine the authenticity and denomination of a banknote. In this respect, our views coincide with those expressed by currency experts such as Brian Lang (2002), then head of currency at the Reserve Bank of New Zealand, who emphasized that building sophisticated security features into banknotes is of limited effectiveness if the public is unaware of the features, and that a highly aware public is the best defense against the circulation of counterfeit banknotes. Throughout, our analysis is based on publicly available information regarding currency design considerations and features. To the extent that banknotes contain covert or secret features, these are not discussed here.

U.S. currency is an especially complicated case: Unique in the world, U.S. currency presents special issues because of its widespread usage outside the United States. Although U.S. currency has been held abroad since before the Second World War, outflows accelerated during the 1970s. Recent estimates are that more than 50 percent of all U.S. banknotes in circulation are held outside the United States.<sup>4</sup> The worldwide presence increases its attractiveness to counterfeiters while, at the same time, councils caution with respect to significant design changes to deter counterfeiting or improve visual accessibility that might confuse the public outside the United States. In foreign nations experiencing political or economic uncertainty, U.S. banknotes are an attractive asset; much of the recent growth in demand for U.S. banknotes has been in countries of the former Soviet Union and Latin America. Indeed, anecdotal press reports tell of Moscow taxi drivers insisting to be paid in U.S. dollars rather than rubles. Other stories tell of merchants in the most

<sup>1</sup> For the economist reading this article, we note that the "currency design problem" may be framed as a constrained optimization problem in which the objective is to maximize the contribution of circulating currency to social welfare. Absent constraints (both economic and technical), social welfare is maximized by producing banknotes that contain "all" desirable features, including those that deter illegal reproduction, make denomination rapid and accurate, make the currency easily used by the blind and visually impaired, and (as with machine-readable features) minimize the cost of high-volume currency handling by third-parties. Because it is reasonable to believe that the objective functions of monetary authorities differ (for example, some might have a relatively larger fraction of their banknotes in circulation abroad, or might face relatively higher labor costs for currency handling), the solutions to their optimization problems—the resulting currency designs—will differ. The underlying structure of our article is such an "optimization subject to constraints" framework. In our opinion, such formalism contributes little to the public's understanding of currency design issues and, hence, for accessibility to the general reader we avoid the use of such jargon in the article. Interested readers should examine Tables 1 and 2, in which the column headings approximately correspond to the constraints that would appear in a formal Kuhn-Tucker optimization statement of the currency design problem.

<sup>2</sup> Published studies on this topic are relatively difficult to locate. An interesting paper is de Heij, DiNunzio, and Strube (2003), which, for the United States, summarizes surveys of public awareness conducted by Deloitte & Touche for the U.S. Bureau of Engraving and Printing. For a recent study of the euro, see de Heij (2006).

<sup>3</sup> Throughout this manuscript, we use the term "visually impaired" to refer to persons with limited visual capacity that affects their ability to carry on their daily lives, and "normal-sighted" to

describe those persons who, while perhaps having some diminished vision, are able to conduct daily major life functions, albeit in some cases with an accommodation or limitations. We recognize that these terms are imprecise and that significant disagreement remains regarding the use of such highly descriptive terms. Among other sources, a more complete discussion is available, for example, in National Research Council (1995).

<sup>4</sup> U.S. Treasury Department (2006b).

remote areas of China accepting—and giving change—in U.S. banknotes. The extensive, widespread use of U.S. banknotes benefits American taxpayers because, unlike Treasury bonds, the banknotes are a liability of the U.S. monetary authorities on which no interest is paid. The use of the banknotes also is a social and economic benefit to the residents of foreign countries who might otherwise lack a currency stable in value and widely accepted in transactions. This same popularity also encourages counterfeiting. Counterfeiters range from the casual, who produce a few notes with desktop scanners and ink jet printers or with color copiers, to professionals using sophisticated lithographic printing systems, to foreign governments that print counterfeit “super-notes” on government-owned intaglio presses.<sup>5</sup> Below, we consider further the ways in which security requirements and a desire for universal acceptability around the world may limit design options for U.S. currency.<sup>6</sup>

We begin by exploring the characteristics of an “ideal” currency and then examine the real-world considerations that affect currency design. We conclude with a comparative analysis of currency features around the world.

## WHAT ARE THE CHARACTERISTICS OF AN IDEAL CURRENCY?

There are relatively few published, analytical studies of currency design. The studies of which we are aware focus on U.S. currency and, for the most part, have been funded by the U.S. Treasury’s Bureau of Engraving and Printing (BEP) and conducted by the National Research Council (NRC), including BEP (1983) and NRC (1993, 1995, 2006, 2007). The U.S. Treasury, in collaboration with other government agencies, has published three studies regarding counterfeiting and the demand for U.S. banknotes abroad (U.S. Treasury, 2000, 2003, 2006b). Our analysis necessarily draws heavily on these studies.

<sup>5</sup> Both the National Research Council (2006) and Mihm (2006) identify North Korea as a producer of “supernotes.”

<sup>6</sup> Interested readers should consult U.S. Treasury (2000, 2003, 2006b).

The U.S. BEP was established during the U.S. Civil War in an effort to reduce counterfeiting. Since that time, the primary focus of U.S. banknote design has been counterfeit deterrence—although features that would ease usage by both the visually impaired and normal-sighted users have not been ignored. The NRC’s Committee on Next-Generation Currency Design (NRC, 1993) described the features of a “perfect” currency:

- Extremely difficult to duplicate
- Easily recognized by the general public
- Durable (remains visible after considerable wear)
- Can be machine-readable
- Easy to produce at low cost
- Acceptable to the public (aesthetically pleasing)
- Non-toxic and non-hazardous

Table 1 compares and contrasts banknotes’ characteristics relative to those of an “ideal currency” for selected countries that belong to the Bank for International Settlements’ Committee on Payment Systems and Services. With respect to counterfeit deterrence, the committee argued that no single feature, by itself, can furnish adequate protection against even the casual counterfeiter because nearly all individual features can be simulated by a determined, well-funded counterfeiter. Instead, the committee recommended a “systems approach” that combined several features with aggressive law enforcement and detection efforts.

To introduce ideas and terminology, consider the current U.S. \$50 note (see Figure 1). On the front, the note contains security features including a watermark, color-shifting ink and subtle shades of various colors; on the reverse, the note contains in the lower right corner a visual accessibility feature, the denomination in 14 mm tall numerals. In the final section of this article, we examine security and visual accessibility features of currencies from several nations.

### *Accessibility Features*

- Large numeral on reverse
- Large portraits
- Subtle over-printed colors on front



## Figure 1

### U.S. \$50 Note: Security and Accessibility Features



Front

#### Security Features

1. Enlarged, off-center portrait
2. Subtle, over-printed colors
3. Color-shifting ink
4. Fine-line printing patterns
5. Microprinting
6. Watermark
7. Security thread

#### Accessibility Features

8. Large denomination numeral on reverse
- Enlarged portrait
- Colors that vary by denomination



Back

NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features. See also the boxed insert on p. 408 and Figure 11 on p. 409.

SOURCE: U.S. Bureau of Engraving and Printing; [www.moneyfactory.com/newmoney](http://www.moneyfactory.com/newmoney).

#### Security Features

- Watermark
- Color-shifting inks
- Fine-line printing patterns
- Enlarged off-center portraits
- Machine-readable feature
- Security thread
- Microprinting

Although the task given to the NRC's 1993 committee on currency design was to explore features that deter counterfeiting, the first item on its evaluation criteria was "visual and tactile recognizability," defined as "an assessment of the ease with which a U.S. citizen...could readily recognize the feature in normal ambient illumination unaided, or aided with a simple, inexpensive

device." It is widely recognized that the "look and feel" of currency is important for determining whether it is genuine, both for normal-sighted users and the visually impaired. The committee concluded that U.S. currency's unique banknote paper, combined with its raised surface created by intaglio printing, were the essential ingredients for notes to have the correct "feel" of U.S. currency.<sup>7</sup> More recently, the NRC has issued two detailed technical reports on counterfeit deterrence (NRC,

<sup>7</sup> Security intaglio printing refers to print produced from hand-engraved plates with a recessed image. Thick paste inks and high printing pressures are used to create a raised surface on the note that cannot be reproduced by planar printing processes. Virtually all banknotes are printed, at least in part, by intaglio methods. Additional features, such as serial numbers and color, often are added via letterpress or offset printing, although color intaglio is feasible. Van Renesse (2005) and NRC (2006) provide detailed discussions of printing techniques.

2006 and 2007). In broad terms, the findings and recommendations resemble the 1993 report: Currency redesign must be an ongoing process to remain ahead of the improving technology available to counterfeiters.

In 1995, the NRC (via its Committee on Currency Features Usable by the Visually Impaired) issued a report focused solely on visual accessibility (NRC, 1995). This study was commissioned by the BEP, and is, as far as we are aware, the most extensive on the topic. We review its recommendations below. In their scope and completeness, the NRC's 1993 and 1995 studies complement each other. Unfortunately, the studies are almost completely compartmentalized in their suggestions for an ideal currency. The studies omitted comparisons between design features to deter counterfeiting and to increase visual accessibility: The 1993 report (NRC, 1993) considered "ideal" features for counterfeit deterrence, while the 1995 report (NRC, 1995) considered "ideal" visual features. The NRC's 1993 report, for example, in approximately 125 pages, never mentions concerns of the blind or visually impaired.<sup>8</sup> The NRC's 1995 report, for example, concluded that "features currently used by other countries...can be considered for inclusion in the forthcoming redesign of U.S. currency without compromising the security of American banknotes" (NRC, 1995, p.11). We discuss below features that have been introduced in newer currency designs.

Our analysis of notes issued worldwide suggests that security-related features (including those to deter counterfeiting) and features that enhance visual accessibility often are complementary. For U.S. banknotes, designing currency robust to counterfeiters but also as highly visually accessible as possible perhaps is more challenging due to the widespread use of U.S. dollars abroad; yet, the Treasury's successful education campaign that surrounded introduction of the redesigned \$100 note suggests that education can overcome initial resistance to design changes.<sup>9</sup>

<sup>8</sup> The 1993 report is the first report specifically linked to a pending currency redesign. Two previous reports by the NRC are discussed in the 1993 document. One of those earlier reports, in 1985, recommended the security thread and small-size intaglio-printed characters implemented in Series 1990 U.S. banknotes.

## CURRENCY DESIGN FEATURES TO DETER COUNTERFEITING

Technological innovation in color copying, scanning, and printing is the most important factor propelling increasingly sophisticated currency designs to deter counterfeiting.

Innovation has intensified the race between increasingly sophisticated banknote counterfeiters and banknote designers. In many lines of business, the improving performance and decreasing cost of information technology have reduced "barriers to entry"—unfortunately, perhaps, the same is true in counterfeiting. The NRC's most recent technical report (NRC, 2007) concludes that this race eventually will be lost for the current generation of paper-based banknotes and explores a wide range of innovative substrates as a replacement for current banknote paper. The report's overall conclusion echoes the conclusions of previous NRC reports (NRC, 1993, 2006) that only continuous design innovation can sustain a low frequency of counterfeit notes in circulation. The report's engineering analysis of alternative substrates is fascinating but speculative. We leave details of the report to the interested reader and focus herein on current banknote designs and features.

Banknote designers worldwide have introduced a number of features to deter counterfeiting. Features to assist authentication for selected countries are summarized in the first column of Table 1. Such features include novel substrates such as polymer with clear windows that include embossed and printed security features<sup>10</sup>; embedded security threads, including ones that glow different colors under ultraviolet (UV) light<sup>11</sup>; high-relief raised intaglio printing; extra color

<sup>9</sup> See U.S. Treasury (2000, 2003, and 2006b) for discussions of uncertainty generated abroad by design changes and the accompanying education campaigns. Lambert and Stanton (2001) discuss holdings of U.S. notes abroad relative to the Series 1996 and 2004 design changes.

<sup>10</sup> The Reserve Bank of Australia issued the world's first polymer note series between 1992 and 1996. The NRC (2006, 2007) reviews the engineering details of such plastics and provides a list of the numerous countries now using such currency.

<sup>11</sup> Among others, U.S. banknotes now contain such threads.



**Table 1****Currency Features for Selected Countries, As Reported by the Currency Issuers**

	<b>Features to assist authentication and denomination (anti-counterfeiting measures)</b>	<b>Features to assist the visually impaired (visual features)</b>
Australia	Clear window Made of polymer substrate instead of paper See-through registration device Shadow image Intaglio printing Background print (offset) Microprinting Fluorescent ink properties	Different sizes Different colors Intaglio printing Large numerals
Canada	Holographic stripe Watermark portrait Windowed color-shifting thread See-through number Raised ink/intaglio printing Fine-line patterns Microprinting Fluorescence/UV-light tests Serial number Colors	Different colors Tactile symbols Large high-contrast numerals Machine readable
Euro Currency Area*	"Feel, look and tilt" Made of pure cotton Raised print/intaglio printing Tactile marks Watermark Security thread See-through number Perforations Hologram patch (€50, €100, €200, €500) Color-changing number (€50, €100, €200, and €500) Glossy/iridescent stripe Microprinting UV-light tests	Different sizes Striking colors Large numerals Intaglio printing Tactile marks (€200 and €500)
Hong Kong SAR	Fluorescent machine-readable barcode Iridescent images Denomination numeral in optical variable ink Holographic windowed thread Concealed image/denomination Intaglio printing Fluorescent fibers/UV-light tests Watermarks Security thread See-through feature Serial numbers	Different sizes Different colors Large numerals Intaglio printing

NOTE: \*For the 12 member states of the European Monetary Union participating in the single currency. †Life span of euro banknotes is calculated by dividing, for each denomination, the average circulation of banknotes during the previous 12 months by the number of banknotes sorted to unfit during the previous 12 months.

SOURCE: European Central Bank.



**Table 1, cont'd****Currency Features for Selected Countries, As Reported by the Currency Issuers**

	<b>Features to assist authentication and denomination (anti-counterfeiting measures)</b>	<b>Features to assist the visually impaired (visual features)</b>
Japan	Watermark Ultra-fine-line printing Intaglio printing Microprinting Luminescent ink Hologram Latent image Pearl ink	Tactile marks/intaglio printing Different sizes Different colors
Singapore	Microprinting Kinegram Lithographic print Engraved portrait Braille codes Asymmetrical serial numbers (vertical and horizontal) Anti-color-copying line structures Lift twin Intaglio printing Highlight watermark Watermark Perfect registration Security thread Invisible feature: non-reflective under UV light See-through windows on polymer notes	Braille codes Different colors Different sizes Intaglio printing
Sweden	Watermark Security thread See-through picture Intaglio printing Additional features for banknotes with foil strip: Fluorescent picture Microlettering Foil strip-hologram Shimmering mother-of-pearl ink Motion feature	Different colors Different sizes Intaglio printing
Switzerland	Transparent register Watermark digits Intaglio printing (digits) Perforated number Optically variable ink UV digits Metallic digits Tilt effect	Different colors Different sizes Perforated number

NOTE: \*Costs of producing a banknote (conception and design, paper, printing, information) average approximately 30 centimes per new note. Yearly production assuming a 3-year lifespan is 10 centimes per note in circulation.

Durability	Cost of production
¥1,000: 1-2 years ¥5,000: 1-2 years ¥10,000: 4-5 years	¥15.1 per banknote
S\$2 polymer: 72-96 months (issued in Jan 2006, still monitoring the performance) S\$5 paper: 18-24 months S\$10 paper: 24-36 months S\$10 polymer: 72-96 months (issued in May 2004, still monitoring the performance) S\$50 paper: 24-36 months S\$100 paper: 48-60 months S\$1,000 paper: 48-60 months S\$10,000 paper: 48-60 months	S\$2 polymer: S\$0.10 S\$5 paper: S\$0.10 S\$10 paper: S\$0.09 S\$10 polymer: S\$0.12 S\$50 paper S\$0.08 S\$100 paper S\$0.07 S\$1,000 paper S\$0.09 S\$10,000 paper S\$0.55
Varies by denomination 20 kronor: about 1 year 1,000 kronor: about 5 years	Approximately 7.5 US cents per banknote
10 CHF: 2 years 20 CHF: 1.5 years 50 CHF: 1.5 years 100 CHF: 3.5 years 200 CHF: 3 years 1,000 CHF: 10 years	About CHF 0.30 centimes per note <sup>‡</sup>

**Table 1, cont'd****Currency Features for Selected Countries, As Reported by the Currency Issuers**

	<b>Features to assist authentication and denomination (anti-counterfeiting measures)</b>	<b>Features to assist the visually impaired (visual features)</b>
United Kingdom	Cotton and linen paper Metallic thread Watermark Print quality Hologram UV-light tests Microlettering Foil (on £50 note)	Different sizes Large denomination numerals Densely colored recognition symbols to indicate denomination: £5: turquoise circle, £10: orange diamond, £20: purple square (on the old £20 note), £50: red triangle
United States	Watermark Color-shifting inks Fine-line printing patterns Enlarged off-center portraits Low-vision feature Machine-readable feature Security thread Microprinting	Oversize denomination numeral on reverse Larger portraits (than previous designs) Subtle over-printed colors on front

NOTE: <sup>§</sup>In the year to end-February 2006, 978 million notes were produced at a total cost of £28 million. <sup>¶</sup>Figure based on 2001 fiscal year figures: A total of 7,004,800,000 notes were produced, and \$219,240,000 was expended on currency production.

features on bills; magnetic ink; and various embedded machine-readable features.<sup>12</sup> Counterfeit deterrence features are discussed further in the final section of this article.

United States banknotes contain a large number of security features to deter counterfeiting, including embedded security threads that glow different colors by denomination under UV light; large, complex line-drawn presidential portraits; watermarks; embedded fibers; color-shifting ink (the color of which differs by denomination); microprinting too small to be reproduced by current-generation photographic copiers and consumer-level scanners; fine-line printing; color over-printing in subtle shades; and embedded machine-readable features. Machine-readable

features, most of which vary by denomination, include the notes' optical spectrum and image (including color-shifting inks, and a fluorescent strip that glows in denomination-specific colors under certain frequencies of light), magnetic ink, UV spectrum, and infrared ink pattern (NRC, 2006, pp. 12-13). The NRC notes that machine-readable features are useful both to authenticate notes and to determine notes denomination. Single-note denominators such as those installed in retail vending machines, for example, "typically use infrared, broad-wavelength optical, or magnetic sensors to detect denomination-specific features," while single-note authenticators "also detect ultraviolet and fluorescent patterns." (NRC, 2006, p. 12). The report notes that low-quality counterfeit notes most commonly are identified by low optical image quality, lack of magnetic and/or infrared ink, or incorrect paper fluorescence (discussed further below). Detection of high-quality counterfeits may require careful sensing of magnetic, infrared, or UV signatures.

<sup>12</sup> Electronic handheld note readers, of significant value to the visually impaired, perhaps can use machine-readable features—but specific technical designs are proprietary and confidential. Although several currency issuers have informed us that the machine-readable features of their banknotes might be suitable for handheld denominators, to our knowledge such machines are available only for Canadian and U.S. banknotes.



Durability	Cost of production
Ranges from around 1 year for the £5 note, to 5 or more years for the £50 note	Approximately £0.029 per banknote <sup>§</sup>
\$ 1: 21 months \$ 5: 16 months \$ 10: 18 months \$ 20: 24 months \$ 50: 55 months \$100: 89 months	Approximately 3 cents per banknote <sup>¶</sup>

Magnetic ink is a difficult feature for counterfeiters to replicate, although careful procedures perhaps can maintain magnetic material in suspension long enough for printing; the NRC report notes that 90 percent of counterfeit notes found by high-speed verifiers are detected as a result of incorrect magnetic signatures (NRC, 2006, p. 12).<sup>13</sup>

The paper substrate of U.S. banknotes has a difficult-to-duplicate light green-yellow tint that is a major deterrent to counterfeiting (NRC, 2006). The paper is manufactured under close security by a single U.S. firm from a mixture of 75 percent cotton and 25 percent flax.<sup>14</sup> The color is a characteristic of the paper manufacturing process during which no clay or other whitening agents are added and no bleach or other chemicals are

used to whiten the paper. As a result, unlike most printing papers, U.S. banknote paper does not fluoresce under UV light. When combined with raised texture provided by intaglio-printed images and numerals, the unique “feel” of U.S. banknotes is reported to be the most common method of counterfeit detection by the public and bank employees. For the visually impaired, this same feel is a tactile clue that helps to determine whether an offered banknote is genuine or not; it does not, however, assist the user with identifying the denomination of the note.

To foreshadow somewhat our discussion below of visual accessibility features, we note that the light green-yellow tint of U.S. banknote paper limits the contrast ratio that can be achieved between printed denomination numerals and their background. A higher contrast ratio improves the visual clarity of numerals (ideally, near black on white). But achieving higher contrast likely would require introducing bleach or other whiteners into the papermaking process. To the extent

<sup>13</sup> We are not aware of comparable discussions of machine-readable features for banknotes issued by monetary authorities outside the United States, although many authorities include machine-readable features in descriptions of their banknotes.

<sup>14</sup> The flax provides a “stiffness” to the notes that is absent in many 100 percent cotton notes and increases their durability.

that such a change would alter the color and “feel” of U.S. banknote paper, it would remove one of the primary features used by the public, including the visually impaired, to detect counterfeit notes. To the extent the modified paper would display fluorescence, the change would also remove a test for the legitimacy of the banknote paper. At least with respect to banknote paper, anti-counterfeiting and visual accessibility considerations interact in a complex way, illustrating the potential trade-offs in currency design.

Preserving the traditional “look and feel” of U.S. banknotes has been an important consideration in recent design changes, and security features have been selected so as not to change the traditional look and feel of U.S. banknotes. The NRC lauds current security features as highly durable, low cost, odorless, and environmentally sound (that is, they do not depend on hazardous materials being included in the note) (NRC, 2006, p. 2). Further, many of the features are detectable by the naked eye.

All monetary authorities, on a continuing basis, monitor the effectiveness of current counterfeit deterrence features and seek to develop new ones. By all estimates, banknote design worldwide has been successful in deterring counterfeiting.<sup>15</sup> In the United States, this work is coordinated by the Advanced Counterfeiting Deterrence Steering Committee, which lists effective currency design first among the three elements that comprise its counterfeit deterrence program (U.S. Treasury, 2006b, p. 7).<sup>16</sup> Discussions that seek to measure counterfeiting must separate two concepts: (i) the fraction of outstanding banknotes that are counterfeit; and (ii) for the volume of notes that flow through a central bank’s cash offices, what fraction are determined to be counterfeit. Counterfeit notes may be detected at any point in the economy,

including by retail merchants, bank tellers, or central bank cash offices. Although central bank processing centers typically own the most sophisticated equipment, in the United States the majority of notes are detected by retail and bank personnel; again, the NRC notes that an incorrect “look and feel” is the most important detection method (NRC, 2006).

The flow of notes through central bank cash offices—relative to the outstanding number of notes in circulation—differs by denomination, by country, and through time, making it difficult to accurately infer the fraction of counterfeit notes in circulation. For almost all countries, the measured frequency of counterfeit notes is regarded as “low.” For U.S. banknotes in circulation both inside the United States and abroad, the Treasury estimates that fewer than 1 in 10,000 are counterfeit.<sup>17</sup> The Federal Reserve reports that it removed from circulation during 2005, and sent to the Secret Service, 6.4 notes per million processed, or a total of approximately 234,000 notes among the 36.5 billion pieces of currency processed.<sup>18</sup> The incidence for the euro also is low: For 2005, the European Central Bank (ECB) reports detecting and confiscating from circulation 579,000 notes during the annual processing of approximately 30 billion notes (as of December 31, 2005, there were 10.4 billion euro notes in circulation).<sup>19</sup> The €50 and €100 were the most frequently counterfeited notes.

<sup>15</sup> The appendix contains a list of internet sources for counterfeiting volume statistics of major world currencies.

<sup>16</sup> The second and third, respectively, are law enforcement and public education programs. The Advanced Counterfeit Deterrence Steering Committee is an interagency group that includes representatives from the Department of the Treasury (including the BEP), the Federal Reserve System, and the Department of Homeland Security’s Secret Service. (Prior to creation of the Department of Homeland Security, the Secret Service was an agency of the Treasury Department.)

<sup>17</sup> The Secret Service has jurisdiction over all matters related to counterfeit Federal Reserve notes. For discussion of methodologies used to estimate counterfeit currency worldwide, see the interagency reports issued by the U.S. Department of the Treasury (2000, 2003, and 2006b).

<sup>18</sup> During 2005, the Federal Reserve Banks processed 36.5 billion pieces of currency (Board of Governors of the Federal Reserve System, 2006). For the number of detected counterfeits, see U.S. Department of the Treasury (2006b, Table 6.3). As of December 31, 2005, 24.9 billion banknotes were in circulation, excluding \$2 notes (U.S. Treasury, 2006a). Of these, approximately 5.4 billion were \$100 notes, a large proportion of which are likely held abroad, and approximately 8.8 billion were \$1 notes, likely seldom counterfeited.

<sup>19</sup> See ECB (2006a, p. 102) and the biannual report of the ECB regarding counterfeiting, available at [www.ecb.int/press/pr/date/2006/html/pr060113\\_1.en.html](http://www.ecb.int/press/pr/date/2006/html/pr060113_1.en.html). European newspaper articles suggest that counterfeiting decreased sharply following introduction of the euro, an example of the familiar result that design changes tend to slow counterfeiting. See also [europa.eu/scadplus/leg/en/s30003.htm](http://europa.eu/scadplus/leg/en/s30003.htm), a website of the European Parliament, and Europol (2006a, 2006b).

Changes in currency design are an important tool to deter counterfeiting. European newspaper articles suggest that counterfeiting rates for the euro are significantly lower than for the individual country banknotes that it replaced. News reports from Canada also illustrate the necessity for updating currency designs. Published reports for 2004 cited the counterfeiting of older-design notes as being at “dangerous” levels, with a rate of 4.7 counterfeit notes per 10,000 notes examined.<sup>20</sup> Published reports affirm that the new-design notes with enhanced deterrence features sharply reduced the rate to 2.2 notes per 10,000 during the first eight months of 2006; features of Canadian banknotes are examined below. The Reserve Bank of New Zealand and the Reserve Bank of Australia reported to us that counterfeiting of polymer notes has been negligible, with ongoing activity limited to remaining paper notes in circulation; polymer notes are described in more detail below.

## CURRENCY DESIGN FEATURES FOR THE VISUALLY IMPAIRED

Banknote designers worldwide are aware of the desire by the visually impaired to use currency in day-to-day transactions. Most banknote issuers consult regularly with advocacy organizations for the visually impaired. The principal issue for the visually impaired (persons with some recognizable visual field, including approximately 90 percent of persons with visual impairment in the United States), is to readily determine the denomination of banknotes during a transaction, say, at a distance of 16 to 24 inches.<sup>21</sup> The principal issue for the blind (persons with no recognizable visual field) is the presence of tactile banknote

features and/or machine-readable features that assist automated recognition of denomination by electronic currency readers. Accessibility features of currencies for selected countries are summarized in column 2 of Table 1.

As in most areas of economics, there is no free lunch in currency design: Those features that are of the highest value to the visually impaired also may, in some circumstances, impose significant costs on other currency users and handlers, including retail merchants, financial institutions, and high-volume currency processors. The application of economic benefit-cost analysis to select a set of features is not straightforward. For example, the benefiting group is not necessarily a closed set. Some features that assist the visually impaired—such as large high-contrast numerals, note sizes that vary by denomination, and sharply different bright primary note colors—also assist normal-sighted users to denominate banknotes under low-light conditions or during hectic transactions. While the benefit is larger for the visually impaired, some benefit accrues to all persons using the notes. The benefits of features also varies by group: Low-cost features, such as larger denomination numerals, do not benefit the blind, whereas high-cost features, such as note sizes that vary by denomination, benefit the blind as well as other note users. Further, the visually impaired are not a homogeneous group and include persons born blind or who became blind during childhood, persons who became blind as adults, and individuals with limited visual acuity. Some know Braille, but many do not.

Previous studies of note design have consistently found that the design feature most valuable to the visually impaired is note sizes that vary by denomination.<sup>22</sup> For example, in the summary section of its 1983 report to the Congress, the BEP wrote (BEP, 1983, p. 17):

<sup>20</sup> More information is available from the Royal Canadian Mounted Police ([www.rcmp-grc.gc.ca/scams/counter\\_e.htm](http://www.rcmp-grc.gc.ca/scams/counter_e.htm)) and various Canadian Broadcasting Corporation reports, including [www.cbc.ca/news/background/counterfeit/](http://www.cbc.ca/news/background/counterfeit/) and [www.cbc.ca/canada/story/2006/11/20/counterfeit-bills.html](http://www.cbc.ca/canada/story/2006/11/20/counterfeit-bills.html).

<sup>21</sup> In our research, we have encountered several standards for classifying persons as “visually impaired” or “blind.” The text in this paragraph uses one such classification. Below, we cite another in which blind is equated to a corrected visual acuity of less than 20/200 and visually impaired as a corrected visual acuity of less than 20/40.

<sup>22</sup> See, for example, the BEP (1983) and the NRC (1995). Both these studies discussed additional proposed currency design features to assist the visually impaired, including Braille or Braille-like tactile features and notched edges or clipped corners. We do not discuss these features here because previous studies have concluded that the features deteriorate rapidly with the usage of the banknote. But, see the discussion of Canadian currency below, which uses non-Braille patterns of raised dots to assist the visually impaired.

...[I]t would appear that the most broadly useful currency design change would be to produce Federal Reserve notes in a different size for each denomination. However, the effects of such a change on broad and diverse segments of the population would be monumental.

Although the report's authors ranked this design feature first when measured by its assistance to the visually impaired, they ranked it second overall due to its cost. Implementing a system of varying-size banknotes would affect all handlers of banknotes, including financial institutions, retail merchants, vending machine operators, high-volume banknote processors, the Federal Reserve System, the BEP, and the non-visually impaired. Instead, the authors ranked first among alternatives a handheld electronic note reader, in part because of its zero impact on most participants in the currency-based segment of the U.S. payment system (BEP, 1983, p.17).

With respect to the cost of implementing a system of varying-size banknotes where none exists, we are not aware of any published, public estimates for the total cost to an economy; undoubtedly, these costs would be dependent on the rate of implementation relative to the normal rate of replacement of depreciated equipment. Some published estimates are available for the BEP alone. In 1983, the Bureau estimated an initial start-up cost of \$25.6 million and annual incremental costs of \$6.7 million (BEP, 1983, p.12). In 2006, the Bureau estimated the implementation cost to be as high as \$230 million (Andrews, 2006). For perspective, these numbers might be compared to the cost of printing current U.S. banknotes. In 1983, the Federal Reserve System purchased 4.6 million banknotes from the BEP, for which the production cost (including certain adjustments for accounting changes and equipment purchases) was \$23.00 per 1,000 banknotes, a total of \$105.8 million (Volcker, 1986, Table 4). Relative to this figure, 1983's start-up costs equal 23 percent of the year's printing cost; the estimated annual incremental cost adds an additional 7 percent. If perhaps the start-up costs were to be amortized over a decade, annual currency manufacturing costs might increase by approximately 10 percent. Consider next 2006, in which the

manufacturing cost for banknotes delivered to the Federal Reserve System was \$467 million (Board of Governors of the Federal Reserve, 2006b, Table 1). Relative to these figures, the 2006 startup costs are approximately 49 percent of the 2006 printing cost. If amortized over a decade, the cost is approximately 5 percent per year, not including any incremental annual cost.<sup>23</sup>

Advances in technology promise increased ease of use for the blind and visually impaired. Canadian banknotes and all U.S. new-design banknotes issued since 1997, for example, contain specific machine-readable features that have been designed to assist the visually impaired.<sup>24</sup> In Canada, through the Canadian National Institute for the Blind, blind and visually impaired persons

<sup>23</sup> The BEP sells banknotes to the Federal Reserve at a markup over the cost of manufacture. Although the Federal Reserve has some control over the quantities of notes ordered, the BEP sets the billing rates so as to recover its costs from the Federal Reserve (and other customers). For fiscal year 2006, BEP reports that the manufacturing cost for notes printed averaged \$27.49 per thousand (U.S. Treasury, 2007, p. 72). The BEP marks up notes (and other products), under Public Laws 81-656 (1950) and 95-81 (1997), to cover direct and indirect costs of operation, including administrative costs, and amounts sufficient to fund capital investments and meet working capital requirements (U.S. Treasury, 2007, p. 71). Denomination-specific BEP billing rates to the Federal Reserve System for notes in fiscal year 2006 ranged from a low of \$43 per thousand for \$1 and \$2 notes, to a high of \$81 per thousand for Series 2004 notes; for calendar year 2006, the Federal Reserve reports paying a volume-weighted average price of \$55.74 per thousand (Board of Governors, 2006b, Table 2). The \$1 and \$2 notes, which have not been redesigned, do not include the Series-1996 and Series-2004 design security features; \$5 notes include watermarks, but not color-shifting ink; Series-1996 \$100 notes include watermarks and color-shifting ink; and Series-2004 \$10, \$20, and \$50 notes include watermarks, color-shifting ink, background colors, and additional security features. The percentage ratios mentioned in the text would be smaller relative to the 2007 currency budget (assuming the costs didn't increase as well). For calendar year 2007, the Federal Reserve reports a currency budget of \$574.3 million, an increase of \$107.3 million, or 23 percent. While the largest reason for the increase is a higher proportion of newer design notes that are more costly to produce, almost one-third (\$32.1 million) is to fund a decade-long BEP capital improvement plan which, during the first four years, will replace production equipment in Washington, D.C., including intaglio presses (some up to 26 years old) and overprinting equipment for some production lines (Board of Governors, 2006b).

<sup>24</sup> In response to our inquiries, other countries replied that their notes contain machine-readable features that could be used to assist the visually impaired, but that such features had not been included specifically to assist the visually impaired. For countries other than the United States and Canada, we are not aware of any available handheld currency authentication or denomination devices that use such features. The machine-readable features, of course, are of value to other currency handlers, including financial institutions, retail stores, and high-volume currency processors. See also Tables 1 and 2.



can obtain at no cost a handheld banknote reader that signals denomination to the user via voice, tone, or vibration. This machine is produced by Brytech ([www.brytech.com](http://www.brytech.com)), which introduced a reader for Canadian currency in 1989 and a reader for U.S. currency in 1992. The readers are not identical: The reader for Canadian notes is smaller and contains features not included in the U.S. reader. In our research, we purchased a Brytech “Note Teller 2” reader for U.S. banknotes; the reader measures  $6 \times 3 \times 1$  inches and weighs 8 ounces.<sup>25</sup> The manufacturer does not publish recognition accuracy statistics for the reader (but offers a 30-day money-back guarantee). We asked approximately 20 of our colleagues to test their banknotes, both old and new designs, in a variety of conditions. Since the note reader “reads” the ends of the banknotes, it failed to read only those notes with folded corners and/or stains at the ends.<sup>26</sup> Brytech staff noted that (i) although some customers find the U.S. currency reader satisfactory, others find it bulky and too expensive; and (ii) some users have reported problems using it with newer 1996 series and later currency designs. Although not inexpensive (at \$280 U.S.), perhaps technological advances will allow future price reductions. Recently, recognition of U.S. banknotes has been added to the Kurzweil-National Federation of the Blind reader.<sup>27</sup> This reader, according to published documentation, captures and parses a digital image of an object, suggesting it is not using machine-readable features of the notes. We are aware of no published figures regarding accuracy of this device. Further, because it uses only a visual scan of the note, it perhaps is less valuable for authenticating than denominating notes. Although the currency feature will be of value to owners of the Kurzweil reader, the

reader’s \$3,500 price very likely places it beyond the means of many visually impaired persons.

When considering costly design features that assist the visually impaired, an economic analysis of the benefit-cost trade-off depends, in part, on the number of affected persons. But, a great deal of uncertainty surrounds such estimates: It is difficult to measure accurately the number of Americans who will today and might in the future benefit from improved banknote visual accessibility. A study published in 2006 (Vitale et al., 2006) estimates the number of people with visual impairment to be about 14 million.<sup>28</sup> The NRC (1995) reports, based on one widely used classification, that as of the early 1990s approximately 9 million Americans were classified as blind or visually impaired. The NRC (1995) report cautions that traditional criteria may greatly understate the true extent of impairment because the determination is made by measuring visual acuity in laboratory settings under ideal lighting and high-contrast conditions. To read text rapidly and accurately in practical situations such as occur at a retail cash register often requires numerals three to five times larger than the sizes commonplace in laboratory visual acuity tests—if used, such a criterion would classify millions of additional persons as visually impaired. In addition, many studies, including NRC (1995), have noted that the design of visually accessible currency is as much an *age-related* issue as a *vision-related* issue. Looking forward, the aging of the world’s population portends visual problems; many conditions related to aging reduce vision, including macular degeneration, glaucoma, and retinitis pigmentosa. In addition, contrast sensitivity and pupil size tend to decrease with age: At 80 years old, the eye often admits only one-quarter the light admitted for a 20-year old. Combined with other age-related factors, the result is “a severe reduction in visual performance under adverse lighting conditions for older people.”<sup>29</sup> (The first

<sup>25</sup> Our Note Teller 2 reader was the “standard” model with voice features. A recently introduced “enhanced” model includes the signal-by-vibration feature available on the Canadian currency model but not previously available on the U.S. model.

<sup>26</sup> The specific machine-readable features and technology used by Brytech are trade secrets.

<sup>27</sup> Details are at [www.knfbreader.com](http://www.knfbreader.com). The web site says the Kurzweil reader makes a digital image of the object, then parses the digital image. Hence, the reader uses no machine-readable features of the notes.

<sup>28</sup> This figure would correspond to the number of U.S. residents aged 12 years or older with visual acuity of 20/50 or worse. The study also found that approximately 83 percent of those people estimated to be visually impaired would qualify for a driver’s license if they had corrective lenses.

<sup>29</sup> NRC (1995).



formal study of the visual accessibility of U.S. banknotes, reviewed below, was conducted at the behest of the U.S. House of Representatives committee on aging.) The National Eye Institute (2002) estimates that the number of Americans who are blind (that is, best corrected visual acuity of 20/200 or less in the better-seeing eye) and have low vision (best corrected visual acuity of 20/40 or less) due to age-related eye diseases will *double* over the next 30 years.

Recognizing these technical shortcomings with respect to measuring visual impairment, the NRC (1995, p. 6) argued for an aggressive stance on vision enhancements: Small enhancements, adequate in laboratory settings, are likely to produce designs that are inadequate in practical settings. Among their conclusions was this:

It is clear that a major need exists for a better means of banknote denomination for the 3.7 million Americans with visual disabilities, with the goal of giving this population the full access to currency handling available to the rest of society and to visually disabled people in other countries. In addition, due to the increasing number of older individuals with impaired vision due to minor eye disease or the normal aging process, such features would be of great benefit to a far wider population than that represented by the current statistics on blindness and low vision. Certain new features, such as color and size, and enhanced existing features, such as larger numerals of higher contrast, would also benefit those with normal vision by making denomination more rapid and convenient for all.

Visual accessibility features of banknotes issued by several member countries of the Bank for International Settlements' Committee on Payment and Settlement Systems (including the United States) are summarized in Table 1. Features include varying note sizes by denomination; over-size numerals to indicate denomination; high-contrast numerals printed in dark inks against light backgrounds, or the reverse; different principal colors for different denominations; and, tactile features such as embossed numerals or patterns of recessed or raised dots.

In Europe, the designers of euro notes at the ECB "consulted extensively" on the design of the

euro banknotes with the European Blind Union and the World Blind Union, the latter a worldwide umbrella organization for advocacy groups of the blind and visually impaired. A number of their specific efforts are described on the web site of the European Blind Union ([www.euroblind.org](http://www.euroblind.org)) under the "Access to Information" heading. Special features include (i) sizes that vary by denomination, (ii) "striking" "clearly contrasting" colors, (iii) denominations printed in large numerals, (iv) high-relief raised intaglio printing, (v) and special tactile marks printed in intaglio along the edges of €200 and €500 banknotes.<sup>30</sup>

There is a similarly long history in the United States of interaction between currency designers at the BEP and advocacy groups for the visually impaired. The American Council of the Blind reportedly has submitted suggestions regularly to the BEP since at least 1972 (NRC, 1995). In 1983, the first (to our knowledge) formal study of the visual accessibility of U.S. banknotes was conducted by representatives from the American Council of the Blind, the Federal Reserve System, the BEP, and the U.S. Secret Service, at the request of Congressman Edward Roybal, chair of the U.S. House Committee on Aging. The subsequent report is BEP (1983).<sup>31</sup> In addition to being the first formal study, the 1983 report is important because its issues resurface in more recent discussions. In its introduction, the report says that "since the early 1970s" there has been a "significant interest" in designs for U.S. currency to assist the visually impaired—that is, since the Netherlands introduced in January 1971 innovative banknotes with raised (embossed) tactile symbols for each denomination. The report continues by citing unpublished 1976 and 1980 studies by the BEP regarding methods for easing the recognition of a banknote's denomination. The 1976 study, it says, examined the incorporation of

<sup>30</sup> See [www.ecb.int/bc/euro/banknotes/visually/html/index.en.html](http://www.ecb.int/bc/euro/banknotes/visually/html/index.en.html), as of July 2007. The €5, €10, €20, €50, €100, €200, and €500 notes, respectively, feature the colors gray, red, blue, orange, green, yellow, and purple.

<sup>31</sup> This report is available from the Federal Reserve Bank of St. Louis in its FRASER archive: [http://fraser.stlouisfed.org/historicaldocs/tresbep/download/30353/study\\_of\\_mechanisms.pdf](http://fraser.stlouisfed.org/historicaldocs/tresbep/download/30353/study_of_mechanisms.pdf).

Braille markings in currency, and the 1980 study examined “notching” and/or cutting the corners of banknotes.<sup>32</sup>

The 1983 report’s original research is presented in three parts. First, the staff reviewed the currencies of 54 countries (including the United States) for characteristics that would assist denomination by the visually impaired and asked each country to provide information on the performance of the features; five countries responded. The report’s summary of the comments notes that “few countries have intentionally designed currency for this purpose” and that the comments received suggest that none are “completely satisfactory.” Second, technical staff from the BEP evaluated “selected features” with respect to cost and usefulness to the visually impaired. Although details are not provided, the report says that the staff affirmed that commonly proposed design features—including colors that varied by denomination, large and clear numerals, note sizes that varied by denomination, cut corners or notches, and Braille-like tactile features—likely would assist denomination by the visually impaired. Costs for implementing various combinations of these features in U.S. banknotes ranged from \$600,000 to \$6 million per year. Third, the staff explored the feasibility of an automated portable currency reader. Noting that such a device already was available but citing its bulk and expense, the staff recommended that funding be sought to develop a handheld electronic currency reader able to denominate currency. Such a device would assist both the visually impaired and the blind, while requiring at most only modest design changes for U.S. banknotes.

Chronologically, the next formal U.S. study of visual accessibility was commissioned by the BEP to the NRC of the National Academy of Sciences (NRC, 1995). The NRC was charged with several tasks:

- assess features that could be used by people who are visually disabled to recognize, denominate, and authenticate banknotes;

- recommend features that could reasonably be incorporated into banknotes using available technology;
- suggest strategies that should be instituted to make the recommended features more effective;
- and identify research needs in particularly promising areas that could lead to attractive future approaches.

The 1995 NRC study is lengthy and complex, considering in detail both practical and technical issues. This quote summarizes the NRC’s view of the state of U.S. currency design in 1995 (NRC, 1995, Chap. 2, p. 13):

The United States is alone in issuing paper currency bills in which all denominations are of identical size and color. The numbers on the corners of the bills are small and of low contrast, making them difficult to read by people with impaired vision. For everyday transactions, U.S. paper currency possesses no non-visual identifying features, rendering it impossible for blind people to denominate bills without assistance. The lack of distinctive visual features and the total absence of nonvisual features for the common user constitute a hindrance to commerce and daily living for millions of visually disabled people. In addition, the lack of distinctive features results in problems of denomination for a much wider population with mild visual impairments, including those impairments acquired during the normal aging process, and for anyone in a poorly lit environment.

The study eventually recommends four features technologically available in 1995:

- banknote sizes that vary by denomination;
- large, high-contrast numerals on a uniform background (for large numerals, the Committee recommended numerals larger than half the note’s height of approximately 65 mm);
- different predominant colors for each of the six denominations being printed;
- and embedded features to assist development of effective, low-cost devices for examining banknotes.

<sup>32</sup> The outcome of such experiments is not noted in BEP (1983). With respect to notches and cut corners, the report does note that the Federal Reserve and U.S. Secret Service “expressed fundamental concerns” that problems might arise during a transition period.

These recommendations are largely the same as those identified in BEP (1983). Consistent with that study, the NRC (1995) concludes that varying banknote sizes by denomination is the most effective feature to assist denomination by both the blind and visually impaired. The study notes, however, that this is the most costly feature to implement. Further, the change would primarily benefit the blind, who are approximately 10 percent of all visually impaired persons in the United States. In contrast, other features—such as larger numerals and different primary colors—would benefit all banknote users by speeding identification of denomination, particularly in low-light situations. Regarding cost, the committee concluded that the costs to redesign U.S. banknotes and modify equipment to handle them (especially in varying sizes) would be high—but the Committee did not temper its recommendations with regard to these costs because a major redesign already was planned during 1996-2001. Instead, the Committee recommended that these features be incorporated during the 1996-2001 currency redesign cycle.

Since 1995, the BEP has introduced two new designs for U.S. banknotes, each containing features to improve accessibility for the visually impaired. These designs are frequently referred to as the Series 1996 “New Currency Design” and Series 2004 “New Color of Money” designs.<sup>33</sup> Series 1996—design notes were introduced beginning with the \$100 note in March 1996, followed by the \$50 note in October 1997, the \$20 note in the fall of 1998, and the \$5 and \$10 notes in May 2000. Series 2004—design notes were introduced with the \$20 note in October 2003, followed by the \$50 note in late 2004 and the \$10 in March 2006 (the \$5 note is anticipated in early 2008). These new designs include a number of security and accessibility features that are visible and useful without machine assistance. For visual accessibility, the Series 1996 design, beginning with the \$50 note, introduced an enlarged, 14 mm tall denomination numeral in the lower right

corner of the notes’ reverse side.<sup>34</sup> The presidential portrait also was enlarged. A machine-readable feature to facilitate development of handheld scanning devices for the blind and visually impaired has been included in all new-design banknotes issued since 1997. The Series 2004 design introduced an additional accessibility feature, subtle background colors:

For the first time since the Series 1905 \$20 Gold Certificate, the new currency featured [sic] subtle background colors, beginning with the new \$20 note on October 9, 2003. In this series, different colors are used for different denominations. This will help everyone—particularly those who are visually impaired—to tell denominations apart. The \$20 note features subtle background colors of green, peach and blue, as well as symbols of freedom representing icons of Americana—in the case of the \$20 note, images of the American eagle.

It is of interest to compare the features of these newer banknotes designs to recommendations made in the previous 1983 and 1995 studies. In its most recent report, the NRC (NRC, 2006, p. 10) concludes that these features “do not provide adequate differentiation for many visually impaired individuals and provide no method of differentiation for blind persons.” This perhaps was not unexpected. Putting aside the enlarged portrait, the Series 1996 design added a single truly usable feature for the visually impaired: the enlarged, 14 mm denomination numeral in the lower right corner of the reverse. But, the NRC previously noted that a numeral this size is near the visual limit for someone with 20/400 acuity when viewed at a reading distance of 16 inches (NRC, 1995): The NRC recommended a numeral more than twice as large. As an example, the NRC cites studies regarding denomination recognition of current \$1 and \$10 banknotes displaying 12 mm-tall numerals on their fronts, which standard acuity tests suggest should be

<sup>33</sup> The BEP refers to additional series (for example, Series 1999, 2001, and 2003) to denote changes in the signatures on the notes; these were not design changes, however. See BEP (2004) and [www.moneyfactory.gov/section.cfm/4/27/](http://www.moneyfactory.gov/section.cfm/4/27/).

<sup>34</sup> U.S. banknotes typically display denomination in numerals of between 8 mm and 12 mm tall. On \$1 and \$10 notes, for example, the upper front numerals are approximately 12 mm tall, while the numerals on the lower front and on the reverse are approximately 8 mm tall. The \$100 note does not have the large high-contrast numeral.

adequate for many visually impaired—in fact, users with measured acuity less than 20/60 have difficulty recognizing such numerals at the distances of 16 to 24 inches that are common in retail cash transactions. With respect to color, the NRC (NRC, 1995) recommended that at least one side of each denomination’s design feature a single prominent color, not subtle shades of background colors. Specifically, they wrote:

Most other countries also use different predominant colors for each denomination. The simple detection color is faster than finding and reading printed numbers, especially for those with poor letter acuity. It should be noted, however, that many people with low vision have difficulty in discriminating subtle shades of color and that color cues are generally less obvious at low levels of illumination. Consequently, any color features should use clearly distinguishable colors. (NRC, 1995, p. 25)

We display Series 2004 notes in Figure 11 and leave final judgment to the reader. Neither NRC report, however, addressed the trade-off between improved visual accessibility and concerns for counterfeit deterrence and widespread recognition and acceptance, especially outside the United States. We are not aware of any study that addresses this trade-off.

Current improvements in technology portend new features that will be of benefit to the blind and visually impaired. The NRC’s 2007 report (NRC, 2007), commissioned by the BEP, concludes that advances in currency substrates will be the only effective future deterrent to counterfeiting as improving digital technology eases image reproduction. But the report also contains fascinating glimpses of new substrates that might permit designers to include innovative features to assist the visually impaired denominate currency. “Shape memory” materials, for example, are ones that allow an object’s shape to change when subject to stress and return to the original shape when stress is released. Similarly, embedded piezoelectric crystals allow an object’s features to change when an electric current is applied. Conceptually, at least, such materials could allow embedded tactile denomination markings—say,

similar to those in Canadian and Japanese notes—to “appear on demand” when a note is stretched or when it is energized by a battery operated device. Unlike current tactile markings, which degrade with abrasion, such markings perhaps could last the lifetime of the note. Technology also suggests the possibility of notes that change color when subject to an electric current, aiding both counterfeit deterrence and the long-sought goal of varying banknotes’ primary colors by denomination: For most users, the appearance of U.S. banknotes would be unchanged, while the visually impaired could energize special visual features as required. More analysis of such materials and features will be required before they could be implemented, and an international education program might be required if the “look and feel” of U.S. banknotes is affected by changes in substrates. But the promise intrigues.

## WHAT DO OTHER COUNTRIES DO? SECURITY AND ACCESSIBILITY FEATURES

Banknote designers worldwide seek to include features both to deter counterfeiters and assist the visually impaired. Most banknotes incorporate several security features, including holograms, microprinting, serial numbers, and watermarks. Most notes also include one or more visual accessibility feature, including different sizes and principal colors for different denominations, oversize high-contrast numerals, and tactile features such as embossed numerals or recessed/raised dots. Among major currency issuers worldwide, only banknotes issued by Canada and the United States do not differ in size by denomination. In this section, we explore the features of currency issued by nine industrialized countries and the euro zone.

In their 1995 study, the NRC surveyed 171 currency-issuing authorities (NRC, 1995). In many countries, security and accessibility features were regarded as complementary. More than 120 countries varied note sizes by denomination, 24 featured oversized denomination numerals, and 167 used different primary color schemes for different denominations. Among larger countries, only the



**Table 2****Summary of Currency Design Features Intended To Assist the Visually Impaired, Major Issuing Authorities**

Issuing authority	Primary colors that differ by denomination*	Size that differs by denomination	Tactile recognition symbols <sup>¶</sup>	Certain oversize numerals <sup>#</sup>	Machine-readable features for banknote readers
Australia	Y	Y	Y	Y	N
Canada	Y	N	Y	Y	Y
Euro Currency Area <sup>†</sup>	Y	Y	Y	Y	N
Hong Kong SAR	Y	Y	Y	Y	N
Japan <sup>‡</sup>	Y	Y	Y	N	N
Singapore	Y	Y	Y	Y	N
Sweden	Y	Y	Y	Y	N
Switzerland	Y	Y	Y	Y	N
United Kingdom	Y	Y	N	Y	N
United States <sup>§</sup>	Y/N	N	N	Y	Y

NOTE: \*In this table, we define the primary color of the banknote as that used for the prominent portrait (if any), borders, and the denomination numerals, or, in some cases, the dominant color of the note. Because we are not aware of any current cross-country study comparing the color design features of banknotes, judgments are those of the authors. <sup>†</sup>For the 13 member states of the European Union participating in the single currency. <sup>‡</sup>Bank of Japan notes use less intense, near-pastel colors. Although each denomination uses a different dominant color for the portrait, background, and numerals, some readers of previous versions of this article felt that the differences are not sufficient to support our conclusion. We disagree. <sup>§</sup>Currently issued Series 2004 U.S. banknotes in denominations of \$10, \$20, and \$50 feature different dominant colors. The U.S. Bureau of Engraving and Printing has announced that new designs for the \$5 and \$100 notes also will feature differing dominant colors. All currently issued notes except the \$1 note feature a large denomination numeral on the reverse. The \$1 note features a prominent “ONE” in the center of the reverse. <sup>¶</sup>Including both embossed symbols and patterns, and special high-relief intaglio printing (if cited by issuing authority as a visual accessibility feature). <sup>#</sup>Included if cited by issuing authority as a visual accessibility feature.

United States and Canada did not vary the size of their notes by denomination.

Table 1 compares and contrasts banknotes’ characteristics relative to those of an “ideal currency.” Table 2 narrows the comparison to five visual accessibility features: colors that vary by denomination, sizes that vary by denomination, inclusion of tactile recognition symbols, oversize denomination numerals, and machine readability features for banknote readers. (The features shown in the tables are as reported by the respective monetary authorities in public documents. We have not undertaken any independent scientific investigation regarding the features of the banknotes.) In short, we find that no currency includes all five features. Seven of the ten currencies include four features, and three currencies include three features.

Currency images reproduced in this article are as accurate as can be achieved with modern high-volume printing but do not necessarily match colors in the original banknotes. For some notes, to deter counterfeiters, designers select colors that cannot be accurately reproduced by office copiers, printers, and high-volume offset presses.

### **Australia<sup>35</sup> (see Figure 2)**

The Reserve Bank of Australia is responsible for printing, issuing, reissuing, and canceling Australian notes (currency name: Australian dollar; currency code<sup>36</sup>: AUD; currency symbol:

<sup>35</sup> Additional information may be found at [www.rba.gov.au/CurrencyNotes/](http://www.rba.gov.au/CurrencyNotes/).

<sup>36</sup> Currency codes for each country discussed correspond to the International Organization for Standardization ISO 4217 three-letter codes. See [www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34749&ICS1=3&ICS2=60&ICS3=](http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=34749&ICS1=3&ICS2=60&ICS3=)



\$ or AU\$). (Notes are printed by Note Printing Australia Limited, a subsidiary of the Reserve Bank.) Since 1996, all Australian banknotes have been printed on a polymer substrate.<sup>37</sup> The substrate is manufactured by Securrency Pty Ltd., a joint venture between the Reserve Bank and Innovia Films. The substrate is created by coating a clear polypropylene film with an opacifying ink. The “press ready” substrate is supplied to Note Printing Australia. Traditional security printing processes are used to print the notes, including offset and intaglio. As a final step, a clear overcoat is applied to the notes. It is possible to achieve the same intaglio height on polymer substrate as on paper, by depositing a greater quantity of ink.<sup>38</sup> When “blind embossing” polymer (using an uninked intaglio plate), a greater degree of emboss can be achieved in the substrate.

According to the Reserve Bank of Australia, the counterfeiting rate for Australian banknotes is “very low,” averaging between five and six counterfeits per million notes in circulation in recent years. Almost all counterfeits of Australian notes are printed on paper rather than polymer. Yet, even polymer notes are not immune to counterfeiting attempts; in March 2006, Interpol seized more than AU\$5 million of such notes in Colombia, a popular location for counterfeiters.<sup>39</sup> Such attempts appear to be rare; so far as we are aware, no such notes were placed into circulation.

Although more costly than paper notes, polymer notes are more durable (they last at least four times longer), more difficult to counterfeit, and recyclable. Australian banknotes vary in color and length according to denomination. The AU\$5 banknote is the shortest (130 mm by

65 mm), and the AU\$100 banknote is the longest (158 mm by 65 mm).

### ***Security Features***

Among the security features included in the banknotes are

- Clear window with “blind” embossing and a printed image
- See-through registration device
- Shadow image (similar to a watermark)
- Intaglio printing
- Background print (including screen traps)
- Microprinting
- Machine-readable features including UV fluorescence, infrared, and magnetics/inks.

### ***Accessibility Features***

The Reserve Bank of Australia consulted with a number of entities representing the visually impaired in designing the polymer note series. Among the accessibility features of the banknotes are

- Lengths that vary by denomination
- Strong color contrasts that vary by denomination
- Bolder numerals

Raised intaglio printing of denomination numerals, portraits, and other elements is both a security and accessibility feature. In addition, Blind Citizens Australia provides, free of charge, a credit-card size device to measure note length and distinguish between denominations. So far as we are aware, no handheld reader is available that uses the included machine-readable features to assist the visually impaired.

## ***Canada (see Figure 3)***

The Bank of Canada has sole responsibility for issuing, designing, producing, and distributing Canadian banknotes (currency name: Canadian dollar; currency code: CAD; currency symbol \$ or C\$).<sup>40</sup> The Bank of Canada’s first banknote series was printed on a combination of flax and

<sup>37</sup> Since 1998, New Zealand banknotes have been produced in Australia by the same process.

<sup>38</sup> The height of the relief on polymer notes has encountered some controversy. With paper substrate, a somewhat higher initial relief may be obtained than on polymer, but advocates of polymer substrates have argued that the higher relief degrades quickly to a lower relief than on polymer notes. We take no position on this, leaving debates regarding the exotic technical details of intaglio printing on alternative substrates to others. See, for example, Coventry (2001), only one of many papers on this topic.

<sup>39</sup> See [www.interpol.int/Public/FinancialCrime/CounterfeitCurrency/recentEvents.asp](http://www.interpol.int/Public/FinancialCrime/CounterfeitCurrency/recentEvents.asp) or the BIS-G10 Central Bank Counterfeit Deterrence Group (CBCDG) joint counterfeit deterrence task force, [www.rulesforuse.org/pub/index.php?lang=en&page=pressreleases](http://www.rulesforuse.org/pub/index.php?lang=en&page=pressreleases).

<sup>40</sup> Additional information may be found at [www.bankofcanada.ca/en/banknotes/](http://www.bankofcanada.ca/en/banknotes/).

**Figure 2**

**Australia: Security and Accessibility Features**



Front

**Security Features**

1. Clear window
2. See-through registration device
3. Shadow image
4. Microprinting

**Accessibility Features**

5. Bolder numerals
  - Length differentials by denomination
  - Strong color contrasts



Back



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: Reserve Bank of Australia.



**Figure 3****Canada: Security and Accessibility Features**

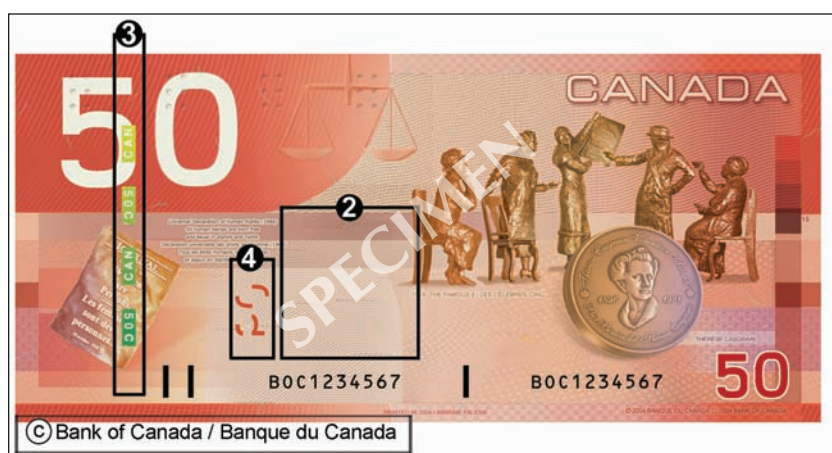
Front

**Security Features**

1. Metallic strip (holographic stripe)
2. Ghost image (watermark)
3. Dashes (security thread)
4. See-through number
5. Raised ink (intaglio printing)

**Accessibility Features**

5. Large, high-contrast numerals
6. Tactile feature
- Varying color by denomination



Back



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.  
SOURCE: Bank of Canada.

cotton paper with the same nominal composition as U.S. banknote paper. Since 1983, however, Canadian banknotes have been printed on 100 percent cotton paper to conform to Quebec environmental laws on flax use.

Canadian banknotes are uniform in size but vary in color by denomination. Notes measure approximately 6 inches long by 2.75 inches wide.<sup>41</sup>

The production cost of Canadian banknotes is approximately 9 Canadian cents per note. The estimated life of the banknotes by denomination is as follows:

- C\$5: 1 to 2 years
- C\$10: 1 to 2 years
- C\$20: 2 to 4 years
- C\$50: 4 to 6 years
- C\$100: 7 to 9 years

According to the Bank of Canada, Canadian counterfeit notes make up a very small percentage of notes in circulation.<sup>42</sup> The most recently issued banknote series—entitled the *Canadian Journey* series—contains both enhanced security features to deter counterfeiting and tactile features to aid the visually impaired.

The Bank of Canada consulted with the Canadian National Institute for the Blind, the Canadian Council for the Blind, and the blind and visually impaired community in the design of their *Canadian Journey* and *Birds of Canada* bank note series to help the blind and visually impaired with recognition of bank notes by sight, touch, or electronic devices. The Bank of Canada, in collaboration with the blind and visually impaired community, has encouraged the development of machines to denominate Canadian notes.

<sup>41</sup> With the exception of the 1935 and 1937 banknote issues, which are 6 inches by 2.875 inches.

<sup>42</sup> The Royal Canadian Mounted Police's Bureau for Counterfeit and Document Examinations estimates that in 2005, the volume of counterfeit notes passed and seized was approximately 422,489 of 1,501,743,000 notes in circulation, or 0.00028 percent of the total notes in circulation ([www.rcmp.ca/factsheets/fact\\_counterfeit\\_e.htm](http://www.rcmp.ca/factsheets/fact_counterfeit_e.htm)). The figure was even lower in 2006: According to the Bank of Canada, 313,207 counterfeit notes were passed and seized, from a total of 1,567,318,000 notes in circulation, or 0.00020 percent.

Through the Canadian National Institute for the Blind, blind and visually impaired persons can obtain (at no cost) a handheld banknote reader that signals denomination to the user via voice, tone, or vibration.

The tactile denomination scheme, of Canadian invention, consists of sets of raised dots that vary in position and number according to denomination. The dot system is not Braille which, contrary to public impressions, is not known by all the blind. The basic “symbol” in the scheme is a tightly spaced rectangular block of six dots—the number and placement of such blocks indicates the denomination. The C\$5 note has one block, for example, while the C\$20 note has three such blocks separated by a smooth surface. Canadian banknotes also include intaglio printing of the denomination numerals, which doubles as a security and accessibility feature.

#### **Security Features**

- Holographic stripe
- Watermark portrait
- Windowed color-shifting thread
- See-through number when note is held to the light
- Raised ink (intaglio printing)
- Fine-line patterns
- Microprinting
- Fluorescence, presence of elements only visible under UV light
- Serial number
- Unique, difficult-to-reproduce colors

#### **Accessibility Features**

- Primary colors that vary by denomination
- Tactile symbols embossed and back-coated for durability
- Large high-contrast denomination numerals
- Machine-readability feature, free banknote readers

### **Euro Currency Area (see Figure 4)**

The euro banknotes (currency name: Euro; currency code: EUR; currency symbol: €) were introduced as legal tender in the Eurosystem on

January 1, 2002.<sup>43</sup> The ECB and the national central banks (NCBs) of the participating countries have the right to issue euro banknotes, but in practice only the NCBs issue banknotes.<sup>44</sup> Banknote production is pooled between the NCBs, and the approximate cost is €0.08 per note.<sup>45</sup>

Euro banknotes are made of 100 percent cotton. Banknotes vary in height, length, and color according to denomination. The €5 banknote is the smallest in size, measuring 120 mm long by 62 mm wide; the €500 banknote is the largest, measuring 160 mm long by 82 mm wide. The estimated life of euro banknotes by denomination is as follows<sup>46</sup>:

- €5: 1.2 years
- €10: 1.2 years
- €20: 1.4 years
- €50: 3.3 years
- €100: 7.5 years
- €200: 10.4 years
- €500: 23.1 years

The weighted average lifetime for all denominations is two years.

The ECB has consulted with the European Blind Union since the beginning of the euro note design phase in 1995 to ensure notes are highly accessible to the blind and visually impaired.

Each banknote—whether €5 or €500—had to be readily identifiable by people with residual or no sight. For example, the differences in height

between the lower, more commonly used denominations were quite distinct. The €100, €200, and €500 banknotes were made the same height—to facilitate automatic handling—but repetitive embossed patterns were placed on the €200 and €500 banknotes to differentiate them.

Large and bold value numerals were placed in a standard position throughout the series, on both sides, and sharply contrasting colors were used. They were derived principally from the color wheel of the Swiss painter and art teacher Johannes Itten (1888-1967). The colors chosen for successive denominations were taken from opposing segments of the color wheel and thus strongly contrast with each other. The same is true for denominations that have digits in common, like the red €10 and green €100 banknotes (ECB, 2007).

While euro banknotes include denomination-specific machine-readable features intended to assist authentication and denomination by third parties (primarily high-volume currency processors and banknote equipment manufacturers), so far as we are aware, electronic banknote readers have not been developed to assist visually impaired individuals.

Counterfeiting of euro banknotes is reportedly low. For 2003-06, the ECB reports detecting and confiscating from circulation approximately 600,000 notes annually (with approximately 10 billion in circulation) (ECB, 2006b). Figures on notes confiscated by law enforcement before entering circulation are confidential.

### **Security Features**

- Made of pure cotton
- Intaglio printing
- Tactile marks (on €200 and €500)
- Wire and multi-tone watermark
- Security thread
- See-through register when note is held to the light
- Perforations in the hologram foil
- Hologram foil
- Optically variable ink (€50, €100, €200, and €500)
- Iridescent stripe (€5, €10, and €200)

<sup>43</sup> The Eurosystem comprises the ECB and the NCBs of the European Union member states that have adopted the euro. Currently, 13 member states of the European Union participate in the single currency—namely, Belgium, Germany, Greece, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Slovenia, and Finland.

<sup>44</sup> Additional information may be found at [www.ecb.int/bc/euro/banknotes/html/index.en.html](http://www.ecb.int/bc/euro/banknotes/html/index.en.html).

<sup>45</sup> The NCBs authorize privately and publicly owned production facilities to print banknotes, and each facility prints one or two of the seven denominations. Once they have printed the banknotes, the issuing central banks exchange them. This process increases efficiency and quality control. The ECB monitors the stocks of the banknotes.

<sup>46</sup> Data furnished by the ECB. Life span of the banknotes is calculated by dividing, for each denomination, the average circulation of banknotes during the previous 12 months, by the number of banknotes determined to be unfit during the previous 12 months.



**Figure 4**

**Euro Currency Area: Security and Accessibility Features**



Front

**Security Features**

1. Holographic image and perforations
2. Color-changing ink
3. Security thread
4. Watermark
5. Partial images printed on the front and back align to form the value numeral (see-through number)
6. Raised ink (intaglio printing)



Back

**Accessibility Features**

- Different sizes: the higher the banknote, the bigger the banknote
- Striking, clearly contrasting colors
- Large numerals
- Intaglio printing



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: European Central Bank.

- Mini and microprinting
- Fluorescence, presence of elements only visible under UV light

### **Accessibility Features**

- Sizes that vary by denomination
- Primary colors that vary by denomination: bold, striking colors/clear, contrasting colors among denominations
- Oversize denomination numerals
- High-relief intaglio printing
- Tactile marks (€200 and €500 only)

## **Hong Kong (see Figure 5)**

The Hong Kong Monetary Authority has authorized (delegated) the issuance of Hong Kong banknotes (currency name: Hong Kong dollar; currency code: HKD; currency symbol: \$ or HK\$) to three commercial banks—The Hongkong and Shanghai Banking Corporation Ltd., the Standard Chartered Bank, and the Bank of China (Hong Kong) Limited—under specific terms and conditions stipulated by the Hong Kong government. The notes issued by the three banks differ somewhat in design although all banknotes are printed in Hong Kong by Hong Kong Note Printing Limited.<sup>47</sup> The notes illustrated here are those issued by HongKong and Shanghai Banking Corporation Ltd. (HSBC).

Under normal usage, a banknote is estimated to last for an average of about two years. Production costs are confidential.

In 2003, the Hong Kong Monetary Authority reported that:

“Forgery of banknotes is not a major problem in Hong Kong, thanks to the quality of our existing banknotes and the good work of the police in tracking down counterfeiters. However, constant changes in technology are increasing the vulnerability to counterfeiting and it is thus necessary to keep more than one step ahead of those who might try to exploit any gaps in the security of our banknotes...”<sup>48</sup>

Although more recently, there has been a problem of counterfeits of the old series (2000 and 2002) Hongkong and Shanghai Banking Corporation \$1,000 banknotes.<sup>49</sup>

Hong Kong banknotes are made of 100 percent cotton fiber,<sup>50</sup> which does not fluoresce under UV light. They vary in length and color according to denomination. The HK\$10 banknote is the smallest (133 mm by 66 mm), and the HK\$1,000 banknote is the largest (163 mm by 81.5 mm). Enhanced intaglio printing serves both as a security and accessibility feature.

In the design phase for the currency issued in 2003 and 2004, the Hong Kong Monetary Authority consulted with major advocacy organizations to include accessibility features for the blind and visually impaired. In addition, the three note-issuing banks and the Hong Kong Monetary Authority produce a template to aid the visually impaired in measuring a banknote's size.

### **Security Features**

- Fluorescent machine-readable barcode
- Iridescent images
- Denomination numeral in optical variable ink
- Holographic windowed thread
- Concealed image/denomination
- Intaglio printing
- Invisible fluorescent fibers
- Watermarks
- Security thread
- See-through feature
- Serial numbers

### **Accessibility Features**

- Sizes that vary by denomination
- Colors that vary by denomination
- A bold, large denomination numeral on the front of all banknotes at a common

<sup>49</sup> See [www.info.gov.hk/hkma/eng/press/2007/20070320e3.htm](http://www.info.gov.hk/hkma/eng/press/2007/20070320e3.htm).

<sup>50</sup> The HK\$10 polymer banknote is scheduled to be put into circulation gradually starting July 9, 2007. See [www.info.gov.hk/hkma/eng/press/2007/20070615e6.htm](http://www.info.gov.hk/hkma/eng/press/2007/20070615e6.htm) and [www.info.gov.hk/hkma/eng/polymer/leaflet\\_polymer\\_eng.pdf](http://www.info.gov.hk/hkma/eng/polymer/leaflet_polymer_eng.pdf).

<sup>47</sup> Additional information may be found at [www.info.gov.hk/hkma/new\\_hk\\_banknotes/eng/index.htm](http://www.info.gov.hk/hkma/new_hk_banknotes/eng/index.htm).

<sup>48</sup> See [www.info.gov.hk/hkma/eng/viewpt/20030904e.htm](http://www.info.gov.hk/hkma/eng/viewpt/20030904e.htm).



**Figure 5**

**Hong Kong: Security and Accessibility Features**



Front

**Security Features**

1. Fluorescent machine-readable barcode
2. See-through feature
3. Denomination numeral in optical variable ink
4. Holographic windowed thread

**Accessibility Features**

- Different sizes
- Distinctive colors
- Large, bold denomination numerals
- Enhanced intaglio printing



Back



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: The Hong Kong and Shanghai Banking Corporation Limited, with permission of the Hong Kong Monetary Authority.

location, with deep engraving to give a pronounced tactile feel

- A bold denomination numeral in negative outline located at a common location at the back of all banknotes
- Enhanced intaglio printing to give stronger embossing effect
- Banknote size measurement template

## Japan (see Figure 6)

The Bank of Japan is the sole issuer of Japanese banknotes (currency name: yen; currency code: JPY; currency symbol: ¥). The banknotes are manufactured by the National Printing Bureau, an incorporated administrative agency.<sup>51</sup>

In response to the increase of Japanese counterfeit banknotes in recent years, the Bank of Japan issued a new series of banknotes in 2004 with improved security features. There are four denominations: ¥1,000, ¥2,000, ¥5,000, and ¥10,000. These redesigned Japanese yen notes vary in width and color according to denomination. The ¥1,000 banknote is the shortest note, measuring 76 mm wide by 150 mm long, and the ¥10,000 banknote is the longest, measuring 76 mm wide by 160 mm long. Bank of Japan notes contain machine-readable features intended to assist mechanical note processing. So far as we are aware, no consumer-level devices to assist the blind and visually impaired have been developed.

The average durability of the Bank of Japan notes is one to two years for the ¥1,000 and ¥5,000 notes and four to five years for the ¥10,000 notes.<sup>52</sup>

In fiscal year 2005, the total manufacturing cost of 4.08 billion banknotes amounted to ¥61.7 billion, approximately ¥15.1 per banknote.

The current series of Bank of Japan notes contain “tactile marks” created by high-relief intaglio printing to assist the visually impaired. High-relief numerals, created by intaglio printing, both deter counterfeiting and assist the visually impaired. The Bank of Japan occasionally makes

studies to improve the accessibility features for the visually impaired.

### *Security Features*

- Hologram (¥10,000 note)
- Watermark bar pattern
- Latent image
- Pearl ink
- Ultra-fine-line printing
- Intaglio printing
- Microprinting
- Luminescent ink

### *Accessibility Features*

- Tactile marks (intaglio printing)
- Sizes that vary by denomination
- Colors that vary by denomination

## Singapore (see Figure 7)

The Monetary Authority of Singapore (MAS) is the sole issuer of banknotes (currency name: dollar; currency code: SGD; currency symbol: \$ or S\$) in Singapore.<sup>53</sup> In 1990, the MAS issued their first polymer note of S\$50 denomination. Polymer notes are more durable and cost-effective. Both paper and polymer banknotes are currently in circulation. Their “Portrait Series” notes were first issued in 1999. This series has seven denominations. The banknotes vary in length, width, and color according to denomination. The smallest note is the S\$2 note, measuring 126 mm in height by 63 mm in width; the largest note is the S\$10,000 note and measures 180 mm in length by 90 mm in height. Singapore banknotes include machine readable features intended to assist currency processing and authentication.

High-relief intaglio printing of several characteristics, including the denomination numeral, serves as an accessibility and anti-counterfeiting feature. During the design phase of the Portrait-series notes, MAS consulted with the Singapore Association of the Visually Handicapped on their needs for the new series of banknotes. The

<sup>51</sup> Additional information may be found at [www.boj.or.jp/en/type/release/zuiji/kako03/bnnew3.htm](http://www.boj.or.jp/en/type/release/zuiji/kako03/bnnew3.htm).

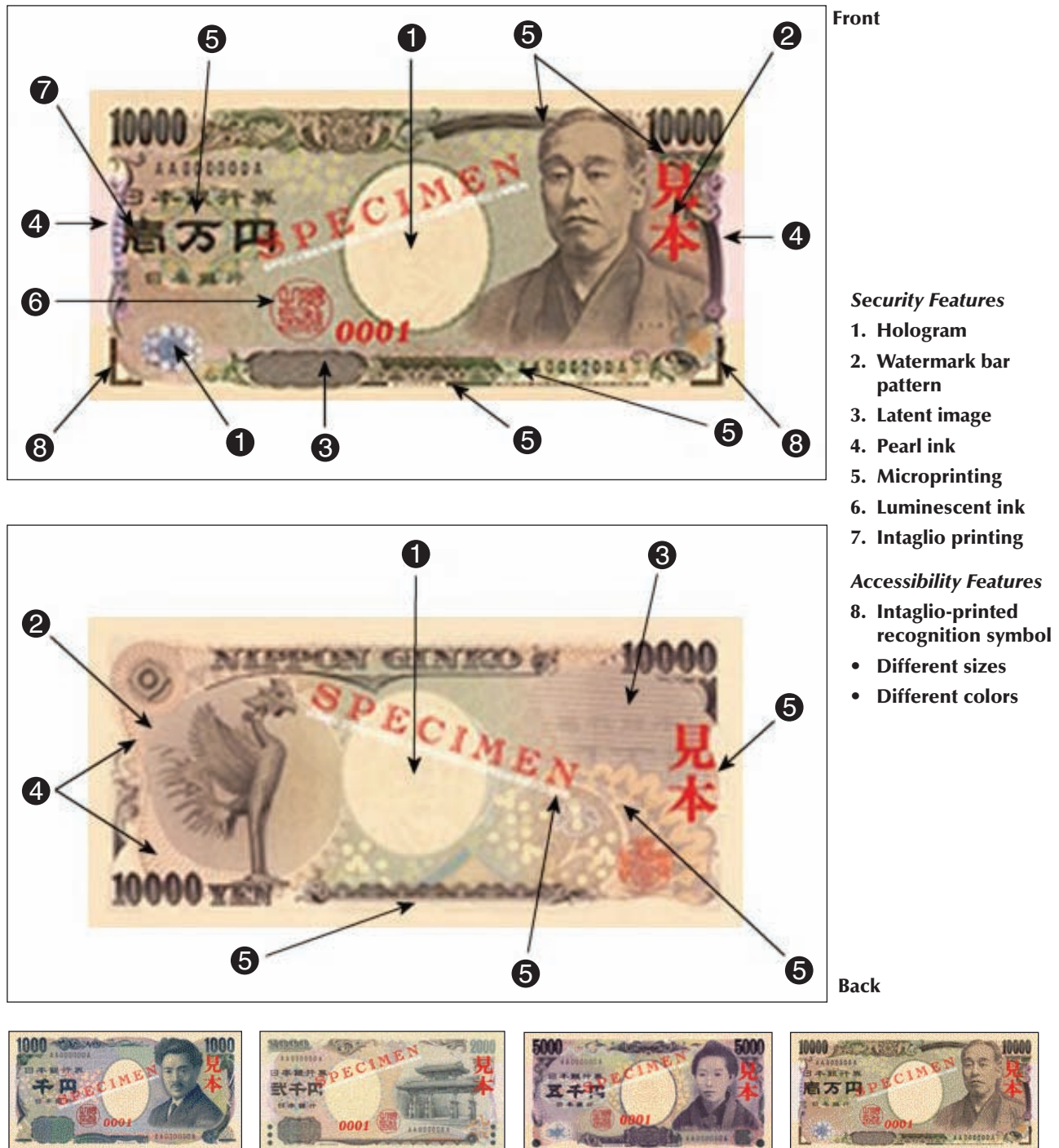
<sup>52</sup> Source: Bank of Japan.

<sup>53</sup> Additional information may be found at [www.mas.gov.sg/masmcm/bin/pt1Singapore\\_Circulation\\_Notes.htm](http://www.mas.gov.sg/masmcm/bin/pt1Singapore_Circulation_Notes.htm).



**Figure 6**

**Japan: Security and Accessibility Features**



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: Bank of Japan.

**Figure 7****Singapore: Security and Accessibility Features****Paper Note****Front****Back****Polymer Note****Security Features**

- |                                       |                         |                        |
|---------------------------------------|-------------------------|------------------------|
| 1. Engraved portrait                  | 6. Perfect registration | 11. Lithographic print |
| 2. Asymmetrical serial number         | 7. Highlight watermark  | 12. Security thread    |
| 3. Anti-color copying line structures | 8. Watermark            | 13. Invisible feature  |
| 4. Lift twin                          | 9. Kinegram             | 14. Fluorescent ink    |
| 5. Intaglio printing                  | 10. Microprinting       |                        |

**Accessibility Features**

- |                   |                   |                    |
|-------------------|-------------------|--------------------|
| 15. Braille codes | • Different sizes | • Different colors |
|-------------------|-------------------|--------------------|



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: Monetary Authority of Singapore.



Association recommended the printing of Braille codes and varying note size by denomination. The Braille codes are printed in heavy, high-relief intaglio on the top right of the front of each note.

According to the Monetary Authority of Singapore, the cost and duration of their banknotes by denomination are as follows:

- S\$2 polymer S\$0.10  
72-96 months (issued in January 2006, still monitoring the performance)
- S\$5 paper S\$0.10  
18-24 months
- S\$10 paper S\$0.09  
24-36 months
- S\$10 polymer S\$0.12  
72-96 months (issued in May 2004, still monitoring the performance)
- S\$50 paper S\$0.08  
24-36 months
- S\$100 paper S\$0.07  
48-60 months
- S\$1,000 paper S\$0.09  
48-60 months
- S\$10,000 paper S\$0.55  
48-60 months

#### ***Security Features***

- Microprinting
- Kinegram
- Lithographic print
- Engraved portrait
- Braille codes
- Asymmetrical serial numbers (vertical and horizontal)
- Anti-color-copying line structures
- Lift twin
- Intaglio printing
- Highlight watermark
- Watermark
- Perfect registration
- Security thread
- Invisible feature: non-reflective under UV light
- See-through windows on polymer notes

#### ***Accessibility Features***

- Braille codes
- Sizes that vary by denomination
- Colors that vary by denomination
- Intaglio printing

#### ***Sweden (see Figure 8)***

The Sveriges Riksbank is the sole issuer of Swedish banknotes (currency name: krona; currency code: SEK; currency symbol: kr).<sup>54</sup> Swedish banknotes are 100 percent cotton. Swedish banknotes are issued in five denominations (20, 50, 100, 500, and 1,000 kronor) and vary in length, width, and color according to denomination. The 20 kronor banknote is the smallest in size, measuring 67 mm in width and 120 mm in length. The 1,000 kronor banknote is the largest, measuring 82 mm in width and 160 mm in length. Banknote lifetime varies by denomination, with 20 kronor banknotes being fit for circulation for about one year and 1,000 kronor for about five years. The cost of production is about 7.5 U.S. cents per banknote. Swedish banknotes contain machine-readable features but, so far as we are aware, no handheld devices are available to assist the visually impaired. Intaglio printing of the denomination and portrait serve as both security and accessibility features.

#### ***Security Features***

- Watermark
- Security thread
- See-through picture
- Intaglio printing
- Foil strip/hologram
- Fluorescent picture (for banknotes with a foil strip)
- Microlettering
- Shimmering mother-of-pearl ink
- Motion (a moving image in the striped bank image; included in the 1,000 krona note with a foil strip only)

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<sup>54</sup> Additional information may be found at [www.riksbank.com/templates/SectionStart.aspx?id=10890](http://www.riksbank.com/templates/SectionStart.aspx?id=10890).

**Figure 8****Sweden: Security and Accessibility Features**

Front

*Security Features*

1. Foil strip with hologram
2. Watermark
3. Security thread
4. See-through picture
5. Raw cotton banknote, gives the note a special texture

*Accessibility Features*

6. Intaglio printing
  - Different sizes
  - Different colors



Back



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: Riksbank.

**Figure 9**

**Switzerland: Security and Accessibility Features**



**Front**



**Back**

**Security Features**

1. Transparent image
2. Fine lines that change colors
3. Microtext
4. Security thread
5. Serial number
6. Tilt effect
7. Metallic digits
8. Optically variable print
9. Intaglio printing

**Accessibility Features**

10. Recognition symbol
11. Perforated number
  - Different sizes
  - Different colors



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: Swiss National Bank.



**Accessibility Features**

- Sizes that vary by denomination
- Colors that vary by denomination
- Intaglio printing

**Switzerland (see Figure 9)**

The Swiss National Bank's (SNB) network of cash distribution services is the issuing and redeeming authority of Swiss banknotes (currency name: Franc; currency code: CHF; currency symbol: CHF, Fr).<sup>55</sup> The network includes the SNB's three bank offices, 16 agencies, and 234 domestic correspondents. Swiss franc notes are printed on paper made of linters and short cotton fibers. Swiss franc banknotes vary in length and color according to denomination. There are six denominations (10, 20, 50, 100, 200, and 1000 francs). All notes measure 74 mm in width. The length varies by denomination, in 11 mm increments, with the 10 franc banknote being the shortest (126 mm) and the 1000 franc being the largest (181 mm). Some of the security elements in Swiss banknotes are machine readable.

The cost of producing Swiss franc banknotes is approximately 30 centimes per new note. The average duration of the banknotes is as follows:

- 10 CHF: 2 years
- 20 CHF: 1.5 years
- 50 CHF: 1.5 years
- 100 CHF: 3.5 years
- 200 CHF: 3 years
- 1000 CHF: 10 years

Perforated numerals serve as both an accessibility and security feature. A tactile symbol varying by denomination is embossed at the lower end of each note as an additional accessibility feature.

**Security Features**

- Transparent register
- Watermark digits
- Intaglio printing (digits)
- Perforated number

- Optically variable ink
- UV digits
- Metallic digits
- Tilt effect

**Accessibility Features**

- Sizes that vary by denomination
- Colors that vary by denomination
- Perforated number
- Intaglio printing (digits)

**United Kingdom (see Figure 10)**

The Bank of England is the sole issuer of banknotes (currency name: pound; currency code: GBP; currency symbol: £) in the United Kingdom.<sup>56</sup> Bank of England banknotes are produced by De La Rue Currency and made from cotton fiber and linen rag. The banknotes vary by color, length, and width according to denomination, with the £5 note measuring 135 mm by 70 mm and the £50 note measuring 156 mm by 85 mm.

The Bank of England estimates an average life of banknotes of about 1 year for the £5 note to five or more years for the £50 note.

During the banknote design phase, advice from the Royal National Institute of the Blind, a U.K. charity, is sought and their recommendations are implemented. For the new £20 series F note, for example, the Royal National Institute of the Blind recommended that large-high contrast numerals be included and the size and color differential between denominations be retained; both were accepted by the Bank of England. In addition, a recognition symbol unique to each denomination is included on the front of the banknote to aid the visually impaired.

**Security Features**

- Made of cotton and linen paper
- Metallic thread
- Watermark
- Print quality

<sup>55</sup> Additional information may be found at [www.snb.ch/en/i/about/cash](http://www.snb.ch/en/i/about/cash).

<sup>56</sup> Additional information may be found at [www.bankofengland.co.uk/banknotes/current/index.htm](http://www.bankofengland.co.uk/banknotes/current/index.htm).

**Figure 10**

**United Kingdom: Security and Accessibility Features**



Front

**Security Features**

1. Intaglio printing
2. Metallic thread
3. Watermark
4. Print quality
5. Holographic strip
6. Microlettering
7. See-through register

**Accessibility Features**

8. Large denomination numerals
  - Different sizes
  - Different colors



Back



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.  
SOURCE: Bank of England.



- Hologram
- UV light
- Microlettering
- Foil (on £50 note)

### ***Accessibility Features***

- Sizes that vary by denomination
- Colors that vary by denomination
- Large denomination numerals
- Densely colored recognition symbols to indicate denomination:
  - £5: turquoise circle
  - £10: orange diamond
  - £20: purple square
  - £50: red triangle

## ***United States (see Figure 11)***

The United States government is the sole issuer of U.S. banknotes (currency name: dollar; currency code: USD; currency symbol: \$).<sup>57</sup> The BEP, a part of the U.S. Treasury Department, produces U.S. banknotes, which are placed into circulation by the Federal Reserve Banks. Banknotes are made of paper composed of 25 percent linen and 75 percent cotton, with red and blue synthetic fibers distributed evenly throughout the paper. U.S. banknotes do not vary by size or primary color across denominations; they measure 2.61 inches wide by 6.14 inches long and 0.0043 inches thick (or 66.3 mm wide × 155.96 mm long and 0.11 mm thick). There are seven denominations of U.S. banknotes (\$1, \$2, \$5, \$10, \$20, \$50, and \$100). The \$100 note has been the largest denomination issued since 1969. The \$2 banknote circulates in small numbers.

The estimated cost of producing U.S. banknotes was 5.6 cents per banknote during fiscal year 2006<sup>58</sup>. The estimated average life of a U.S. banknote varies by denomination:

- \$1: 21 months
- \$5: 16 months
- \$10: 18 months
- \$20: 24 months
- \$50: 55 months
- \$100: 89 months

The U.S. government introduced the “New Currency Design” U.S. banknotes in 1996. This was the first major redesign of U.S. banknotes since 1928. Sophisticated security features were added to deter counterfeiting domestically as well as abroad. Security features include color-shifting ink, watermarks, and security threads. In 2003, The “New Color of Money” banknotes were introduced. These banknotes feature different subtle background colors for different denominations to assist the visually impaired. A larger numeral in the lower right corner on the back of the notes was included as an additional accessibility feature. All new Federal Reserve notes issued since 1997 include machine-readable features (such as infrared markings) that might be used by handheld currency readers for the visually impaired. To date, few such readers have been introduced and some users have reported difficulty using them with newer design banknotes (see footnote 25).

### ***Security Features***

- Watermark
- Color-shifting inks
- Fine-line printing patterns (intaglio printing on both the face and back)
- Enlarged off-center portraits
- Low-vision feature
- Machine-readable feature
- Security thread
- Microprinting

### ***Accessibility Features***

- Larger denomination numeral on reverse
- Large portraits
- Subtle color patterns on face and back (Series 2004)

<sup>57</sup> The BEP prints all banknotes, based on production orders sent by the Federal Reserve Banks, and ships the notes to the Federal Reserve; at this point, they are just paper. The notes are placed into circulation by the Federal Reserve Banks, which means the Fed ships them from their vaults to a non-Fed location. Additional information may be found at [www.moneyfactory.gov/](http://www.moneyfactory.gov/).

<sup>58</sup> [www.federalreserve.gov/generalinfo/foia/2007newcurrency.htm](http://www.federalreserve.gov/generalinfo/foia/2007newcurrency.htm).

## DETAIL OF SELECT SECURITY FEATURES FOR THE \$50 U.S. BANKNOTE



### Security Thread

Hold the bill up to the light and look for the security thread, or plastic strip, that is embedded in the paper and runs vertically to the right of the portrait. If you look closely, the words "USA 50" and a small flag are visible along the thread from both sides of the note. This thread glows yellow when held under an ultraviolet light.

### Color-Shifting Ink

Look at the number "50" in the lower right corner on the face of the note. When you tilt the note up and down the color-shifting ink changes color from copper to green.

### Watermark

Hold the bill up to the light and look for the watermark, or faint image, similar to the large portrait of President Ulysses S. Grant. The watermark is part of the paper itself and it can be seen from both sides of the note.

NOTE: The above insert is a partial reproduction of an image from the web site of the U.S. Bureau of Engraving and Printing. The site provides numerous images, information, and tutorials on the characteristics of U.S. banknotes: [www.moneyfactory.gov/newmoney/files/Sec\\_Features\\_50.pdf](http://www.moneyfactory.gov/newmoney/files/Sec_Features_50.pdf).



**Figure 11****United States: Security and Accessibility Features****Front****Security Features**

1. Enlarged, off-center portrait
2. Subtle, over-printed colors
3. Color-shifting ink
4. Fine-line printing patterns
5. Microprinting
6. Watermark
7. Security thread

**Back****Accessibility Features**

8. Large denomination numeral on reverse
- Enlarged portrait
- Colors that vary by denomination



NOTE: See Tables 1 and 2 and the appendix for a complete listing of security and accessibility features.

SOURCE: U.S. Bureau of Engraving and Printing.

## SUMMARY AND CONCLUSIONS

Currency is widely used in the payment systems of all countries. In each system, there are a large number of participants—households, retail merchants, vending machine firms, financial institutions, high-volume currency processors, and the central bank or currency-issuing authority. The objectives of these stakeholders need not necessarily coincide, and some difficulties in settling on an acceptable currency design for the nation is to be anticipated.

In this analysis, we have focused on currency design features that enhance counterfeit deterrence and improve accessibility for the visually impaired. All currencies issued worldwide contain some of these design features but, interestingly, different countries have made different choices. Among banknotes worldwide, only U.S. notes are widely held outside their country of issue. These foreign holdings benefit the United States when interpreted as a type of non-interest-bearing U.S. government debt, and simultaneously benefit foreign holders by providing a stable store of value and medium of exchange in often unstable countries. As a result, the effectiveness of U.S. banknotes' counterfeit deterrence features is a matter of concern worldwide.

All banknotes contain features to deter counterfeiting. Some features, including paper or polymer substrate and intaglio printing, assist the public to readily authenticate notes by touch; indeed, it is widely reported that counterfeit notes are most often detected by the public and bank tellers because "they don't feel right." For authentication, these tactile features are valuable both to normally sighted and visually impaired users. Other note features, including microprinting, magnetic inks, color-varying fluorescent threads, and infrared components, are valuable for machine authentication across a wide range of devices, from handheld devices and vending machines to high-speed currency sorters. Recently published analyses argue that continuing advances in printing technology will require banknote designers to work aggressively to remain ahead of sophisticated counterfeiters.

All banknotes also contain features to assist the visually impaired. Published studies have concluded that the single feature of greatest value for the visually impaired in denominating notes is note sizes that vary by denomination. More than 180 countries in the world issue banknotes. Only two major currency-issuing authorities issue notes that do not vary in size by denomination—Canada and the United States. Some nation's have selected designs in which bright primary colors vary by denomination—Canadian and euro notes, for example—while in others, such as the Series-2004 U.S. banknotes and Bank of Japan notes, subtle background colors vary by denomination. Most current note designs include larger denomination numerals than previous designs—Canadian and euro notes feature perhaps the most prominent numerals. Series-2004 Federal Reserve notes feature an enlarged denomination numeral on the reverse, albeit smaller than the Canadian or euro note numerals.

The goal of our analysis has been to increase public awareness of the variety, and the trade-offs, among currency design features worldwide. We will have been successful if each reader appreciates a bit more the banknotes they use every day.

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## APPENDIX

### **Web Sites for Data on Currency Features, Counterfeit Activity, and Numbers of Notes in Circulation**

#### **Australia**

##### *Currency features:*

Currency Features: [www.rba.gov.au/CurrencyNotes/SecurityFeaturesAndCounterfeitDetection/security\\_features\\_on\\_australias\\_notes.html](http://www.rba.gov.au/CurrencyNotes/SecurityFeaturesAndCounterfeitDetection/security_features_on_australias_notes.html) [www.rba.gov.au/CurrencyNotes/vision\\_impaired.html](http://www.rba.gov.au/CurrencyNotes/vision_impaired.html)

##### *Counterfeit volume:*

[www.rba.gov.au/PublicationsAndResearch/RBAAnnualReports/2005/Html/bus\\_serv.html](http://www.rba.gov.au/PublicationsAndResearch/RBAAnnualReports/2005/Html/bus_serv.html)  
[www.rba.gov.au/PublicationsAndResearch/RBAAnnualReports/2006/Html/bus\\_serv.html](http://www.rba.gov.au/PublicationsAndResearch/RBAAnnualReports/2006/Html/bus_serv.html)

##### *Notes in circulation:*

[www.rba.gov.au/CurrencyNotes/Statistics/notes\\_on\\_issue.html](http://www.rba.gov.au/CurrencyNotes/Statistics/notes_on_issue.html)

#### **Canada**

##### *Currency features:*

[www.bankofcanada.ca/en/banknotes/counterfeit/security\\_features.html](http://www.bankofcanada.ca/en/banknotes/counterfeit/security_features.html) [www.bankofcanada.ca/en/banknotes/accessibility.html](http://www.bankofcanada.ca/en/banknotes/accessibility.html)

*Counterfeit volume*

[www.rcmp.ca/factsheets/fact\\_counterfeit\\_e.htm](http://www.rcmp.ca/factsheets/fact_counterfeit_e.htm)  
[www.rcmp.ca/scams/counter\\_e.htm](http://www.rcmp.ca/scams/counter_e.htm)

*Notes in circulation:*

[www.bankofcanada.ca/en/annual/2006/annualreport\\_2006.pdf](http://www.bankofcanada.ca/en/annual/2006/annualreport_2006.pdf)

**Euro Currency Area**

*Currency features:*

[www.ecb.int/bc/euro/banknotes/security/html/index.en.html](http://www.ecb.int/bc/euro/banknotes/security/html/index.en.html)  
[www.ecb.int/bc/euro/banknotes/visually/html/index.en.html](http://www.ecb.int/bc/euro/banknotes/visually/html/index.en.html)

*Counterfeit volume:*

[www.ecb.int/press/pr/date/2007/html/pr070112.en.html](http://www.ecb.int/press/pr/date/2007/html/pr070112.en.html)

*Notes in circulation:*

[www.ecb.int/bc/faqbc/figures/shared/number\\_of\\_banknotes\\_circulation\\_pdf\\_web.pdf?](http://www.ecb.int/bc/faqbc/figures/shared/number_of_banknotes_circulation_pdf_web.pdf?)

**Hong Kong**

*Currency features:*

[www.info.gov.hk/hkma/new\\_hk\\_banknotes/eng/index.htm](http://www.info.gov.hk/hkma/new_hk_banknotes/eng/index.htm)  
[www.info.gov.hk/hkma/eng/viewpt/20030904e.htm](http://www.info.gov.hk/hkma/eng/viewpt/20030904e.htm)

*Counterfeit volume:*

Not available

*Some discussion on counterfeiting:*

[www.info.gov.hk/hkma/eng/press/2007/20070320e3.htm](http://www.info.gov.hk/hkma/eng/press/2007/20070320e3.htm)

*Notes in circulation:*

[www.info.gov.hk/hkma/eng/statistics/msb/new\\_msb\\_tables\\_b.htm#money](http://www.info.gov.hk/hkma/eng/statistics/msb/new_msb_tables_b.htm#money)  
[www.info.gov.hk/hkma/ar2005/english/economic/economic06.htm](http://www.info.gov.hk/hkma/ar2005/english/economic/economic06.htm)

**Japan**

*Currency features:*

[www.boj.or.jp/en/type/release/zuiji/kako03/bnnew3.htm](http://www.boj.or.jp/en/type/release/zuiji/kako03/bnnew3.htm)

*Counterfeit volume:*

[www.boj.or.jp/en/type/release/teiki/ar/data/ar0605.pdf](http://www.boj.or.jp/en/type/release/teiki/ar/data/ar0605.pdf)

*Notes in circulation:*

[www.boj.or.jp/en/type/stat/dlong/fin\\_stat/money/cdab0010.csv](http://www.boj.or.jp/en/type/stat/dlong/fin_stat/money/cdab0010.csv)

**Singapore**

*Currency features:*

[www.mas.gov.sg/currency/currency\\_info/The\\_Singapore\\_Currency.html](http://www.mas.gov.sg/currency/currency_info/The_Singapore_Currency.html)  
[www.mas.gov.sg/resource/currency/currency\\_info/Brochure%20on%20\\$2%20Polymer%20Note.pdf](http://www.mas.gov.sg/resource/currency/currency_info/Brochure%20on%20$2%20Polymer%20Note.pdf)

*Counterfeit volume:*

Not available

*Some discussion on counterfeiting:*

[www.mas.gov.sg/news\\_room/letters\\_to\\_editors/2007/No\\_reason\\_for\\_retailers\\_not\\_to\\_accept\\_100dollars.html](http://www.mas.gov.sg/news_room/letters_to_editors/2007/No_reason_for_retailers_not_to_accept_100dollars.html)

*Notes in circulation:*

[www.mas.gov.sg/currency/currency\\_stat/Currency\\_in\\_Circulation\\_Notes.html](http://www.mas.gov.sg/currency/currency_stat/Currency_in_Circulation_Notes.html)

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### **Sweden**

#### *Currency features:*

[www.riksbank.com/templates/SectionStart.aspx?id=10890](http://www.riksbank.com/templates/SectionStart.aspx?id=10890)  
[www.riksbank.com/upload/Dokument\\_riksbank/Kat\\_publicerat/Broschyrer/banknotes\\_coins\\_060925.pdf](http://www.riksbank.com/upload/Dokument_riksbank/Kat_publicerat/Broschyrer/banknotes_coins_060925.pdf)  
[www.riksbank.com/templates/Page.aspx?id=23941](http://www.riksbank.com/templates/Page.aspx?id=23941)

#### *Counterfeit volume:*

[www.riksbank.com/upload/Dokument\\_riksbank/Kat\\_publicerat/Rapporter/2007/arsred\\_popvers\\_06\\_eng.pdf](http://www.riksbank.com/upload/Dokument_riksbank/Kat_publicerat/Rapporter/2007/arsred_popvers_06_eng.pdf)

#### *Notes in circulation:*

[www.riksbank.com/upload/Dokument\\_riksbank/Kat\\_publicerat/Rapporter/2007/arsred\\_popvers\\_06\\_eng.pdf](http://www.riksbank.com/upload/Dokument_riksbank/Kat_publicerat/Rapporter/2007/arsred_popvers_06_eng.pdf)

### **Switzerland**

#### *Currency features:*

[www.snb.ch/en/iabout/cash/current/design/id/cash\\_current\\_design\\_principle](http://www.snb.ch/en/iabout/cash/current/design/id/cash_current_design_principle)  
[www.snb.ch/en/iabout/cash/current/id/cash\\_security](http://www.snb.ch/en/iabout/cash/current/id/cash_security)

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[www.snb.ch/ext/link?url=%2fen%2fmmr%2freference%2fannrep\\_2004\\_accrep%2fsource](http://www.snb.ch/ext/link?url=%2fen%2fmmr%2freference%2fannrep_2004_accrep%2fsource)  
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### **United Kingdom**

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[www.bankofengland.co.uk/banknotes/kyb\\_lo\\_res.pdf](http://www.bankofengland.co.uk/banknotes/kyb_lo_res.pdf)  
[www.bankofengland.co.uk/banknotes/security/index.htm](http://www.bankofengland.co.uk/banknotes/security/index.htm)

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# Experiments in Financial Liberalization: The Mexican Banking Sector

Rubén Hernández-Murillo

Since the liberalization of its trade in the mid-1980s, Mexico has pursued an aggressive globalization strategy, which today makes it the country with the most free trade agreements in the world. This liberalization strategy has also included the banking sector, particularly since 1997, when all restrictions to the entry of foreign banks were removed. The history of the banking sector in Mexico includes episodes of nationalization in 1982, privatization in 1992, and near-complete failure in 1995. Since then, however, the Mexican government has undertaken a series of bold reforms that have contributed to the modernization of its financial system. This paper documents the evolution of Mexico's banking sector starting from its nationalization in 1982 and culminating with the increased entry of foreign banks in recent years that has driven the recovery of bank credit to the private sector. (JEL G18, G21, G28, P11, D23)

Federal Reserve Bank of St. Louis *Review*, September/October 2007, 89(5), pp. 415-32.

In the mid-1980s Mexico started to liberalize its trade; and, since the signing of the North American Free Trade Agreement (NAFTA) in early 1994, Mexico has followed an aggressive globalization strategy, placing about 90 percent of its trade flows under free trade agreements with over 40 countries. These policies have made Mexico the country with the most free trade agreements in the world.<sup>1</sup> Mexico's liberalization strategy has also included its financial sector and, in particular, the banking industry.

Mexico's experience with financial liberalization provides an interesting case study for at least two reasons. First, economic theory suggests that financial liberalization bolsters economic growth. Mexico's path toward financial liberalization has been an arduous one and includes several failed attempts, which, until recently, prevented the

development of its banking sector and limited the growth of financial credit to the private sector, which is necessary for economic development.

Second, given the nature of some of the experiments that have been followed, Mexico's experience can also provide lessons about the effectiveness of aggressive openness reforms targeted at improving competition in the banking industry and at increasing credit to the private sector—namely, the elimination of all restrictions on foreign ownership of banking assets in 1997, which allowed foreign banks to dominate the sector. One of the most recent developments in this regard is the approval in 2006 of Wal-Mart's bid to create a commercial bank in Mexico.

In this paper I describe the evolution of Mexico's banking sector by reviewing (roughly in chronological order) the reforms that have been implemented since 1982, when Mexico's financial system was nationalized. Continuing problems with Mexico's institutional and legal framework persisted even after the banking sector

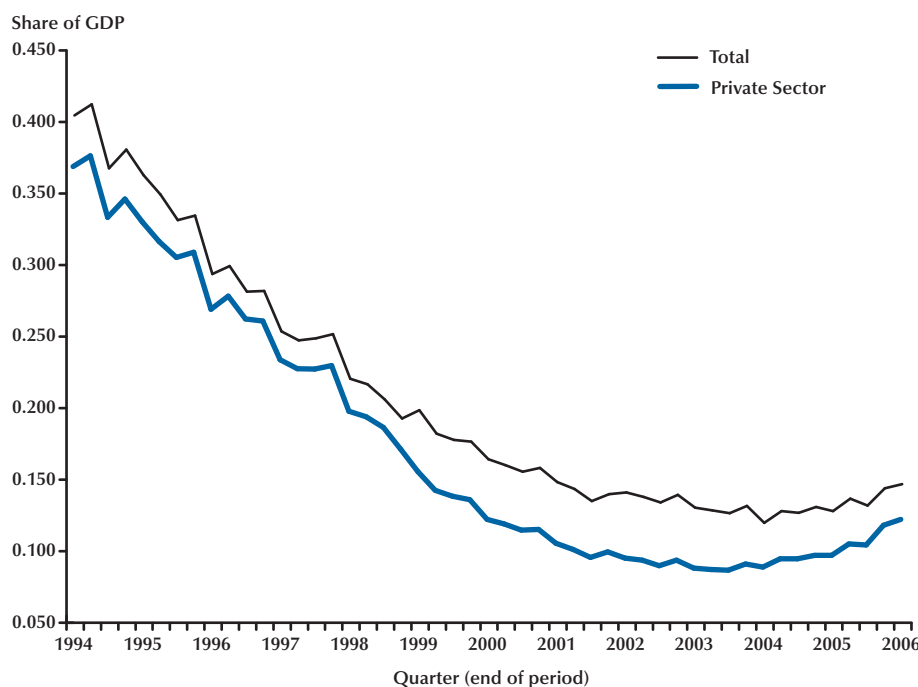
<sup>1</sup> At the time of this writing, Mexico was negotiating a free trade agreement with *Mercosur* to join this bloc as an associate member.

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Rubén Hernández-Murillo is a senior economist at the Federal Reserve Bank of St. Louis. The author thanks Gabriel Cuadra at Banco de Mexico for help in obtaining the data used for the figures. Marcela Williams and Christopher Martinek provided research assistance.

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**Figure 1****Credit by Commercial Banks**

SOURCE: Banco de México.

was re-privatized in 1992 and generated distorted incentives among lenders who engaged in risky lending practices. These practices ultimately led to a banking crisis by 1995, forcing the Mexican government to implement a massive rescue program to prevent generalized failure in the sector.

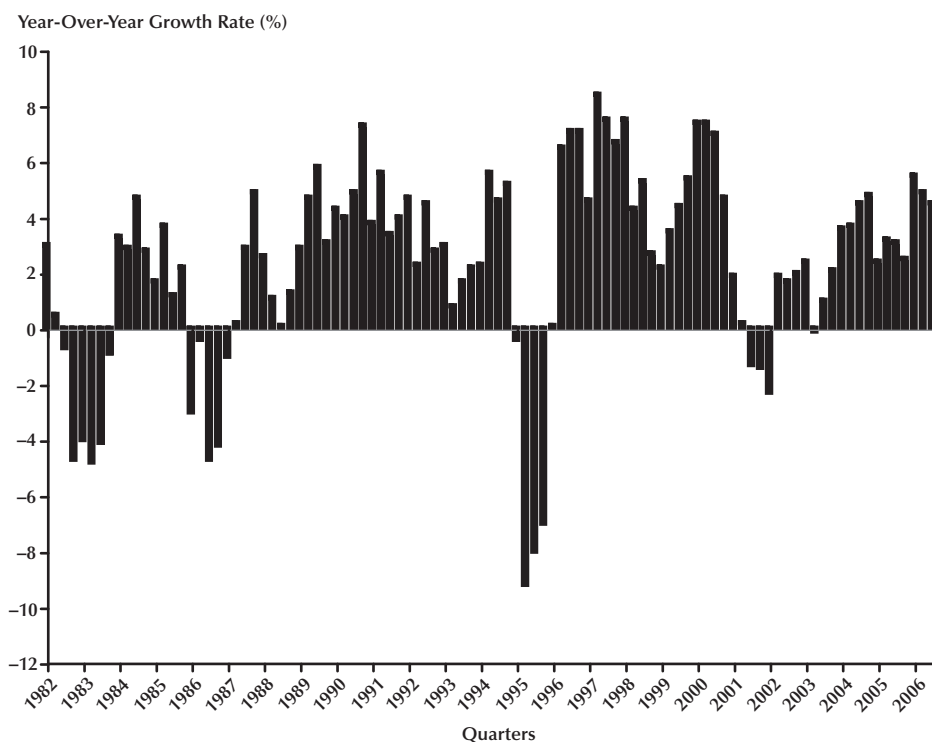
Since 1997, however, the Mexican government has undertaken a series of bold reforms: for example, extensive reforms to banks' accounting standards, elimination of all barriers to the entry of foreign banks, reforms to personal and business bankruptcy laws, improvements in credit rating technology and regulatory changes to promote the use of credit bureaus, reforms to capitalization and risk management standards that conform with the recommendations of the Basel II accords, and, more recently, reforms that promote the securitization of mortgage loans. By the end of 2006, banks in Mexico were owned almost entirely by foreign financial institutions, with subsidiaries of

foreign banks representing more than 80 percent of total banking assets in the system.

These reforms have started to produce positive results and promise even more favorable changes in the years ahead. The most positive result thus far is that the credit crunch that followed the banking crisis of 1995 appears to have subsided; and bank credit to the private sector has been growing rapidly since 2004. (See Figure 1.)

## NATIONALIZATION OF THE BANKING SYSTEM, 1982

At the end of the administration of President López Portillo, in 1982, Mexico experienced its most severe crisis since 1932, with real gross domestic product (GDP) declining by 4.7 percent in the fourth quarter of 1982. (See Figure 2.) The crisis was triggered by adverse shocks to oil prices

**Figure 2****Real GDP**

SOURCE: Banco de México.

and world interest rates, but was ultimately caused by a disorderly expansionary fiscal policy largely supported by borrowing from international capital markets and by borrowing from the central bank (i.e., simply printing money to finance the deficit), which the government had followed since the 1970s. The government devalued the currency and defaulted on foreign debt payments, which caused Mexico to lose access to international credit markets.

In September 1982, the government also announced a decree to amend the constitution and nationalize 58 of the 60 banks in the sector. The exceptions were Citibank, which has had a presence in Mexico since 1929, and Banco Obrero, which was owned by a labor union.<sup>2</sup>

During the new administration of President Miguel de la Madrid Hurtado, the banking system was consolidated into a smaller number of banks,

but remained heavily regulated otherwise. The number of commercial banks was reduced to 29 in 1983, to 20 in 1985, and finally to 18 in 1988.

In the early 1980s, the banking sector was the dominant financial intermediary and, along with the stock market, it constituted the core of the financial system. However, its role was diminished throughout the nationalization episode as the government restricted universal banking activities, prohibiting banks from forming integrated financial groups to offer other financial services beyond banking; consequently, other types of financial intermediaries began to take on more important roles.<sup>3</sup> Private investors turned to alternative sources of financing, such as commercial paper,

<sup>2</sup> See Bubel and Skelton (2002).

<sup>3</sup> With the re-privatization of the banking sector in 1992, banks would again operate under a universal banking structure.

further reducing the role of banks as financial intermediaries.

From 1982 to 1984, for example, brokerage firms essentially controlled the sale and purchase of financial instruments, which included commercial paper and bonds.<sup>4</sup> Although short-term Mexican Treasury bills had been introduced since 1978, the interest rate on these instruments was set exogenously. This policy limited the extent of their use to finance the public deficit. In 1982, however, a new auction mechanism was developed for their exchange, allowing the market to determine the rate of return.<sup>5</sup>

In 1984, the new administration began to sell off bank operations that did not take deposits and make loans. The goal was to separate different financial intermediation roles among independent types of operations to allow private investors (often former bank owners) to form and operate stock brokerage firms, insurance and re-insurance firms, and currency exchange firms.<sup>6</sup>

After being excluded from international credit markets, from 1982 to 1988, the Mexican government turned to domestic credit to finance its fiscal deficits, imposing heavy reserve requirements on the newly nationalized banks. As a result, bank lending to the private sector declined dramatically.<sup>7</sup> The government also imposed many other constraints on the banking sector, which induced lending inefficiencies, including interest rate ceilings on bank deposits and loans, as well as mandated lending quotas on high-priority economic sectors.<sup>8</sup>

Commercial banks could freely allocate only up to 25 percent of their credit, for which they could charge market lending rates; but they were required to allocate all other loans to the federal government or to targeted sectors of the economy. Furthermore, until 1989, the government also controlled banks' operational procedures, such as deciding on the location and number of bank

branches that could be created and the number of employees that were hired and approving the banks' annual budgets for income and expenses.

## FINANCIAL LIBERALIZATION REFORMS, 1988-89

Starting in 1988, a new series of reforms were initiated to make the financial system more competitive. Among these reforms was the elimination in April 1989 of controls on interest rates and the sectoral quotas imposed by the government on commercial lending. The reserve requirements on private deposits were eliminated in 1991. These reforms culminated with the re-privatization of the banking sector in 1991 and 1992 under the administration of President Carlos Salinas de Gortari.

By this time, the Mexican money market had become more liquid and the government increased the issuance of short-term Treasury bills so that it no longer relied on commercial bank financing.<sup>9</sup> Mexico had also regained entry to international capital markets by 1989 after the implementation of the Brady Plan and enactment of a stabilization plan (begun in 1987).<sup>10</sup> Bank credit to the private sector began to increase dramatically after 1989.<sup>11</sup>

Development banks, that is, state-controlled banks charged with providing credit to private and state-owned enterprises in targeted sectors in the economy, also changed significantly. The share of loans allocated to state-owned firms decreased and loans were increasingly allocated to private enterprises. At the same time, however, total development bank credit to nonfinancial firms in the private sector decreased as the regulations on commercial banking were removed.<sup>12</sup>

During this period, the regulatory framework of the financial system was updated and new laws

<sup>4</sup> See Trigueros (1995).

<sup>5</sup> See Katz (1990).

<sup>6</sup> See Gruben and McComb (1997).

<sup>7</sup> See Gruben and McComb (1997).

<sup>8</sup> See Gelos and Werner (2002).

<sup>9</sup> See Gruben and McComb (1997).

<sup>10</sup> The Brady Plan, named after U.S. Treasury Secretary Nicholas Brady, was the mechanism used to restructure bonds issued by many Latin American countries that defaulted on their debt in the 1980s. Mexico was the first country to repay its Brady debt, in 2003.

<sup>11</sup> See Gelos and Werner (2002).

<sup>12</sup> See Gonzalez-Anaya and Marrufo (2001).

were drafted to regulate commercial banks and insurance and bonding companies, as well as the stock market and investment banks. In 1990, the Salinas administration created a new deposit insurance authority, FOBAPROA (Banking Fund for the Protection of Savings).

In July 1990, the government passed laws allowing for the formation of integrated financial groups that could consolidate different types of financial intermediation under a scheme of universal banking. The law allowed for the integration of banks with leasing, factoring, currency exchange, mutual fund management, and asset-based warehousing firms; and, separately, it allowed for the integration of brokerage firms with leasing, factoring, currency exchange, mutual fund management, and asset-based warehousing firms.<sup>13</sup> The final group allowed was holding companies.<sup>14</sup> Initially, however, restrictions remained for the integration of commercial banks with brokerage firms and insurance and bonding firms.<sup>15</sup>

## THE PRIVATIZATION OF THE BANKING SECTOR, 1990-92

The privatization of commercial banks was part of a broad program of privatization of state-run enterprises under a general stabilization program that included increased fiscal discipline and cuts in government spending, as well as inflation-reduction measures initiated by the de la Madrid administration. The constitutional amendment allowing for the re-privatization of the banking sector was announced in May 1990. In August of that year, the finance ministry announced the principles that would inspire the privatization process. Two of the goals of the program were to increase competition and efficiency in the financial system and to improve bank capitalization.

The government took great efforts to guarantee transparency of the process; they indicated that the sale price of the banks would be consistent with valuations based on objective criteria. But the results of these valuations, however, were not made public, and the overvaluation of some banks became obvious after the purchase was completed.

Some studies underscore several problems with the financing schemes that buyers adopted to purchase these banks from the government, which in some cases included borrowing from the same banks they were buying.<sup>16</sup> These studies seem to agree that the privatization auctions were designed to maximize the purchase price of the banks.

The auctions were conducted from June 1991 through July 1992. Interested parties were allowed to acquire the controlling shares of only one bank, and the privatization was open only to Mexican nationals. There were six rounds of bidding. Packages of three or four banks were sold in each round. The sequencing of the sale was designed to increase competition in subsequent stages of the bidding process. The largest banks were sold in the first rounds. Interestingly, the government provided no minimum bid or reserve price information.<sup>17</sup> At the end of the process, banks were sold at an average price-to-book value ratio of 3.04, producing about \$12.4 billion for the government.<sup>18</sup>

Some studies suggest that buyers paid those prices anticipating a concentrated market structure with oligopolistic profits. In fact, of the existing 18 banks, the 4 largest banks controlled 70 percent of total bank assets, and Mexican banks did not face competition from the entry of foreign banks, as they were not allowed to participate in the privatization auctions.<sup>19</sup>

The lack of a competitive market structure in the newly privatized banks was not the only prob-

<sup>13</sup> Asset-based warehousing firms, or *almacenes generales de depósito*, stored goods in exchange for certificates of deposit, which could be sold to other credit institutions. See Katz (1990).

<sup>14</sup> See Unal and Navarro (1999).

<sup>15</sup> See Katz (1990).

<sup>16</sup> See Unal and Navarro (1999) and Haber (2005b).

<sup>17</sup> See Avalos and Hernández Trillo (2006).

<sup>18</sup> The calculation of the average is weighted by assets. See Murillo (2002) and Unal and Navarro (1999).

<sup>19</sup> See Haber (2005b,c).



lem. More fundamental problems plagued the institutional framework under which the banks were to operate. From the outset of the new privatization era, bankers faced incentives that would encourage inefficient, risky lending.

Haber (2005b,c), for example, argues that at the time of the privatization, Mexico had weak property rights institutions to assess the credit worthiness of borrowers and to enforce the contract rights of bankers. Furthermore, he also argues that out of the privatization process emerged a set of institutions that reduced the incentives of bank directors, bank depositors, and bank regulators to enforce the prudent behavior of the newly privatized banks. Some of these institutions would not be reformed until after the 1995 collapse. This view is shared by Unal and Navarro (1999), who argue that, despite the recent reforms, the new banks operated under an outdated regulatory environment and that the supervisory agencies were often unable to implement newly adopted regulations or to enforce existing rules.

Efficient monitoring both internally and by the government was also lacking. No regulatory body required the banking sector to adhere to the generally accepted accounting principles in international markets. Accounting standards were very lax and, in particular, did not require banks to report the entire value of past-due loans as nonperforming, but only the past-due interest payments; banks were allowed to roll over the principal of those loans. Banks were not required to provide consolidated financial reports until 1995, even though at this time they were operating under a universal banking structure.<sup>20</sup> This lack of regulation made it difficult to establish limits on lending within financial groups. In addition, the Mexican central bank implicitly guaranteed unlimited deposit insurance through FOBAPROA. There were no credit bureaus, and legal institutions in Mexico did not provide an adequate enforcement of lending contracts.

In contrast with the expectations of an oligopolistic market structure, banks soon were competing for market share.<sup>21</sup> Credit was growing very

rapidly, and nonperforming loans soon became a problem.

## THE BANKING BAILOUT

### *Risky Lending Practices*

The December 1994 devaluation and macroeconomic crisis that ensued was not the origin of the banking crisis; it was merely the trigger.<sup>22</sup> Induced by the lack of an appropriate legal and regulatory environment, banks had been engaged in risky lending practices almost immediately after the privatization process was concluded and past-due loans had been rising dramatically prior to the devaluation.

Several factors—including low inflation, improvements in the fiscal surplus of the government, an exchange rate under a controlled rate of depreciation, and low real interest rates—contributed to an expansion of both bank credit and financial intermediation in general. The size of the financial sector, given by M4 as a share of GDP, reached 47 percent at its peak in 1994.<sup>23</sup> (See Figure 3.)

From December 1988 to November 1994, credit from local commercial banks to the private sector rose in real terms by 277 percent, or 25 percent per year.<sup>24</sup> Nonperforming loans, however, grew even faster. Between December 1991 and December 1993 alone, gross past-due loans more than tripled in absolute terms, while the share of *reported* nonperforming loans to total loans rose from 4.13 to 7.26 percent.<sup>25</sup> This situation per-

<sup>22</sup> After a failed attempt of a controlled devaluation on December 20, 1994, a run against the peso led to the collapse of the semi-fixed exchange rate regime and the peso was allowed to float on December 22, 1994. For a detailed account of the events and an analysis of the factors contributing to the vulnerability of Mexico's financial sector, see Calvo and Mendoza (1996) and Gil-Díaz (1998), and also Gruben and McComb (1997).

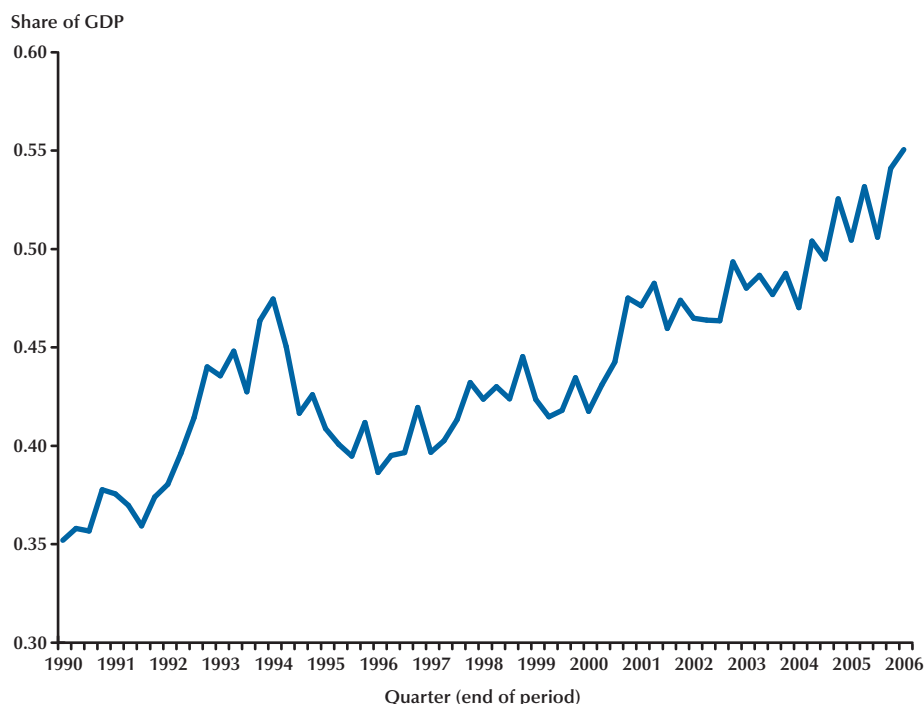
<sup>23</sup> M4 is a broad monetary aggregate defined as M3 + deposits in branches of domestic banks abroad, where M3 = M2 + domestic financial assets held by non-residents, M2 = M1 + domestic financial assets held by residents, and M1 = currency outside of banks, domestic and foreign currency checking accounts in resident banks, domestic and foreign currency current account deposits in resident banks, and sight deposits in savings and loan associations.

<sup>24</sup> See Gil-Díaz (1998).

<sup>25</sup> See Gruben and McComb (2003).

<sup>20</sup> See Gonzalez and Marrufo (2001).

<sup>21</sup> See Gruben and McComb (1997).

**Figure 3****Size of the Financial Sector: M4**

SOURCE: Banco de México.

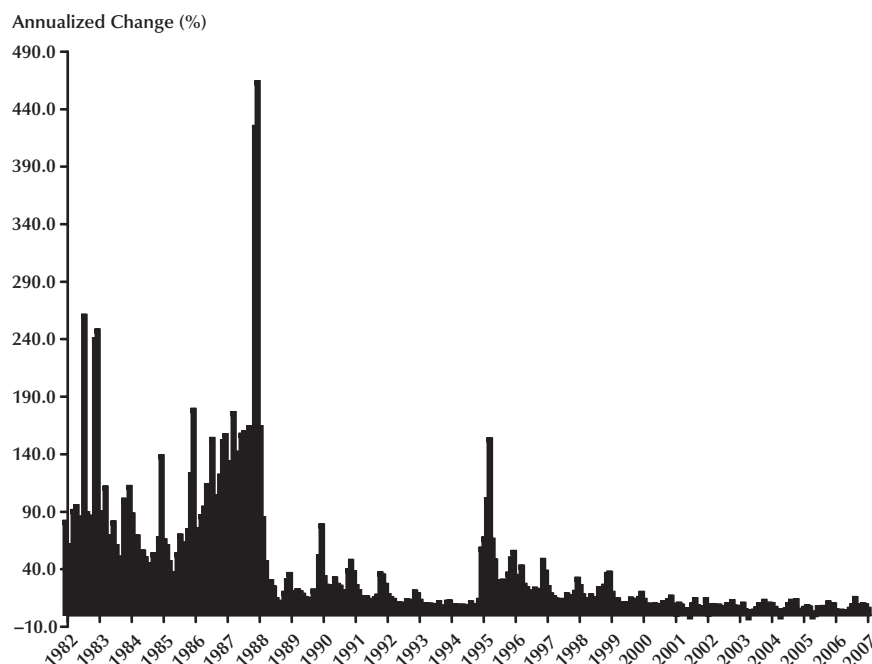
sisted into the bailout episode that followed. Haber (2005b) estimates that, as of December 1991, the ratio of nonperforming loans to total loans (including principal rollovers and the value of loans transferred to FOBAPROA) was 13.5 percent; it increased to 17.1 percent by December 1994, to 36.3 percent by December 1995, and to 52.6 percent by December of 1996.

An example of risky lending behavior was *related lending*, a topic studied by La Porta, López de Silanes, and Zamarripa (2003). Related lending refers to the practice of lending to separate firms in which bank officials have interests either because they own these other firms or their associates or family members do. In their study, the authors tracked a sample of loans outstanding at Mexican banks from the end of 1995 through 1999. They found that about 20 percent of loans were to related parties. They also found that these

parties were more likely to borrow at lower rates, were less likely to post collateral, and were more likely to default than unrelated parties. The authors examined the regulations set forth after the 1990 privatization and noted that very few rules addressed conflicts of interest arising from lending to related parties. The authors identified other key factors, beyond regulation of conflict of interests, that provided incentives to engage in risky lending policies: the universal guarantees provided by FOBAPROA (which guaranteed all deposits up to 100 percent, regardless of the creditworthiness of the bank and the total amount of deposits) and the minimal capitalization requirements imposed on the banks (which were unrelated to the riskiness of the bank's loan portfolio). So, because of the presence of deposit insurance, the lower a bank's capital, the greater its incentive was to take on additional risk because

## Figure 4

### Inflation



SOURCE: Banco de México.

less of their own wealth was at stake.<sup>26</sup> La Porta, López de Silanes, and Zamarripa (2003) argued that banks engaged in excessive related lending because of moral hazard: Legally, bank assets were considered separate from the related firm's assets and regulatory authorities were insuring these loans, too.<sup>27</sup>

### The Rescue Program

The devaluation of December 1994 generated capital outflows and high inflation. Real GDP declined by 6.2 percent in 1995, while the annualized inflation rate reached 46.9 percent in December 1995. (See Figures 2 and 4, respectively.) The central bank imposed restrictive credit

and monetary policies in February 1995, and interest rates skyrocketed. Many borrowers were unable to repay their loans. The rising level of past-due loans had put the banking system at the brink of total collapse.<sup>28</sup>

Three regulatory authorities intervened in the design and implementation of the rescue package that started in 1995 and continued through December 1998. The first was Mexico's central bank, Banco de México. The second authority was Mexico's finance ministry, Secretaría de Hacienda y Crédito Público, which is the main financial authority in Mexico ultimately responsible for regulating and supervising the entire financial system. These tasks, however, are delegated to the third regulatory authority, the national banking and securities commission, Comisión Nacional Bancaria y de Valores, which regulates

<sup>26</sup> See Furlong and Keeley (1989) and Keeley (1990).

<sup>27</sup> For additional literature on the moral hazard problems generated by deposit insurance institutions, see Demirgüç-Kunt and Detragiache (2002), Cull, Senbet, and Sorge (2005), and also Martin (2006), as well as references therein.

<sup>28</sup> See Gruben and McComb (1997) and McQuerry (1999).

and supervises all financial intermediaries in Mexico.<sup>29</sup>

The Mexican government adopted several measures to prevent the collapse of the banking system, including efforts to improve banks' immediate liquidity requirements following the December 1994 devaluation, measures to improve capitalization, various debtor relief efforts, and ultimately the transfer of nonperforming loans into public debt, approved by the Mexican Congress in December 1998. The funding of these programs was channeled through the nation's bank deposits insurance institution, whose liabilities amounted to about \$60 billion in February 1998 near the end of the rescue program and represented almost five times the amount received by the government when banks were privatized.<sup>30</sup>

I now review some of the specific programs included in the rescue package that followed the 1995 crisis.

**Liquidity Window.** After the December 1994 devaluation, several banks were unable to roll over their dollar-denominated liabilities. During 1995, the central bank offered short-term dollar-denominated credit through FOBAPROA so that banks could meet immediate dollar liabilities. The terms of these loans were designed so banks could soon find alternative funding sources. The program served its purpose, and all banks that received these loans repayed them.

**Initial Capitalization Program.** In February 1995, the government created a special short-term recapitalization program that would allow banks to raise capital by selling 5-year convertible bonds to FOBAPROA. The goal was to help banks increase their capital-to-assets ratio above 8 percent while they tried to raise additional capital on their own.<sup>31</sup> The program included reforms that removed restrictions on the ways banks could increase capital. Banks were charged higher interbank interest rates and were prohib-

ited from issuing other subordinated debt until they exited the program. The program was not entirely successful, as many banks avoided participation, motivated in part because the market seemed to interpret participation as a sign of weakness and imminent regulatory intervention by the authorities.<sup>32</sup> Many banks tried to raise capital on their own and failed to attain the capitalization requirements.

**Loans for Bonds Swaps.** The core program in the rescue package had the goal of preventing generalized failure in the banking system. With this program, FOBAPROA initially acquired only a portion of past-due loans from commercial banks and acquired the rights to any payments that could be recovered by the banks.<sup>33</sup> In exchange, banks had to purchase FOBAPROA-issued special 10-year non-negotiable bonds backed by Mexico's central bank. Banks were also required to raise new capital at the rate of one peso for each two pesos of loans transferred to FOBAPROA. Additionally, FOBAPROA bonds were indexed in a new unit of account (referred to as UDI or Unidad de Inversión) created in 1995, which was indexed to the inflation rate to guarantee the real value of funds. When the maturities of these bonds were reached, banks would be allowed to either roll over the debt or sell it. Mortgage loans were also included in the rescue package.

Participating banks agreed to surrender their institutions to banking authorities if they were unable to convert their debt with FOBAPROA into equity capital.<sup>34</sup> Some banks were unable to raise additional capital, and FOBAPROA undertook further capitalization efforts to help these banks. These efforts allowed banks to continue to operate. When FOBAPROA determined that a bank was no longer viable, the bank would be liquidated and its assets would be sold. Banks acquiring these assets would also take over the bank's liabilities, which were backed by matching loans from FOBAPROA.

<sup>29</sup> Prior to 1995, the banking and securities commissions were two separate agencies.

<sup>30</sup> See Hernández Trillo and López Escarpulli (2001).

<sup>31</sup> This was the minimum capitalization ratio recommended by the Basel I accords.

<sup>32</sup> See Mackey (1999).

<sup>33</sup> Later, as past-due loans continued to rise, more loans were also included in the rescue package.

<sup>34</sup> See McQuerry (1999).



The national banking commission had the right to formally intervene in cases of irregular practices, which ranged from failure to meet reserve and capitalization requirements to illicit operations and fraud. The authorities would take control of the bank's management and suspend stockholder privileges while the investigations were ongoing. Meanwhile, FOBAPROA continued to support these banks in their capitalization efforts. By June 1998, the authorities had intervened in the operations of 12 banks. Two of these, Banca Cremi and Banco Unión, were under the authorities' control prior to the peso devaluation. Additionally, several banks, including Banca Serfín, Mexico's third largest bank, underwent de facto intervention and were subjected to a more strict supervisory process, which included many of the controls used in a formal intervention.<sup>35</sup>

**NAFTA and Foreign Banks.** As part of the rescue program, early in 1995, the government also allowed foreign investors to purchase a troubled bank, if that bank accounted for no more than 6 percent of total Mexican bank capital; but these foreign entities were not allowed to start new banks yet. This reform legalized the purchase of all but the three largest banks.<sup>36</sup> The new law also raised the maximum amount of banking capital that could be controlled by foreign banks to 25 percent, compared with the previous limit of 9 percent initially allowed by NAFTA in 1994.

**Debt Relief Programs.** Throughout the 1995-98 banking bailout episode, there were several debt relief programs designed to provide support to small borrowers (individually or in specific industry sectors) and help them repay their bank loans. Some programs were financed by the government and others involved negotiations among the banks and their borrowers. All these programs were supervised by the national banking commission.

These programs included features such as reduced interest rates, payment discounts, and debt restructuring into the newly created inflation-indexed accounting unit with a fixed real interest rate. Debtors were responsible for repaying the

real interest rate, while the government covered the difference between the nominal and real interest rates.

Mackey (1999) found that these debt relief programs succeeded in helping a large number of small debtors repay their loans. The overall impact on these programs on total past-due loans was most probably minimal. However, Mackey (1999) argues that in designing these programs, the authorities were more interested in preventing generalized runs against the banking system caused by lack of depositors' trust.

## POST-CRISIS FINANCIAL REFORMS

Since 1995 the national banking commission has sought the advice of U.S. government agencies, such as the Federal Reserve and the Office of the Comptroller of the Currency, as well as international organizations, such as the World Bank and the International Monetary Fund, to improve its regulatory practices (Mackey, 1999). The Mexican government has also striven since 1997 to align these practices with international standards, particularly with regard to banking accounting standards, capitalization requirements, and credit risk qualifications; it has also enacted reforms since then to improve bankers' incentives, including changes to FOBAPROA and reforms to bankruptcy and mortgage laws, as well as the promotion of private credit bureaus.

### *Bank Accounting Standards and Supervision Practices*

New bank accounting standards in Mexico were approved by the banking regulatory authority in December of 1995 and were adopted in January 1997.<sup>37</sup> The new criteria imposed greater disclosure on banks and made their balance sheets more directly comparable with those in other countries, particularly with regard to the disclosure of nonperforming loans. The new rules also required consolidated balance sheets and income statements for financial groups.

<sup>35</sup> See Mackey (1999).

<sup>36</sup> See Gruben and McComb (1997).

<sup>37</sup> See Mackey (1999), McQuerry and Espinosa (1998), and Del Ángel, Haber, and Musacchio (2006).

As related earlier, one of the problems that led to the banking crisis of 1995 was the lack of strict disclosure rules regarding nonperforming loans. Banks calculated nonperforming loans with a *due payments criteria*; that is, only loan payments 90-days past due were recorded as nonperforming, as opposed to classifying as nonperforming the value of the entire loan itself. All the while, the outstanding balance could still accrue interest. In addition, if loans were restructured or renegotiated, the loan was reclassified as a new loan. As a result of these practices, a bank's income statement and its capital adequacy ratios did not reflect accurate information about the bank's financial health.<sup>38</sup>

Under the new laws, the value reported as past due was now the total unpaid balance of the loan, and loans were listed as nonperforming after a set number of payments went unpaid. The new criteria also required more strict provisions for loan losses, and interest could no longer be accumulated.

The new laws also set stricter standards to deal with related lending. In particular, a bank was required to inform the banking regulatory authority of all the details of a related loan, after the loan was approved by a majority of the bank's directors. Limits were also set on the total amount of loans made to related parties.<sup>39</sup>

In 1999, the banking authorities also established new rules for the assessment and measurement of risks; these rules were strengthened in 2003 to conform with recommendations on capital adequacy and contingency reserve requirements from the Basel II accords.

### Reforms to FOBAPROA

In December 1998, Mexico's deposit insurance institution, FOBAPROA, was replaced by a new entity, the Institute for the Protection of Bank Savings, or IPAB. This institution is now responsible for insuring bank deposits and managing bank support programs. It differs from FOBAPROA in several aspects and is more similar in design

to other international deposits insurance institutions, such as the Federal Deposit Insurance Corporation in the United States. This new institution is designed to offer more protection to small depositors and allows larger depositors to face more risk. In particular, whereas FOBAPROA offered implicitly unlimited guarantees on deposits, IPAB offers limited guarantees explicitly. IPAB also has the authority to formally intervene if it detects irregularities in a member bank, although the authority of the national banking commission supersedes that of the IPAB.

In 2005, regulations established an upper bound on the total amount of insured deposits of 400,000 UDIs (about \$100,000 at the then-prevailing exchange rate) per individual or business by bank.<sup>40</sup> In general, the reason to limit deposit-insurance coverage is to encourage depositors with large balances to monitor bank behavior and thereby establish a better link between deposit interest rates and balances and a bank's risk taking.

### Bankruptcy Laws

Before the re-privatization, Mexican laws on bankruptcy and debt moratory dated back to 1943. A reform in 1988 created special bankruptcy courts to deal with business bankruptcies, which fell within the purview of federal legislation; personal bankruptcies, in contrast, were legislated at the state level and dealt with in state civil courts. In spite of these reforms, bankruptcy cases in Mexico continued to be notoriously lengthy and complex, as the laws generally provided little incentives for the repayment of debts. As a consequence, lenders often faced difficulties recovering assets from insolvent borrowers. In addition, there were not enough such bankruptcy courts. Banks often settled negotiations with debtors outside of the courts, with great advantages to the latter.<sup>41</sup>

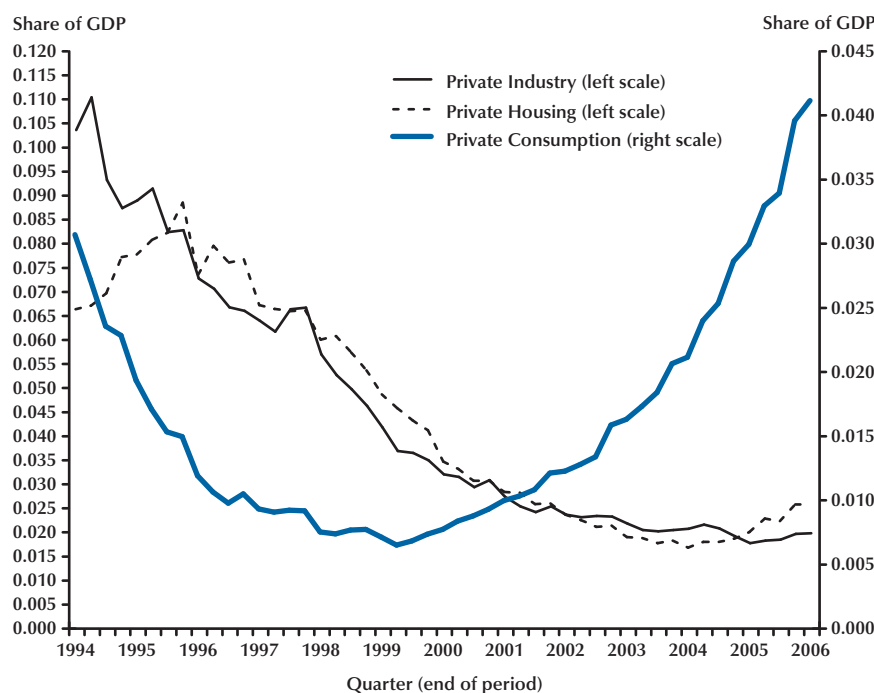
On April 25, 2000, a new law was approved by the lower house of the Mexican Congress that would replace existing bankruptcy laws for per-

<sup>38</sup> See Gil-Díaz (1998).

<sup>39</sup> See Mackey (1999).

<sup>40</sup> See Haber (2005a).

<sup>41</sup> See Mackey (1999).

**Figure 5****Bank Credit to Private Sector**

SOURCE: Banco de México.

sons and businesses. It seems, however, that this new law still falls short in terms of providing banks with adequate repayment guarantees.<sup>42</sup>

### **Mortgage Markets**

After the 1995 crisis, mortgage lending by commercial banks plummeted along with total private lending, and banks all but exited the housing lending market. (See Figure 5.) New financial associations with limited functions (known in Mexico as SOFOLES) had been created in 1993 to foster competition in the financial system; after the 1995 crisis, these non-bank financial intermediaries became important players in the low-income mortgage market.

These non-bank banks borrowed funds from government development banks as well as from

private commercial banks; in turn they gave loans to consumers to purchase homes and autos but were initially prohibited from accepting deposits or investing in securities or derivatives.<sup>43</sup>

In recent years, the role of non-bank banks in providing financing services to the private sector has increased remarkably. From 2000 to 2006 the share of total loans to the private sector provided by non-bank banks increased from 6.3 percent to 9.1 percent. In real terms, total loans by these intermediaries grew by about 130 percent.<sup>44</sup> By December 2006, there were 56 non-bank banks. The largest share of total loans granted by these institutions has been for private housing, reaching about 42 percent by December 2006. The next-largest categories are loans to private industry

<sup>43</sup> See Haber and Musacchio (2005).

<sup>42</sup> See Hernández Trillo and López Escarpulli (2001) and Avalos and Hernández (2006).

<sup>44</sup> Data through September 2006. Source: Secretaría de Hacienda y Crédito Público.

(37 percent) and for private consumption (18 percent).<sup>45</sup>

Mortgage markets in Mexico are currently undergoing a very remarkable transformation. From 2001 to 2006, the average compound annual growth rate of housing loans was 27.3 percent; in 2006, these loans amounted to about \$79.6 billion.<sup>46</sup> Bank lending for private housing began to increase in 2004. (See Figure 5.)

From 1995 to 2002, two government institutions provided most of the funding to non-bank banks; since about 2003, however, mortgage origination by non-bank banks and commercial banks has been funded largely by other sources.<sup>47</sup>

Non-bank banks, investment banks, and the Federal Mortgage Association had been pushing forward the securitization of mortgage-backed bonds to develop a secondary market, which started in 2003, when the first mortgage-backed security was issued for \$178 million.<sup>48</sup>

In 2006, the first commercial bank entered this market. Also in 2006, a new unified property registry began operations in Mexico. Its objective has been to concentrate records for all the existing housing supply as well as new starts that can be purchased with funding by private and public mortgages lenders. By maintaining updated information, which can be used by developers, lenders, and consumers, the registry is expected to help improve efficiency and boost the development of housing and mortgage markets.

In 2007, Mexico's Federal Mortgage Association, in association with the Netherlands Development Finance Company, created a new company called HiTo to provide a bridge between mortgage lending and the bond market by standardizing mortgage-backed securities into large pools, with the goal of increasing liquidity and efficiency in the market.<sup>49</sup>

<sup>45</sup> Source: Comisión Nacional Bancaria y de Valores.

<sup>46</sup> See [www.shf.gob.mx/files/pdf/Estrategia%202007-2013.pdf](http://www.shf.gob.mx/files/pdf/Estrategia%202007-2013.pdf).

<sup>47</sup> The first government mortgage institution is a trust for lower-income housing whose liabilities are funded by Mexico's central bank, the World Bank, and other sources (see Pickering, 2000). The second institution is the Federal Mortgage Association created in 2001 to promote the development of a secondary mortgage market.

<sup>48</sup> See Skelton (2006).

<sup>49</sup> See *The Economist* (2007).

## Credit Bureaus

A credit bureau operated by the central bank has existed in Mexico since 1964, but it was only for business loans and was rarely used.<sup>50</sup> From 1993 to 1998, Mexican regulatory authorities laid the framework for the existence of private credit bureaus, which was designed to improve the way individuals' credit history information was collected.<sup>51</sup> Additional laws to regulate the credit bureaus were passed in 2002 and 2004.

The goal of credit bureaus is to improve credit screening and assessment of repayment capabilities of individuals and firms. Starting in 1998, the banking commission has required banks to establish reserves for 100 percent of those loans in which borrowers are found to have poor or no credit history.<sup>52</sup>

Since 1995, three firms have entered the market; but today only one, Buró de Crédito, remains, and it now tracks the credit histories of both consumers and businesses.

## Increased Participation of Foreign Banks

Some of the most remarkable developments that followed the 1995 crisis were the reforms that allowed for increased foreign ownership of commercial banks. Today, foreign participation has essentially rebuilt the sector, improving capitalization and the quality of bank assets and contributing to the accelerated decline of bad loans. Since 2004, foreign participation has helped to increase bank credit in the economy. (See Figures 1 and 5.)

In 1994, NAFTA allowed foreign-owned banks to operate in Mexico, although there remained severe restrictions on the market share that foreign banks were allowed to control. NAFTA also restricted the equity share controlled by foreign nationals on Mexican banks. By 1994 there were 35 banks in the system, and only 2 banks, which

<sup>50</sup> See Gil-Díaz (1998).

<sup>51</sup> See Negrin (2001).

<sup>52</sup> See Mackey (1999).



**Table 1****Commercial Bank Assets as of December 2006**

Bank name	Assets (million pesos)	Share of total	Foreign control
All banks total	2,564,279.8	100.0	
BBVA Bancomer	600,836.3	23.4	Yes
Banamex	538,881.1	21.0	Yes
Santander	402,075.2	15.7	Yes
HSBC	284,045.4	11.1	Yes
Mercantil del Norte	209,031.9	8.2	No
Scotiabank Inverlat	127,150.0	5.0	Yes
Inbursa	80,800.3	3.2	No
I.N.G. Bank	57,980.6	2.3	Yes
Del Bajío	46,131.4	1.8	No
Banco Azteca	44,088.5	1.7	No
J.P. Morgan	31,911.9	1.2	Yes
Bank of America	16,609.3	0.7	Yes
IXE	15,226.0	0.6	No
Interacciones	12,881.2	0.5	No
Afirme	11,438.6	0.5	No
American Express	10,707.5	0.4	Yes
Invex	10,345.7	0.4	No
Banregio	9,720.7	0.4	No
G.E. Capital	9,598.3	0.4	Yes
Mifel	7,581.5	0.3	No
BBVA Bancomer Servicios	5,982.1	0.2	Yes
Deutsche Bank	5,880.9	0.2	Yes
Ve por más	4,890.2	0.2	No
Bansí	4,264.5	0.2	No
Credit Suisse	3,614.5	0.1	Yes
Compartamos	3,283.8	0.1	No
A.B.N. Amro Bank	3,269.9	0.1	Yes
Barclays Bank	2,728.5	0.1	Yes
Tokio-Mitsubishi UFJ	2,402.4	0.1	Yes
Monex	569.7	0.0	No
Autofín	352.0	0.0	No

SOURCE: Assets are from Boletín Estadístico de Banca Múltiple, Comisión Nacional Bancaria y de Valores, December 2006, [www.cnbv.gob.mx](http://www.cnbv.gob.mx).

provided retail lending, were controlled by foreign ownership.<sup>53</sup>

By December 1996, only 7 percent of total bank assets were controlled by foreign banks, but this share increased to 11 percent by December 1997 after all the restrictions were removed. By December 1999, 20 percent of bank assets were controlled by foreign banks; by December 2004, 83 percent of bank assets in Mexico were controlled by foreign banks.<sup>54</sup> As of December 2006, foreign banks still controlled about 82 percent of total bank assets. (See Table 1.)

Haber and Musacchio (2005) argue that the entry of foreign banks has increased competitive pressures, which have improved efficiency in the sector, even among those banks not controlled by foreign banks. They find that, while foreign entry between 1997 and 2004 improved the profitability of the sector, foreign banks were not more profitable, on average, than domestic banks, although foreign banks may have been initially better at screening borrowers. Schulz (2004) has also found that increased entry of foreign banks has helped improve various measures of productivity in the sector.

The entry of foreign banks in the sector has been instrumental to the recovery of bank credit, which had plunged after the 1994 devaluation. Total credit by commercial banks declined from about 40 percent of GDP in the fourth quarter of 1994 to about 13 percent in the first quarter of 2004. Similarly, bank credit to the private sector declined from about 37 percent of GDP in the fourth quarter of 1994 to about 9 percent in the first quarter of 2004. (See Figure 1.)

In contrast to total bank credit, credit for private consumption started recovering soon after the bank rescue program was completed in 1999, reflecting in part an increase in the use of credit cards. Other types of bank credit to the private sector—in particular, housing loans—would not begin to recover until 2004. Bank credit to the private industry, however, still remains stagnant at about 2 percent of GDP. (See Figure 5.)

The recovery in private bank credit, driven by entry of foreign banks, has produced significant welfare gains (in the form of lower net interest margins) among Mexican consumers.<sup>55</sup> The entry of foreign banks has also generated positive effects on banks' productivity and capitalization derived from the increase in foreign capital, and the improvement in bank asset quality has helped accelerate the reduction of bad loans in the banking system.<sup>56</sup>

FOBAPROA/IPAB bonds had begun to mature by the end of 2005 and are now being rolled over into negotiable bonds, which will provide banks with additional liquidity to lend to the private sector. The cumulative effects of Mexico's reforms in the financial system, including the widespread presence of foreign banks in the sector, suggest that the recent reversal in bank credit will continue.<sup>57</sup>

## WAL-MART'S BANK IN MEXICO

In November 2006, Wal-Mart's subsidiary in Mexico received approval to open a bank and became the second retail chain in Mexico to operate a bank. The first, Grupo Elektra, has been operating a full-service bank, Banco Azteca, since 2002. In 2006, other retailers also applied for and received licenses to operate banks. The stated goal of both Wal-Mart's and Elektra's banks is to provide banking services to Mexico's low-income individuals, who have traditionally faced barriers to loans from commercial banks or have chosen not to maintain checking or savings accounts because of steep maintenance fees. Elektra, whose retail operations include mostly consumer electronics and home appliances, for example, provided consumer loans for about five decades before creating a commercial bank.

Wal-Mart entered the retail chain market in Mexico in 1991 when the first Sam's Club opened in December. In 1992, Wal-Mart started an alliance with Grupo Cifra, which controlled a successful chain of retail stores. In 1993, Wal-Mart's first

<sup>53</sup> See Bubel and Skelton (2005) and also Haber (2005b).

<sup>54</sup> See Haber (2005c) and also Haber and Musacchio (2005).

<sup>55</sup> See Haber and Musacchio (2005).

<sup>56</sup> See Schulz (2004).

<sup>57</sup> See Bubel and Skelton (2005).

Supercenter opened, and more companies (a chain of restaurants and a chain of clothing stores) joined the alliance with Cifra. Wal-Mart quickly gained market share and in 1997 bought a controlling stake in Grupo Cifra. By 2001, Wal-Mart de México controlled about half of all supermarket sales in the country. In 2006 alone, 120 stores were opened and total sales reached about \$18.3 billion, an inflation-adjusted increase of 15.9 percent over 2005 sales.<sup>58</sup> Today, Wal-Mart is Mexico's largest private employer, with 149,584 employees; it owns 917 stores in 147 cities, which include supermarkets, restaurants, and clothing stores.

Wal-Mart's banking experiment is interesting because of the regulatory environment it will face in Mexico. Gelpert (2007) notes that all other foreign banks in Mexico, although established by law as wholly owned and separately capitalized subsidiaries, have parent institutions that are themselves regulated and subject to supervision by their home country authorities. Given Wal-Mart's failed attempts to enter the banking sector in the United States, Wal-Mart's bank in Mexico remains its only banking venture in the world, and therefore the Mexican authorities will have sole responsibility over its regulation and supervision, while Wal-Mart's headquarters in the United States will remain outside of Mexican authorities' regulatory scope. Gelpert warns, however, that although the banking license establishes limits to the ties between Wal-Mart's banking and retail businesses, Mexico's limited leverage over Wal-Mart activities outside of Mexico puts Wal-Mart in a unique position to demand support from Mexican authorities. This, Gelpert argues, is because of Wal-Mart's strength in the retail sector, because no other foreign bank has retail stores, and because other retail chains with banks are currently owned by Mexican nationals and therefore subject entirely to Mexican laws.

Thus far, Wal-Mart's strategy in entering the banking sector appears to be similar to Elektra's: first, approach customers who have traditionally avoided the banking sector; afterwards, expand

to middle-income consumers. The effects of Wal-Mart's entry on banking competition are yet to be seen. However, Wal-Mart's entry into the banking sector should provide for an interesting environment in the very immediate future: Despite the improved conditions in the sector, Mexican consumers still face high fees for banking services, and Wal-Mart may extend its traditionally aggressive low-pricing strategy to its banking business.

## WHAT NEXT?

Apart from recent favorable developments in Mexico's bank credit, at its core, the country still faces fundamental problems with its legal infrastructure. Property rights in Mexico were until very recently not well defined and in many cases continue to be poorly enforced.<sup>59</sup> Even today, it is difficult even to ascertain who owns a particular asset (recall that a unified property registry was not put in place until 2006); and, as a consequence, it is still difficult for banks to repossess assets given as collateral in a loan. Haber (2005c) argues that, as long as these institutional problems are not resolved, they will continue to limit the type of contracts that bankers can enforce. Haber's view reflects the notion that the protection of property rights has positive effects on long-run economic performance, a notion that is widely recognized by economists. (See, for example, Acemoglu and Robinson, 2000; Acemoglu, Johnson, and Robinson, 2002; and, more recently, Gradstein, 2007, among others.) It would seem, then, that Mexico stands to gain from continuing to foster the development of its banking sector and, as a long-run goal for its overall development, modernize its legal infrastructure, especially contract enforcement and the definition and defense of private property rights.

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<sup>58</sup> Source: sales and store counts from [www.walmartmexico.com.mx](http://www.walmartmexico.com.mx); United States–Mexico exchange rate as of December 2006 from [research.stlouisfed.org/fred2/data/EXMXUS.txt](http://research.stlouisfed.org/fred2/data/EXMXUS.txt).

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# How Well Does Employment Predict Output?

Kevin L. Kliesen

Economists, policymakers, and financial market analysts typically pay close attention to aggregate employment trends because employment is thought to be an important indicator of macroeconomic conditions. One difficulty is that there are two separate surveys of employment, which can diverge widely from one another, as the previous and current economic expansions demonstrate. The conventional wisdom is that, for assessing economic conditions, the survey that counts the number of jobs (establishment survey) is preferable to the survey that counts the number of people employed (household survey). However, results from a one-quarter-ahead forecasting exercise presented in this paper suggest that analysts should question whether employment is a useful indicator for predicting output growth. (JEL C53, E24)

Federal Reserve Bank of St. Louis *Review*, September/October 2007, 89(5), pp. 433-46.

**E**ach month, the Bureau of Labor Statistics (BLS) publishes the *Employment Situation*, a comprehensive report of key labor market statistics derived from separate surveys of nonagricultural business establishments (including government) and private households. Labor market conditions are among the most closely watched of all sources of economic statistics because they are, collectively, thought to be a comprehensive indicator of economic activity. In addition, many of its components (for example, hours worked) are used in the construction of other key economic statistics, such as the Federal Reserve Board's index of industrial production (IP). As a result, policymakers and economic analysts monitor labor market conditions carefully to help them gauge the evolving strength or weakness in the pace of aggregate economic activity over the near-term. In fact, policymakers and analysts use these data, ideally, to more accurately predict economic activity and avoid forecast surprises, which have

been shown to significantly affect the behavior of financial markets.<sup>1</sup>

This article will first briefly discuss the two surveys that the BLS uses to measure employment and then discuss the different patterns in employment growth registered by each measure over the past two business cycles. The article will provide some evidence, with a one-quarter-ahead pseudo out-of-sample forecasting exercise, that neither measure of employment is a reliable predictor of the growth of IP or real gross domestic product (GDP).

## TWO EMPLOYMENT SURVEYS

One difficulty that confronts economic analysts who use employment to help predict the growth of real GDP is which employment measure to use. The BLS publishes two measures of employment that receive the most attention.

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<sup>1</sup> See Kliesen and Schmid (2004 and 2006).

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**Table 1****Differences Between the CES and the CPS**

CES	CPS
<ul style="list-style-type: none"> <li>• Monthly sample survey of 160,000 <i>businesses and government agencies</i>; firms of all sizes are included</li> <li>• Designed to measure employment, hours, and earnings with significant <i>industrial and geographic</i> detail</li> <li>• Reference period is the <i>pay period</i> (could be weekly, biweekly, monthly, and so forth) that includes the 12th of the month</li> <li>• Employees of <i>all ages</i> are included</li> <li>• Employment measure reflects the number of nonfarm payroll <i>jobs</i></li> <li>• Multiple jobholders are counted <i>for each payroll job</i></li> <li>• Self-employed persons are <i>excluded</i></li> <li>• Agriculture sector is <i>excluded</i></li> <li>• Private household workers (nannies, housekeepers, and the like) are <i>excluded</i></li> <li>• Unpaid family workers (persons working without formal pay in their family's business) are <i>excluded</i></li> <li>• Workers on leave without pay throughout the reference period are <i>excluded</i></li> </ul>	<ul style="list-style-type: none"> <li>• Monthly sample survey of approximately 60,000 <i>households</i></li> <li>• Designed to measure employment and unemployment with significant <i>demographic</i> detail</li> <li>• Reference period is the <i>week</i> that includes the 12th of the month</li> <li>• Only workers <i>aged 16 and older</i> are included</li> <li>• Employment measure reflects the number of employed <i>persons</i></li> <li>• Multiple jobholders are counted <i>once</i></li> <li>• Self-employed persons are <i>included</i></li> <li>• Agriculture sector is <i>included</i></li> <li>• Private household workers are <i>included</i></li> <li>• Unpaid family workers are <i>included</i></li> <li>• Workers on leave without pay throughout the reference period are <i>included</i></li> </ul>

NOTE: Reprinted from Bowler and Morisi (2006, p. 24) with permission.

One is nonfarm payroll employment. This measure is taken from the Current Employment Statistics survey (CES), which is a survey of about 160,000 businesses and government agencies (establishments) that cover about a third of all nonfarm payroll workers. The other measure is civilian employment, which is taken from the Current Population Survey (CPS). The CPS is a survey of about 60,000 households, of roughly 110 million households in the United States. It is often referred to as the household survey or household employment.

These two series are reported each month in the *Employment Situation*, which is typically released on the first Friday of each month by the BLS. According to the BLS, the CES is designed chiefly to track changes such as jobs and hours, whereas the CPS is designed chiefly to track changes in *rates*, such as the unemployment rate or the labor force participation rate.<sup>2</sup>

As seen in Table 1, there are several differences between the two surveys. For example, the CPS (household survey) includes agricultural and unincorporated self-employed workers, as well as those who are on unpaid absence; the CES (establishment survey) includes none of these.<sup>3</sup> Also, the CES includes multiple jobholders and workers of all ages, whereas the CPS counts an employed person only once and only those who are at least 16 years old. Finally, each year the CES estimates are benchmarked to the actual employment levels reported by the state unemployment

<sup>2</sup> Bowler and Morisi (2006).

<sup>3</sup> There are two measures of self-employment: incorporated and unincorporated. Unincorporated self-employed individuals have the status of unpaid family workers—that is, they are assumed not to be paid employees. These are reported in the CPS only. However, the incorporated self-employed are assumed to be paid employees of their own corporations and, hence, are counted in the CES.

insurance records.<sup>4</sup> Typically, the benchmark revisions are relatively small. According to the BLS, the benchmark revisions averaged  $\pm 0.2$  percent from 1996 to 2005. However, the 2006 benchmark revision was unusually large, measuring 0.6 percent.<sup>5</sup> In contrast, the CPS estimates are derived from annual estimates of the civilian noninstitutional population provided by the Bureau of the Census.<sup>6</sup>

Although the coverage of the labor market is broader in the household survey, most economists probably place more emphasis on the establishment survey because it is constructed from a much larger sample and is less volatile than the household survey. Of course, this assumes that each survey is a statistically representative sampling of the population; typically, a larger sample of the population produces more accurate estimates than a smaller sample of the population.

To see why the CES might be a superior time-series measure, consider the following. The BLS survey of businesses and government agencies encompasses about 400,000 individual worksites, which covers about a third of all workers.<sup>7</sup> Thus, the BLS is implicitly surveying a little more than 45 million workers. By contrast, the CPS encompasses about 60,000 households (or about 76,000 workers). This represents only 0.05 percent of total households and 0.2 percent of those implicitly surveyed by the CES.<sup>8,9</sup>

<sup>4</sup> These data are reported every three months in the Quarterly Census of Employment and Wages, also known as the ES-202. See [www.bls.gov/cew/home.htm](http://www.bls.gov/cew/home.htm).

<sup>5</sup> See [www.bls.gov/web/cesmart.htm](http://www.bls.gov/web/cesmart.htm).

<sup>6</sup> The population controls for the CPS are based on the decennial census. Intercensal population estimates from the Census Bureau are based on births, deaths, and estimates of net internal immigration.

<sup>7</sup> See BLS Handbook of Methods (Chapter 2); [www.bls.gov/opub/hom/homch2\\_a.htm](http://www.bls.gov/opub/hom/homch2_a.htm).

<sup>8</sup> According to Bowler and Morisi (2006), the monthly CPS sampling error is four times larger than that of the CES.

<sup>9</sup> The CPS surveys about 60,000 households. This represents only 0.05 percent of total households. Viewed another way, there are 1.26 employees per household, which represents nearly 76,000 persons surveyed. This sample is less than 0.2 percent of those implicitly surveyed by the CES.

## Reconciling the Two Employment Measures

Despite the marked differences in their structural characteristics, the two series have increased at comparable rates since their inception. From 1948 to 2006, the CES has grown at a 1.6 percent annual rate, whereas the CPS has grown at a 1.9 percent annual rate. At shorter time horizons, though, the growth rates have diverged considerably. For example, Figure 1 shows that peak and trough growth rates of the CES are generally larger (in absolute terms) than those of the CPS. To help reconcile divergences, the BLS creates an adjusted series that attempts to net out, as much as possible, the methodological differences between the two surveys.

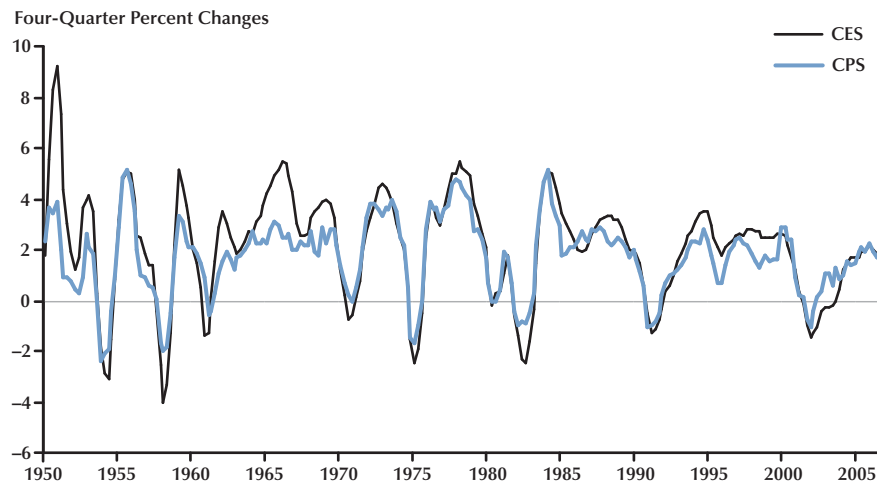
Each month, the BLS computes an employment measure from the CPS that is designed to be conceptually equivalent to that of the CES. This adjusted measure has been published on a monthly basis since January 1994, when there was a major redesign of the CPS.<sup>10</sup> To make the CPS measure conceptually equivalent to the CES measure, as seen in Table 2, the BLS subtracts the following employment categories of the CES that are outside of the scope of the CPS: (i) agriculture, (ii) nonagricultural self-employment, (iii) nonagricultural unpaid family workers, (iv) private household workers, and (v) unpaid absences. To this adjustment, the BLS also adds the number of workers with multiple jobs.<sup>11</sup> Table 2 shows, as of 2006, that CES employment totaled 136.935 million and CPS-adjusted employment totaled 139.415 million—an unexplained difference of 2.48 million. (In December 2005, it was 1.67 million.)

Figure 2 shows the evolution of the CES-CPS discrepancy during the past two business cycles. Panel A shows employment trends during the 1990s expansion, and panel B shows employment trends during the current business expansion. Each employment series is indexed to equal 1 during the trough months of the recessions in

<sup>10</sup> See Polivka and Miller (1998).

<sup>11</sup> The number of multiple jobholders are those 16 and older with secondary jobs.



**Figure 1****Employment Growth, 1950 to 2006**

SOURCE: BLS and author's calculations.

**Table 2****CES-CPS Reconciliation Table (in thousands)**

Employment	December 2005	December 2006	Percent change
Payroll jobs	135,041	136,935	1.4
Household employment*	142,918	146,081	2.2
Less: Agriculture	1,942	2,079	7.1
Nonagricultural self-employed	9,294	9,751	4.9
Nonagricultural unpaid family workers	66	99	50.0
Private household workers	782	722	-7.7
Unpaid absences	1,412	1,547	9.6
Total	13,496	14,198	5.2
Plus: Multiple jobholders <sup>†</sup>	7,289	7,533	3.3
Adjusted household employment*	136,711	139,415	2.0
Adjusted household employment less payroll jobs	1,670	2,480	48.5
Addenda: Nonagricultural wage and salary workers	130,755	132,901	1.6

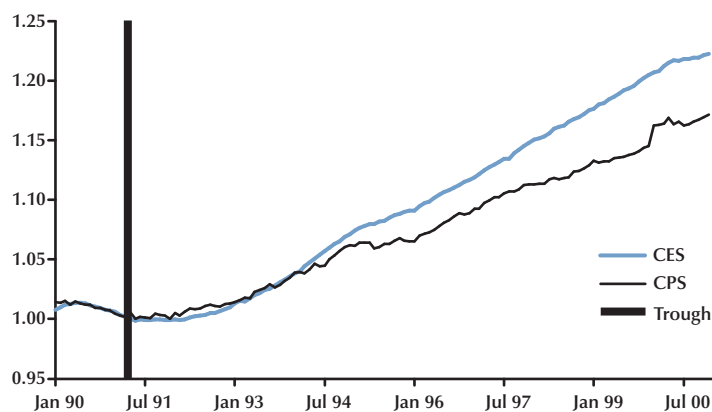
NOTE: \*The changes in household employment and adjusted household employment have been adjusted to account for the introduction of new population controls in January 2006. <sup>†</sup>Multiple jobholders who are nonagricultural wage and salary workers on their primary job. Totals and changes in household employment series are based on unrounded numbers. Data are not seasonally adjusted, and the published numbers are those prior to the March 2006 benchmark revisions published in February 2007.

SOURCE: BLS.

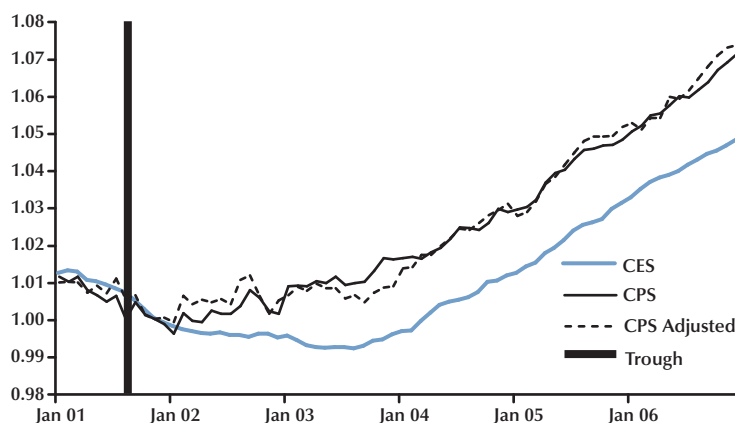
## Figure 2

### Establishment and Household Employment During the 1991-2001 and Current Business Expansion

A. January 1990 to December 2000 (Index, March 1991 = 1.0)



B. January 2001 to December 2006 (Index, November 2001 = 1.0)



NOTE: Data are seasonally adjusted by the BLS and reflect the March 2006 benchmark revision published in February 2007. Vertical lines indicate the month declared to be the end of the recession (trough).

SOURCE: BLS and author's calculations.

1990-91 (July 1990) and 2001 (November 2001), respectively. The CES and CPS measures are shown in each panel, but panel B also includes the CPS-adjusted measure. Recall that this series has been available only since January 1994.<sup>12</sup>

Although the CPS growth and CPS-adjusted rates have kept up with the CES growth rate overall since 1994, the CES and CPS measures have moved in distinct patterns since that year (see Figure 2A).<sup>13</sup> From January 1994 to March 2001, increases in payroll employment (CES) averaged about 233,000 per month, while they averaged only about 184,000 per month for household employment (CPS). From November 2001 to December 2006, the opposite occurred: Household employment increased by an average of about 159,000 per month, while payroll employment increased by an average of only 103,000 per month. Panel B also shows that the CPS-adjusted measure has increased in line with total household employment, although there has been some slight widening between the two measures in 2006. From November 2001 to December 2006, the CPS-adjusted measure increased by 155,000 per month, which is virtually identical to the average increase in the unadjusted CPS.

### **Analysis in the Literature**

Numerous studies have attempted to explain the discrepancies between the two growth rates of the two main employment series during these two periods. Many researchers have focused on structural changes in the economy, such as innovations in the production and distribution of manufactured goods, or increases in trend labor productivity growth rates: See Kahn (1993), Schreft and Singh (2003), and Groshen and Potter (2003). In this vein, Koenders and Rogerson (2005) argue that slow employment growth tends to follow long expansions—such as those in 1982-90 and 1991-2001—because firms postpone structural changes during periods of relatively strong growth.

One potential difficulty with these explanations, as Aaronson, Rissman, and Sullivan (2004) point out, is that structural change is a regular feature of a dynamic economy that is continually subject to waves of creative destruction.

Bowler and Morisi (2006) take a somewhat different approach by reviewing several possible explanations tied to methodological differences between the two employment surveys. They found that the population undercount explained roughly one-third of the 4.5 million cumulative gap between the CES and CPS measures of employment that arose in the late 1990s.<sup>14</sup> This is consistent with an earlier finding by Juhn and Potter (1999), who argued that the widening gap between the CES and CPS in the 1990s was likely due to an underestimate of the working-age population. Recall that employment estimates in the CPS are derived from estimates of the noninstitutional population that are provided by the Bureau of the Census. In January 2003, the BLS incorporated into the CPS the decennial census population estimate. This introduction resulted in revisions to the population controls, and thus the CPS data, from January 2000 through December 2002.<sup>15</sup> A second major revision occurred in January 2003 because of the annual intercensal population adjustment.<sup>16</sup>

Bowler and Morisi also reviewed other sources of systematic error, such as workers with multiple jobs, military personnel with secondary civilian jobs, foreign commuters, and differences in the reference periods between the two surveys. None of these factors, they argued, could explain the 1990s discrepancy with any significance. Regarding developments since 2001—that is, the relatively faster growth of household employment—they argue that the causes of this discrepancy are also not fully known. Two possibilities are increased job turnover and potential inaccuracies in the population controls. An earlier BLS paper by Nardone et al. (2003) argued that undoc-

<sup>12</sup> The CPS-adjusted series is adjusted to smooth out the discrete jumps in population that occurred because of revisions in January 2000, 2003, 2004, 2005, and 2006.

<sup>13</sup> From January 1994 to December 2006, the average monthly gains are as follows: CES, 159,000; CPS, 155,000; CPS adjusted, 159,000.

<sup>14</sup> Their sample period was 1994-2000. The 4.5 million gap does not include the population revisions associated with the introduction of the Census 2000 population controls in January 2003.

<sup>15</sup> See Bowler et al. (2003).

<sup>16</sup> See footnote 4.

**Table 3**

**Correlation Between Various Measures of Employment and Output Growth (one-quarter percent changes)**

	1950:Q1 to 1993:Q4		1994:Q1 to 2001:Q4		2002:Q1 to 2006:Q4	
	CES	CPS	CES	CPS	CES	CPS
IP	0.82	0.63	0.89	0.62	0.28	0.08
Real GDP	0.72	0.56	0.59	0.37	0.24	-0.02

SOURCE: Author's calculations.

umented immigration may also bias population controls and thus also the estimates of CPS employment. The divergent pattern of employment growth in the current expansion potentially presents another difficulty for economic analysts who use employment as a predictor of near-term economic activity.

## GAUGING THE INFORMATION CONTENT OF THE EMPLOYMENT MEASURES

In the short term, changes in the demand for goods and services are assumed to cause changes in the demand for labor. But because the employment statistics are reported in advance of the primary measure of aggregate output (real GDP), policymakers tend to view them as a gauge for future changes in output. However, predicting output based solely on changes in labor input is complicated by changes in labor productivity.

A key question among economic analysts during the 1990s was whether the faster growth of CES employment was a more accurate portrayal of underlying trends in employment than was household employment. With the converse being true since the 2001 recession, a parallel question is whether the relatively faster growth of household employment is a truer measure of the economy's employment growth and thus its near-term growth of economic activity. If so, should economic analysts pay more attention to CPS employment to predict real GDP growth? Or should they continue to rely more on the CES? The conventional wisdom, as recently expressed by Federal

Reserve Chairman Ben Bernanke (2003), is that the CES is the preferred measure:

[B]ecause of the larger sample used in the payroll survey and because of possible problems with the population estimates used to scale the household survey, somewhat greater reliance should probably be placed on the payroll survey.

Table 3 provides a preliminary assessment of whether economic analysts should continue to rely more on the CES or put more weight on the CPS. Table 3 shows simple correlations between the annualized one-quarter growth rate of two measures of economic activity—IP and real GDP—and the two primary measures of employment plotted in panel A of Figure 2—CES and CPS. The table lists the correlations over three separate periods: (i) 1950:Q1–1993:Q4; (ii) 1994:Q1–2001:Q4; and (iii) 2002:Q1–2006:Q4. The 1994 breakpoint is chosen because, as noted earlier, the CPS was changed in several important ways in that year; the 2001 break point was chosen to be consistent with the analysis presented earlier.

As seen in Table 3, correlations between the growth of employment and IP are invariably stronger than those between the growth of employment and real GDP. This result holds across all three periods and for each employment series. This finding seems surprising given that IP measures the output of the goods-producing sector, which is only about 35 percent of real GDP.<sup>17</sup> It

<sup>17</sup> This share increases to 45 percent if structures are added to goods production. In nominal terms, the goods share is 31 percent and the sum of goods and structures is 42 percent.



is also the case that the correlation coefficients for the CES series are larger than those for the CPS series. This is consistent with the conventional wisdom noted earlier that most economists follow: The CES is as a better measure of employment conditions.

A second finding from Table 3 is that the correlations between employment and output have changed significantly over time.<sup>18</sup> For example, the correlation coefficient between the growth of CES employment and IP increased from 0.82 in the 1950-93 period to 0.89 in the 1994-2001 period. This result may reflect both the faster growth of CES employment during the 1990s and the strong gains in labor productivity and equity prices that helped spur a boom in business capital spending. Since 2001, the correlation between the growth of CES employment and IP has dropped to 0.28. A similar finding is found for real GDP growth and employment. Over time, the correlation between the growth of CES employment and real GDP declined from 0.72 (1950-93) to 0.59 (1994-2001) to 0.24 (2002-06). A similar result was found for the correlation between the growth of CPS employment and real GDP growth. In fact, the CPS-real GDP correlation during the current period (2002-06) is now negative. This seems surprising given that the growth of CPS employment has been stronger than CES employment over this period.

The finding that the correlation between the growth of household employment and real GDP has decreased over time contrasts with the results shown in Perry (2005). He provides evidence that, since 1994, household employment has been a better measure of aggregate employment than payroll employment when predicting real GDP growth or growth of nonfarm business output (a subset of GDP). Perry concludes that both measures include important information and that an economic analyst might benefit from adopting

the simple rule of thumb of averaging the monthly changes in the two series. However, the correlations presented in Table 3 suggest that economic analysts should pay less attention to the CPS relative to the CES (conventional wisdom). In the next section, I formally assess the validity of this conventional wisdom.

## FORECASTING OUTPUT USING MEASURES OF EMPLOYMENT

Expectations about the state of the U.S. economy matter tremendously to policymakers. Accordingly, the Federal Open Market Committee (FOMC) closely monitors the incoming flow of economic data to see whether its information content is consistent with the prevailing forecast for inflation and key indicators of real activity. Chairman Bernanke and other senior Federal Reserve officials have called this a “data-dependent policy.”<sup>19</sup> One of the most important data series that shapes the FOMC’s view is the monthly change in employment. The purpose of this section is to assess whether employment changes are a good predictor of real output growth over the following quarter.

For this analysis, I use two measures of output and six measures of employment, with data measured at a quarterly frequency. The two measures of output are real GDP and IP, the same measures used in Table 3. There are six measures of employment:

- nonfarm payroll employment (CES);
- civilian employment (CPS);
- civilian wage and salary workers (CPS W&S);
- the Perry (2005) rule-of-thumb series, which measures the average change of the CES and CPS (CES-CPS AVG);
- nonfarm payroll employment plus the measure of self-employed workers (CES + SE);
- the CPS less the measure of self-employed workers from the CPS (CPS – SE).

<sup>18</sup> The correlations in Table 3 are somewhat sensitive to the end points, depending on whether the 2001 recession is moved to the second or third period. For example, choosing 2000:Q4 as the end point of the second period lowers the correlations between employment and output in the second period while raising them in the third period. However, this does not change the overall conclusion that the correlations between employment and output growth have generally weakened over time.

<sup>19</sup> See Poole (2006).

**Table 4****Summary Statistics for Output and Employment (one-quarter percent changes, not annualized)**

	Real GDP	IP	CES	CPS	CPS W&S	CES-CPS AVG	CES + SE	CPS – SE
<b>1950:Q1 to 1993:Q4</b>								
Average	0.89	0.94	0.54	0.42	0.52	0.48	0.51	0.45
Standard deviation	1.09	2.24	0.70	0.56	0.63	0.59	0.65	0.61
<b>1994:Q1 to 2006:Q4</b>								
Average	0.80	0.83	0.39	0.36	0.40	0.37	0.37	0.37
Standard deviation	0.48	0.93	0.35	0.36	0.41	0.31	0.35	0.36

SOURCE: Author's calculations.

The rationale for including the final two measures stems from the fact that the growth of self-employment has been considerably stronger in the period following the 2001 recession.<sup>20</sup> From November 2001 through December 2006, self-employment increased by 11 percent, while total CPS employment increased by 7.1 percent. Hence, self-employment may be one potential explanation for the current growth gap between the CES and the CPS. Finally, I do not use the BLS's CPS series that is conceptually equivalent to the CES because that series is not available before the first quarter of 1994.

Table 4 provides some basic statistics for the economic series that will be used in the empirical analysis. I look at two periods: 1950:Q1–1993:Q4 and 1994:Q1–2006:Q4. Table 4 offers a few key findings. First, average growth of real GDP and IP are approximately equal in each period. Second, volatility declined by more than half for GDP growth and by slightly more than that for IP growth in the second period. Third, the growth of CES employment is larger than the growth of CPS employment, but the gap narrowed by three-fourths in the second period. Finally, volatility has also declined for employment growth, though less than it has for output. Moreover, in the second period, CES and CPS employment volatility are

approximately equal, which contrasts with the earlier period. Although, the differences in volatility among the employment series are small, the CES-CPS average is the least volatile.

I use the following autoregressive model (AR), with four lags of the dependent variable, as the benchmark one-quarter-ahead forecast for the quarterly change in output:

$$(1) \quad X_t = \alpha_t + \sum_{i=1}^4 \beta_i X_{t-i} + \mu_t,$$

where  $X_t$  is the log change (annualized) in real GDP or IP. To test whether adding information from employment produces a more accurate one-quarter-ahead forecast than the benchmark model, I add, in six separate regressions, the log changes of employment described earlier. Finally, I consider two separate modifications to the benchmark model. In the first specification, I add the first lag of the quarterly log change (annualized) in employment,  $Y_{t-1}$ , to the baseline model:

$$(2) \quad X_t = \alpha_t + \sum_{i=1}^4 \beta_i X_{t-i} + \gamma Y_{t-1} + \mu_t.$$

In the second specification, I add (separately) the contemporaneous value of the quarterly log change (annualized) in employment,  $Y_t$ , to the baseline model:

$$(3) \quad X_t = \alpha_t + \sum_{i=1}^4 \beta_i X_{t-i} + \gamma Y_t + \mu_t.$$

<sup>20</sup> From 1948 to 1966, self-employment averaged 9.5 percent of civilian employment, but it has held fairly steady since the mid-1960s, fluctuating between 6.5 and 7.5 percent since 1967.

This form of a nested, one-step-ahead forecast is common in the literature, where (1) is termed the restricted model and (2) and (3) are unrestricted models.<sup>21</sup>

Tables 5 and 6 show the root mean-squared errors (RMSE) from this one-step-ahead pseudo out-of-sample forecasting exercise for the restricted model and for both specifications of the unrestricted model.<sup>22</sup> In both tables, the starting point for the estimation period is the first quarter of 1950. To see how the one-step-ahead pseudo out-of-sample forecasting exercise is conducted, consider Table 5. In this case, the out-of-sample forecast horizon is from 1994:Q1 to 2001:Q4. Thus, the model is estimated using data from 1950:Q1 to 1993:Q4. Next, the model forecasts the growth of real GDP in 1994:Q1 and uses either the lagged (specification (1)) or contemporaneous (specification (2)) growth of employment in 1994:Q1. To forecast the growth of real GDP in 1994:Q2, the model is run using actual data through 1994:Q1 and so forth for each quarter. In essence, the forecasting exercise tests whether knowing the quarterly change in employment—either the contemporaneous change or its value in the previous quarter—is useful for predicting the growth rate of real GDP or IP.<sup>23</sup> A similar exercise is repeated in Table 6, but the out-of-sample forecast horizon is from 2002:Q1 to 2006:Q4. RMSEs in Tables 5 and 6, then, are the averages for the out-of-sample forecast period indicated for each model.

Tables 5 and 6 indicate that the RMSEs from the restricted and unrestricted models are always less for forecasts of real GDP than for IP. This perhaps reflects that (i) more than half of GDP is services output and (ii) goods output is more volatile than services output. Another key finding is that the RMSEs for the benchmark forecasts for IP and

real GDP growth are significantly lower in the latter period (Table 6) than in the earlier period (Table 5). This finding suggests that reduced volatility helps a forecaster produce more accurate (lower RMSEs) forecasts.<sup>24</sup>

A more interesting finding from the tables is that forecast accuracy in either period appears to depend significantly on whether the lagged or contemporaneous value of employment is used to forecast output. Table 5 suggests that adding the contemporaneous value of CES employment substantially lowers the RMSE in the earlier period but not in the latter period. For example, in the forecast period encompassing 1994:Q1–2001:Q4, adding CES employment lowers the RMSE for the IP forecast from 3.25 percent to 2.48 percent and for real GDP from 2.05 percent to 1.65 percent. Using the lagged value of the CES in the earlier period lowers the RMSE for real GDP only slightly (from 2.05 to 2.00), but it raises the RMSE slightly for IP (from 3.25 to 3.31). The remaining specifications of the unrestricted model in the earlier period uniformly produced higher RMSEs than the contemporaneous value of the CES.

In contrast, Table 6 shows the opposite finding. In the latter period (2002:Q1–2006:Q4), adding the lagged value of the CES to the restricted model produces a lower RMSE, whereas using the contemporaneous value of the CES produces a higher RMSE. For example, using the lagged specification, adding the CES to the restricted model lowers the RMSE for IP from 2.78 to 2.50 percent; for real GDP, the RMSE declines from 1.61 to 1.54 percent. A similar-size RMSE is produced using either the CPS W&S or the CES-CPS AVG in the real GDP forecast in the lagged specification. The latter finding is consistent with Perry's (2005) results noted earlier. Adding the self-employed to the CES (CES + SE) produces a more accurate forecast than the contemporaneous value of the CES by itself; however, the result fails to hold when using the lagged values of employment in this period.

<sup>21</sup> See Clark and McCracken (2001), who cite the seminal work of Meese and Rogoff (1983). See Stock and Watson (2003) for an application to forecasting inflation with asset prices.

<sup>22</sup> The forecasts are termed “pseudo” because actual data are used to generate a one-step-ahead forecast that will be compared with the actual growth rate.

<sup>23</sup> The data in this article incorporate all previous revisions (current-vintage data). An interesting extension of this exercise would be a test of whether the results would change if real-time data were used.

<sup>24</sup> This point is made by Stock and Watson (2005). They argue that RMSEs for inflation and output forecasts have been reduced since the mid-1980s because of the Great Moderation. Regarding the latter, see McConnell and Pérez-Quirós (2000) or Ahmed, Levin, and Wilson (2004).

**Table 5****One-Quarter-Ahead Forecast Errors (RMSEs), 1994:Q1 to 2001:Q4**

	IP		Real GDP	
	Lagged	Contemporaneous	Lagged	Contemporaneous
<b>Restricted model</b>				
AR(4)	3.25	3.25	2.05	2.05
<b>Unrestricted models</b>				
CES	3.31	2.48	2.00	1.65
CPS	3.24	3.33	2.01	2.18
CPS W&S	3.42	3.62	2.07	2.22
CES-CPS AVG	3.27	2.94	1.99	1.90
CES + SE	3.27	2.85	1.91	1.97
CPS – SE	3.27	3.14	2.06	1.97

NOTE: CES, nonfarm payroll employment; CPS, civilian employment; CPS W&S, civilian employment, nonfarm wage, and salary workers; CES-CPS AVG, average of civilian and nonfarm payroll employment; CES + SE, nonfarm payroll employment plus self employment; CPS – SE, civilian employment less self employment. First actual observation: 1950:Q1.

**Table 6****One-Quarter-Ahead Forecast Errors (RMSEs), 2002:Q1 to 2006:Q4**

	IP		Real GDP	
	Lagged	Contemporaneous	Lagged	Contemporaneous
<b>Restricted model</b>				
AR(4)	2.78	2.78	1.61	1.61
<b>Unrestricted models</b>				
CES	2.50	3.24	1.54	1.87
CPS	2.75	3.02	1.57	1.81
CPS W&S	2.77	3.19	1.53	2.06
CES-CPS AVG	2.56	2.74	1.54	1.77
CES + SE	2.55	2.96	1.61	1.75
CPS – SE	2.73	3.08	1.56	1.91

NOTE: See Table 5 for descriptions of the mnemonics.



**Table 7****Clark-McCracken Tests of Forecast Accuracy, 1994:Q1 to 2001:Q4**

	IP		Real GDP	
	Lagged	Contemporaneous	Lagged	Contemporaneous
<b>Unrestricted models</b>				
CES	-0.0004	0.0262	0.0012	0.0182
CPS	0.0006	0.0095	0.0010	0.0046
CPS W&S	-0.0002	0.0082	0.0003	0.0058
CES-CPS AVG	0.0002	0.0191	0.0015	0.0116
CES + SE	0.0000	0.0179	0.0031	0.0084
CPS – SE	0.0002	0.0109	0.0001	0.0084

**10% critical value: 0.473**

NOTE: See Table 5 for descriptions of the mnemonics. In each case, the forecast from the unrestricted model is tested against the forecast from the restricted model. The null is that there is no difference between the two forecasts.

**Table 8****Clark-McCracken Tests of Forecast Accuracy, 2002:Q1 to 2006:Q4**

	IP		Real GDP	
	Lagged	Contemporaneous	Lagged	Contemporaneous
<b>Unrestricted models</b>				
CES	0.0070	0.0316	0.0056	0.0146
CPS	0.0012	0.0038	0.0018	0.0018
CPS W&S	0.0025	0.0080	0.0043	0.0021
CES-CPS AVG	0.0057	0.0244	0.0044	0.0093
CES + SE	0.0059	0.0294	0.0034	0.0140
CPS – SE	0.0016	0.0057	0.0019	0.0018

**10% critical value: 0.335**

NOTE: See Table 5 for descriptions of the mnemonics. In each case, the forecast from the unrestricted model is tested against the forecast from the restricted model. The null is that there is no difference between the two forecasts.

Ultimately, the value of any forecast is its accuracy. A standard test of forecast accuracy is the nonparametric test proposed by Diebold and Mariano (1995). However, as Clark and McCracken (2001) point out, the Diebold and Mariano test is not appropriate for nested models like the one used in this paper. The reason is that the limiting distribution of the Diebold and Mariano test is not normal when the null hypothesis is equal predictive power (of the restricted and unrestricted test).<sup>25</sup> Tables 7 and 8 show test statistics based on an alternative test proposed by Clark and McCracken (2005). In each case, the forecasts from the unrestricted models in Tables 5 and 6 are tested against the restricted model. The null hypothesis is that the two forecasts have the same predictive power.

Despite the sizable difference between the RMSEs of the restricted model and certain unrestricted models—especially the latter featuring the CES—the Clark-McCracken test statistics indicate that the information contained in quarterly changes in employment does not significantly improve upon the benchmark AR(4) forecast. This result holds for both periods and regardless of whether one uses the contemporaneous specification or the lagged specification. Accordingly, employment does not appear to be a statistically useful predictor of output growth in the following quarter, which seems contrary to the conventional wisdom.

## CONCLUSION

Economists, policymakers, and financial market analysts typically pay close attention to aggregate employment trends, because employment is thought to be an important indicator of macroeconomic conditions. One difficulty is that there are two separate surveys of employment, and, moreover, these measures can diverge from one another in a significant fashion, as the previous and current economic expansions demonstrate. The conventional wisdom is that the employment survey that counts the number of

jobs (establishment survey) is preferable to the survey that counts the number of people employed (household survey) when attempting to discern current economic conditions. However, results from the pseudo out-of-sample forecasting exercise presented in this paper suggest that analysts question whether employment is a useful predictor of output growth over a one-quarter horizon.

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<sup>25</sup> Also see McGuckin, Ozyildirim, and Zarnowitz (2007).

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# The Effectiveness of Monetary Policy

Robert H. Rasche and Marcela M. Williams

This analysis addresses changing views of the role and effectiveness of monetary policy, inflation targeting as an “effective monetary policy,” monetary policy and short-run (output) stabilization, and problems in implementing a short-run stabilization policy. (JEL E520)

Federal Reserve Bank of St. Louis *Review*, September/October 2007, 89(5), pp. 447-89.

**T**he effectiveness of monetary policy has been a long-standing question in the monetary economics and central banking literature. Perspectives on the question have been influenced in part by developments in monetary theory and in part by interpretations of monetary history. Progress in the discussion has also been influenced—indeed, some might say hindered—by changing definitions of both “monetary policy” and “effectiveness.” Our discussion will address (i) changing views of the role and effectiveness of monetary policy, (ii) inflation targeting as an “effective monetary policy,” (iii) monetary policy and short-run (output) stabilization, and (iv) problems in implementing a short-run stabilization policy.

## CHANGING VIEWS ON THE ROLE AND EFFECTIVENESS OF MONETARY POLICY

What do analysts mean by “monetary policy” and the “effectiveness” thereof? Each term is something of a moving target. At times “monetary policy” has referred to central bank actions to influence and/or target some measure of the

money stock. Frequently, though certainly not always, the definition of monetary policy has focused on a measure of “high powered money”—liabilities of the central bank. For a long time, this was the definition incorporated in theoretical models; in the policy arena this definition was the foundation of the “monetarist revolution” in the 1960s and 1970s. A counter definition that was likely the dominant perspective of policymakers was that monetary policy referred to central bank actions to influence and/or target short-term interest rates or nominal exchange rates. Sargent and Wallace (1975) advanced the proposition that, in a model with “rational expectations,” the price level (and all other nominal variables) could be indeterminate if central banks set targets for nominal interest rates, because the economy would lack a “nominal anchor.” McCallum (1981) showed that an appropriately defined interest rate rule would avoid such indeterminacy. The interest rate rule had to include a “nominal anchor.” In recent years, in particular since Taylor’s (1993) proposed characterization of Federal Open Market Committee (FOMC) behavior in the early Greenspan years, interest rate rules that include a “nominal anchor” in the form of a desired or target inflation rate have become the basic speci-

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fication of “monetary policy” in theoretical analyses. (See, for example, Clarida, Galí, and Gertler, 1999.)

The legacy of the Great Depression in the United States and other industrialized economies was that monetary policy was “ineffective.” This perspective is most prominent in Keynes’s *General Theory* and in the writings of the “Keynesian economists” in the 1940s through the 1960s. For example, the Radcliffe Committee in the United Kingdom reported that

[t]he immediate object of monetary policy action is to affect the level of total demand... In theory, monetary action may work upon total demand by changing the interest incentive; we believe that only very limited reliance can be placed on this. More certainly, monetary action works upon total demand by altering the liquidity position of financial institutions and of firms and people desiring to spend on real resources; the supply of money itself is not the critical factor. (Radcliffe, 1959, p. 135)

In the United States the minimalist perspective on the role and effectiveness of monetary policy can be seen in the first two reports of the Kennedy Council of Economic Advisers:

Unless the Government acts to make compensating changes in the monetary base, expansion of general economic activity, accompanied by increased demands for liquid balances and for investment funds will tend to tighten interest rates and restrict the availability of credit... Discretionary policy is essential, sometimes to reinforce, sometimes to mitigate or overcome, the monetary consequences of short-run fluctuations of economic activity. In addition, discretionary policy must provide the base for expanding liquidity and credit in line with the growing potential of the economy. (Council of Economic Advisers, 1962, p. 85)

Monetary policy as well as debt management policy must be coordinated with fiscal policy to secure the objectives of high employment and growth without inflation. We are, and for some time still will be, in a situation of substantial slack in labor force and capital resources, a situation in which expansionary policies are required...What matters most at this time is

that financial policy should be designed to facilitate rather than retard the expansionary process which the tax program is designed to launch. (Council of Economic Advisers, 1963, p. 55)

A decade later, perspectives on the effectiveness of monetary policy had changed; and, in some circles, monetary policy was viewed as equally important as fiscal policy for affecting both inflation and output fluctuations:

The past 10 years have been characterized by an average growth rate of aggregate expenditures that is very high by historical standards and that has substantially outstripped the sustainable growth of supply of real goods and services. Contributing significantly to the growth of aggregate demand were rapidly increasing Government expenditures along with monetary policies that were appreciably more expansionary than those in earlier post-World War II periods...When the inflationary phase has lasted so long that expectations of further inflation are firmly embedded in the cost trend, a shift to policies of restraint first exerts an adverse influence on output and the desired price deceleration effect materializes only with a lag. Any convincing interpretation of the events during 1970 and 1973-4 must stress this difficulty. (Council of Economic Advisers, 1975, pp. 128-29)

This was not the only view of monetary and fiscal policy at that time. The 1960s saw the rise of “monetarism” subsequent to the work of Friedman and Schwartz (1963), Friedman and Meiselman (1963), and Andersen and Jordan (1968). There were several planks in the monetarism platform. First and foremost was that sustained inflation was a monetary phenomenon and that central banks should be held accountable for maintaining price stability. Monetarists contended that central banks should control the stock of money in the economy, and not focus on targeting short-term nominal interest rates, as the mechanism to achieve this long-run inflation objective. The rationale for the focus on the growth of the money stock was that, in a fiat money economy, the money stock provided the nominal anchor for the system.

In the eyes of monetarists, inflation control was not the only concern of the monetary authorities. They saw monetary policy as having significant effects on short-run fluctuations in real output (Andersen and Jordan, 1968; and Andersen and Carlson, 1970), though not affecting long-run output growth. Indeed, many monetarists (see Brunner and Meltzer, 1968; Meltzer, 1976, 2003; and Friedman and Schwartz, 1963) believed monetary policy was responsible for aggravating, not attenuating, historical cyclical fluctuations in real output.

With the “rational expectations revolution” in macroeconomics came the “policy ineffectiveness proposition” of the New Classical Macroeconomics (Sargent and Wallace, 1975). The initial interpretations of this paradigm were that, in any macroeconomic model, the assumption of rational expectations would render monetary policy ineffective in influencing real output, both in the short run and long run. Hence, there was no role for monetary policy in output stabilization. Subsequent research (Fischer, 1977; Taylor, 1980; and Calvo, 1983) demonstrated that it was the interaction of the rational expectations hypothesis and an assumption of perfectly flexible wages and/or prices that generated the “policy ineffectiveness proposition.” The outgrowth of this insight was the New Keynesian perspective.

With the widespread use of New Keynesian models, the monetarist tenets about how “monetary policy” affects economic activity have become widely held throughout academia and central banking circles today, though most academics and almost all central bankers would disown a monetarist label. Money has largely disappeared from discussions on monetary policy. Fry et al. (2000, Chart 7.2, p. 123), using data from a Bank of England survey, report that in the 1970s 11 (of 22) central banks in industrial countries reported using a money and credit framework to formulate monetary policy; but, by the 1990s, only 2 of these banks maintained this framework. Von Hagen (2004, Table 4) found a negative trend from 1970 to 2002 in the fraction of titles of articles in major economics journals that included the word “money,” though the frequency of titles including

“inflation” was relatively constant. He also found that the frequency of “money” in the annual reports of major central banks declined over the period 1996-2002 (Von Hagen, 2004, Table 5). King (2002) notes that

there is a paradox in the role of money in economic policy. It is this: that as price stability has become recognized as the central objective of central banks, the attention actually paid by central banks to money has declined. (p. 162)

The decline and fall of money in policy formation is confirmed by a fall in the number of references to money in speeches of central bank governors. So much so that over the past two years, Governor Eddie George has made one reference to money in 29 speeches, Chairman Greenspan one in 17, Governor Hayami one in 11 and Wim Duisenberg three in 30. (pp. 162-63)

In contemporary literature, models, and policy discussions, attention is given to the role of an inflation objective in a central bank “policy rule” as the nominal anchor in a fiat money economy. “Taylor rules” (Taylor, 1993) that specify a systematic relation between the target for a short-term interest rate and deviations of inflation from an inflation target and of real output from a measure of “potential output” have become the norm for the analysis of the impact of monetary policy.<sup>1</sup> In this “rule like” environment, the setting of the interest rate value is the policy action; the policy itself is represented by the parameters of the “rule,” including the inflation objective ( $\pi^*$ ) and the respective weights that are assigned to deviations of observed inflation from that objective and deviations of real output from “potential output.”

<sup>1</sup> There is an active discussion in the contemporary literature over the design of monetary policy rules. Some economists (for example, Svensson, 2005) argue for instrument rules that are optimized from an objective function of the central bank and models of the macroeconomy. Others (for example, McCallum and Nelson, 2004) argue for independently constructed target rules in the spirit of Taylor (1993). Both sides in this debate appear to accept the proposition that monetary policy can affect both inflation and real output in the short run, but only inflation in the long run. Hence, this theoretical debate is about how to best implement monetary policy rules, not about the effectiveness of policy.

**Table 1****Inflation-Targeting Countries by Year of Adoption**

Year	Country	Total
1990	New Zealand	2
	Chile	
1991	Canada	2
	Israel	
1992	United Kingdom	1
1993	Sweden	3
	Australia	
	Finland*	
1994	Peru	2
	Spain*	
1995	—	0
1996	—	0
1997	—	0
1998	Czech Republic	3
	Korea	
	Poland	
1999	Mexico	3
	Brazil	
	Colombia	
2000	South Africa	3
	Switzerland	
	Thailand	
2001	Norway	3
	Iceland	
	Hungary	
2002	Philippines	1

NOTE: \*Finland and Spain are considered to have become non-inflation-targeting countries on joining the third stage of the European Monetary Union in 1999.

SOURCE: Authors' compilation based on monetary policy and inflation reports of each country's central bank and Mishkin and Schmidt-Hebbel (2002) and Morande (2002).

## LONG-RUN STABILIZATION OBJECTIVES FOR MONETARY POLICY

Over the past 15 years, a number of countries, starting with New Zealand, have announced explicit numeric inflation objectives (the  $\pi^*$  term in the Taylor rule framework). The relevant question is, How effective are central banks at hitting explicit numeric inflation targets?

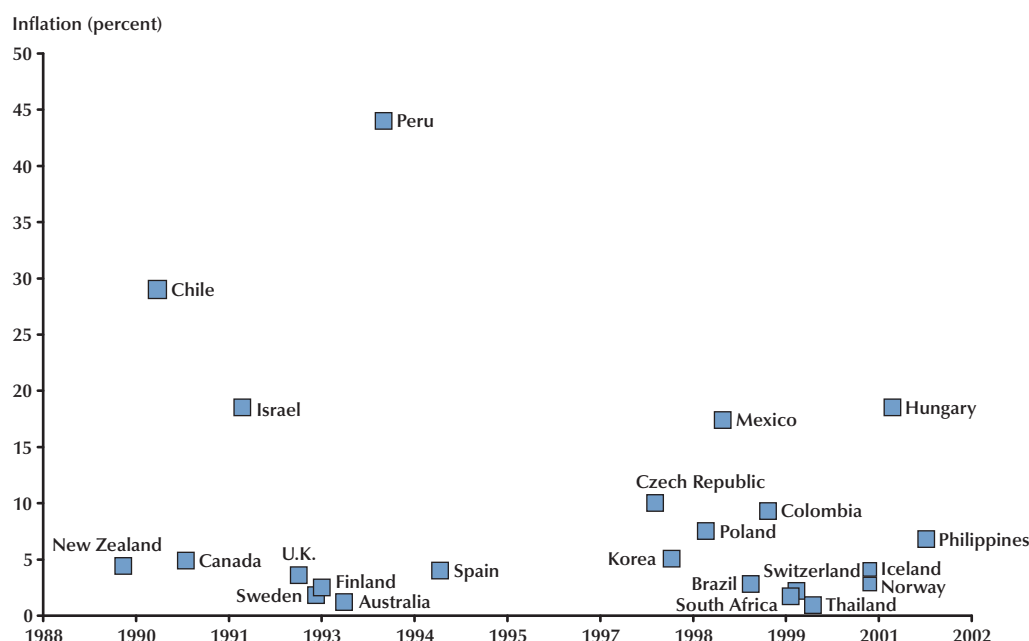
Clearly, one straightforward way to address this question is to look at the performance of those countries that have announced explicit numeric inflation targets. Our list of the countries in this group (23 in all) is shown in Table 1. For each country, Figure 1 graphs the year a target was adopted and the inflation rate at that time.<sup>2,3</sup> As far as we have been able to determine, no country has joined the group since 2002. In many, but certainly not all of these countries, inflation was below 5 percent at the time of the announcement of the inflation-targeting regime. The appendix provides the details on the target index(es), the target ranges, dates of target adoption, target setting responsibility, and public reporting on the performance of the inflation policy.

Figures 2 through 22 show the history of inflation for each of the inflation-targeting countries.<sup>4</sup> For those countries that have changed the index in which they define their inflation target, there is a separate graph for each index. The graphs show the inflation target range (the shaded area) or the point inflation target as appropriate. It is immediately apparent from these graphs that the period-to-period (month-to-month or quarter-to-quarter) annualized rate of inflation is highly volatile in all of the countries that pursue an explicit numeric inflation target. These short-run inflation rates are as likely as not to be outside the target range. If effective monetary policy were to be defined in terms of stability of high-frequency rates of inflation, then all of these central banks would have to be judged as failing to achieve the objective. However, it is neither reasonable nor desirable to define the objective in such short-run terms. Shocks to the price level—that is, transitory shocks to inflation—originate from numerous sources, both monetary and nonmonetary. No central bank can foresee such shocks and probably

<sup>2</sup> We consider two countries that at one time had explicit numeric targets—Finland and Spain—that have dropped from the group upon accession to the European Monetary Union.

<sup>3</sup> This figure updates similar figures that can be found in Loayza and Soto (2002) and Mishkin and Schmidt-Hebbel (2002).

<sup>4</sup> For early discussions of the implementation of and experience with inflation targeting for several of these countries, see Leiderman and Svensson (1995).

**Figure 1****The Year of Adoption and Initial Inflation in Twenty-Three Inflation-Targeting Countries**

cannot accurately predict the dynamics by which such shocks ultimately impact the price level. Economic theory suggests that central banks can be held accountable for “sustained inflation.” Correspondingly, inflation-targeting central banks, and even central banks without explicit numeric targets, such as the Fed, typically focus on “medium term” inflation. The duration of the medium term is frequently, and probably intentionally, left ambiguous.<sup>5</sup> Absent a precise definition of the medium term, some measures must be specified to judge the effectiveness of the inflation-targeting policies.

We examine two measures of the effectiveness of explicit numeric inflation targeting. Both measures are based on moving averages of the observed rates of inflation. These measures are

indicated in Figures 2 to 23 by the heavy lines. Relative to the dates indicated on the horizontal axis, this line shows the leading moving average of the rate of inflation to the end of 2004. The shortest moving average shown is one year. The question is, What is the maximum period, ending with 2004, that the moving average of the inflation rate remained within the bounds determined by the current (end of 2004) inflation target? These periods are shown for each of the inflation-targeting countries in Table 2.

Judged by this metric, there are a number of inflation-targeting countries in which monetary policy has been very effective. For five countries, New Zealand, Norway, Switzerland, Thailand, and the United Kingdom, the moving average of the rate of inflation has been within the current announced target range since before the adoption of the inflation-targeting procedure.<sup>6</sup> Canada and

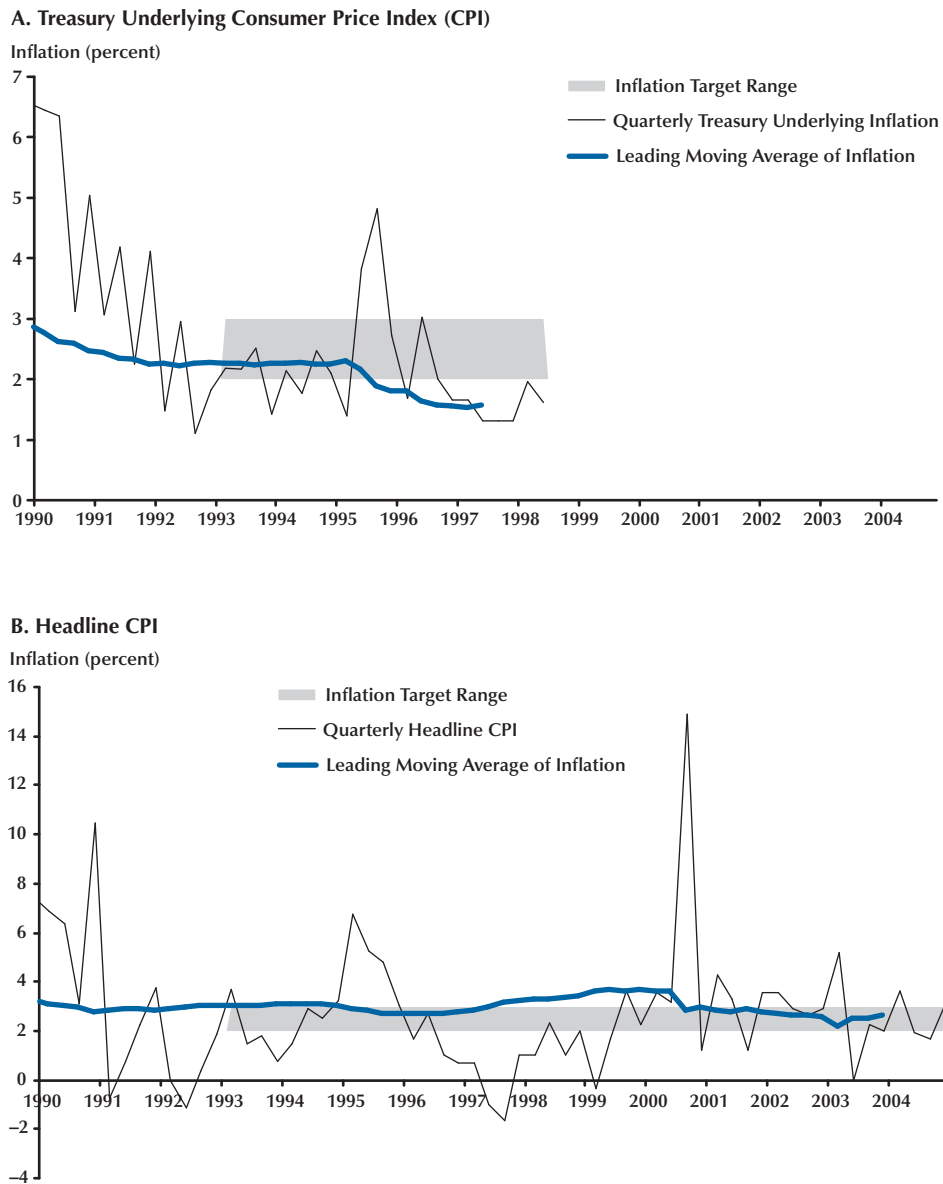
<sup>5</sup> President Santomero of the Federal Reserve Bank of Philadelphia stated that he preferred measuring inflation against an explicit target range on a 12-month moving-average (year-over-year) basis. Few central bankers have been this explicit about their definitions of a “medium term.”

<sup>6</sup> Norway has a stated target of 2.5 percent, not an inflation range. The moving average of the inflation rate has been below this value since 2000 and only dipped slightly below zero in early 2003.



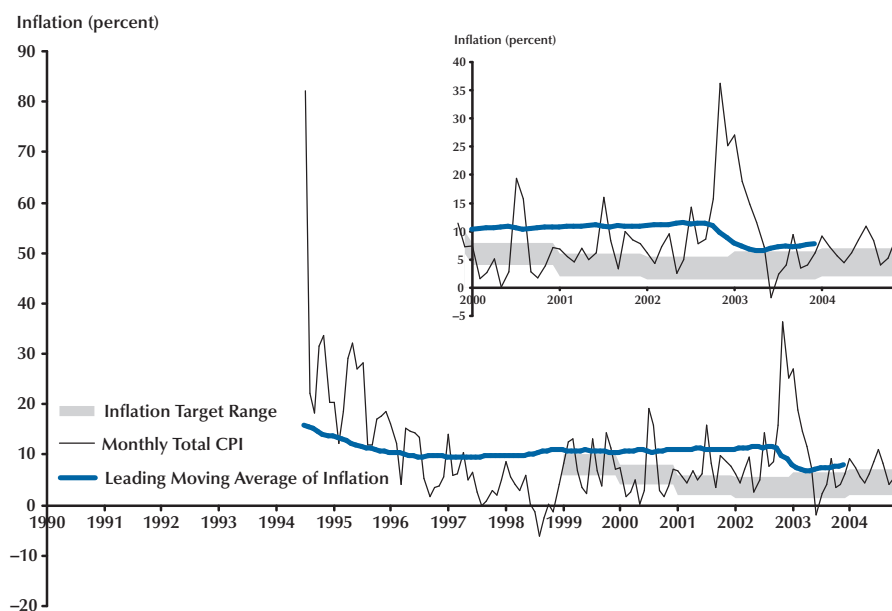
## Figure 2

### Australia: Moving Average of Inflation and Inflation Target Range

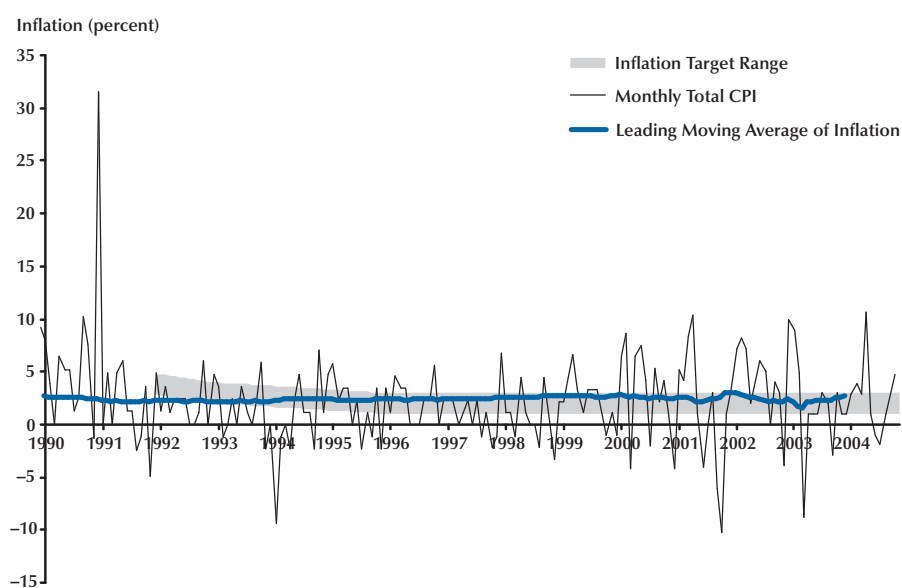


NOTE: The initial, formal inflation target related to the Treasury underlying measure of the CPI. When interest charges were removed from the CPI in the June quarter 1998, this target was amended to the headline CPI inflation rate.

SOURCE: Reserve Bank of Australia.

**Figure 3****Brazil: Moving Average of Inflation and Inflation Target Range**

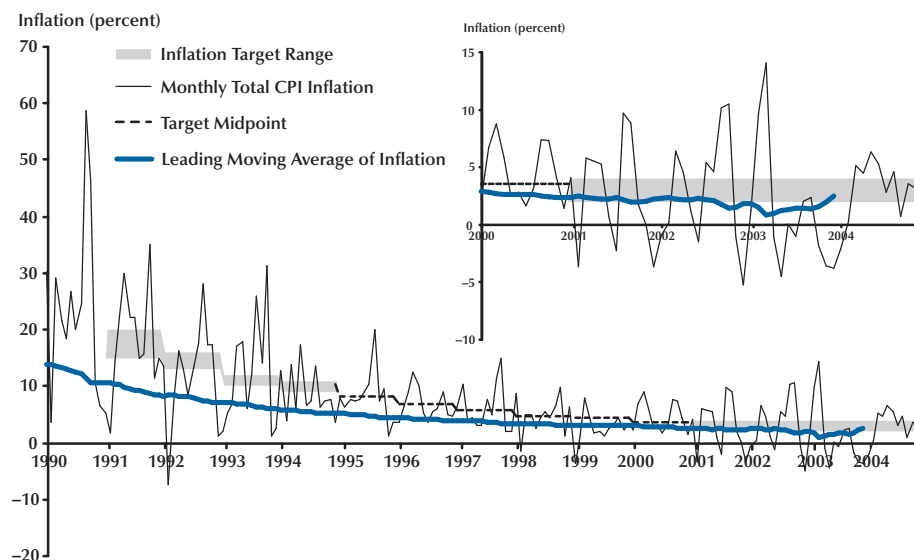
SOURCE: Banco Central do Brazil.

**Figure 4****Canada: Moving Average of Inflation and Inflation Target Range**

SOURCE: Banque du Canada.

**Figure 5**

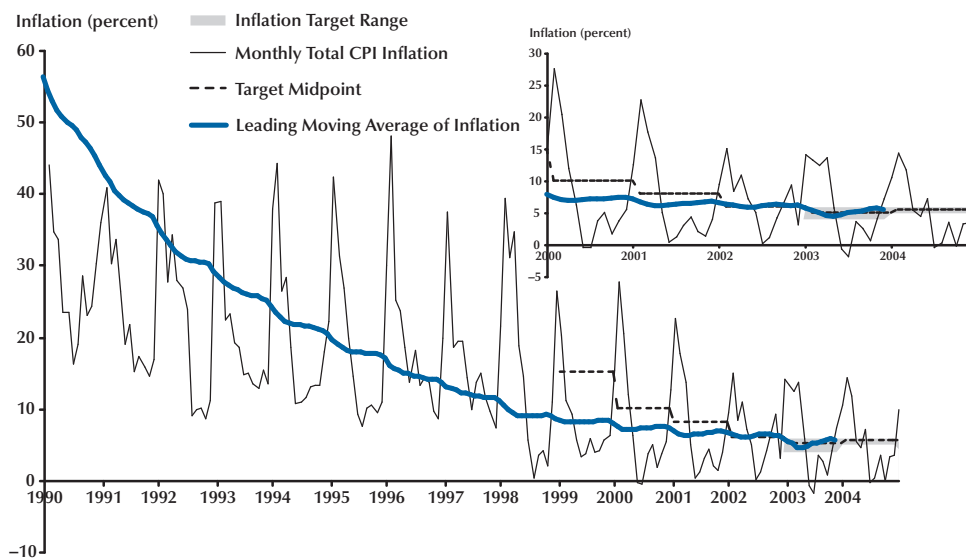
**Chile: Moving Average of Inflation and Inflation Target Range**



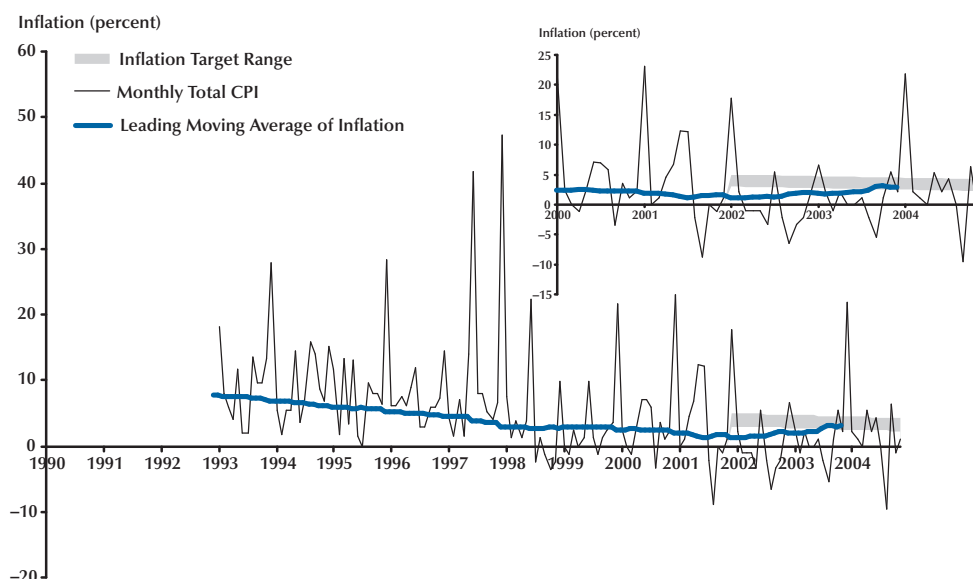
SOURCE: Banco Central de Chile.

**Figure 6**

**Colombia: Moving Average of Inflation and Inflation Target Range**

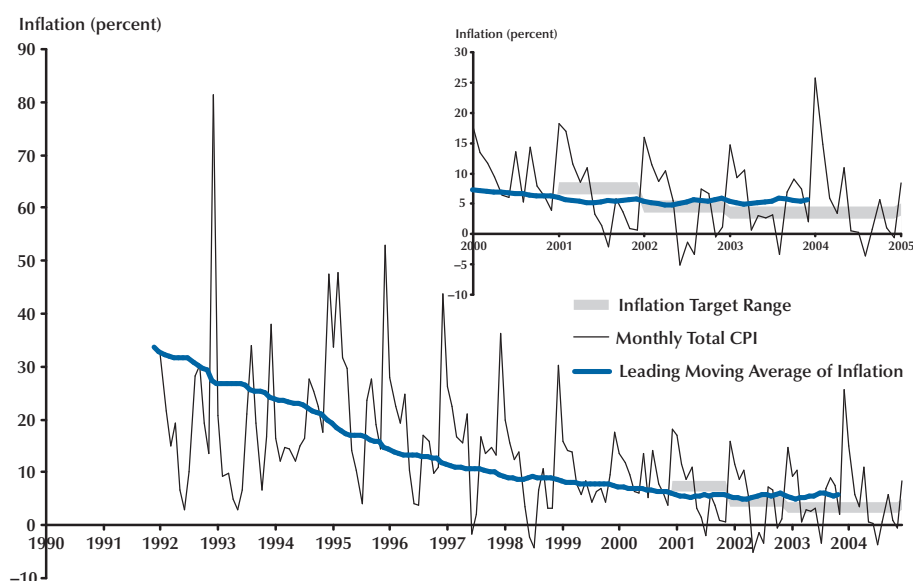


SOURCE: Banco Central de Colombia.

**Figure 7**
**Czech Republic: Moving Average of Inflation and Inflation Target Range, Headline CPI**


NOTE: Czech Republic targeted net inflation through 2001 and headline CPI thereafter.

SOURCE: Czech Statistical Office.

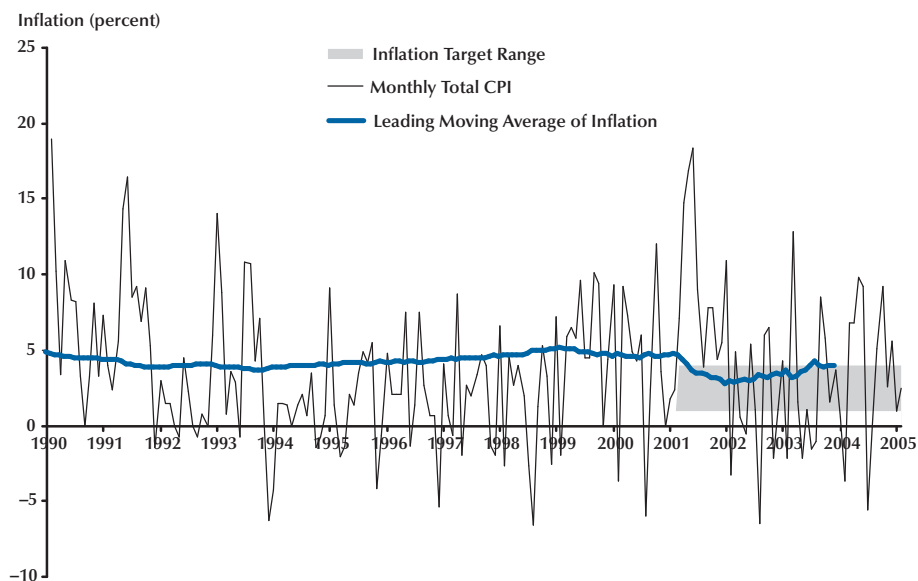
**Figure 8**
**Hungary: Moving Average of Inflation and Inflation Target Range**


SOURCE: Hungarian Central Statistical Office.



**Figure 9**

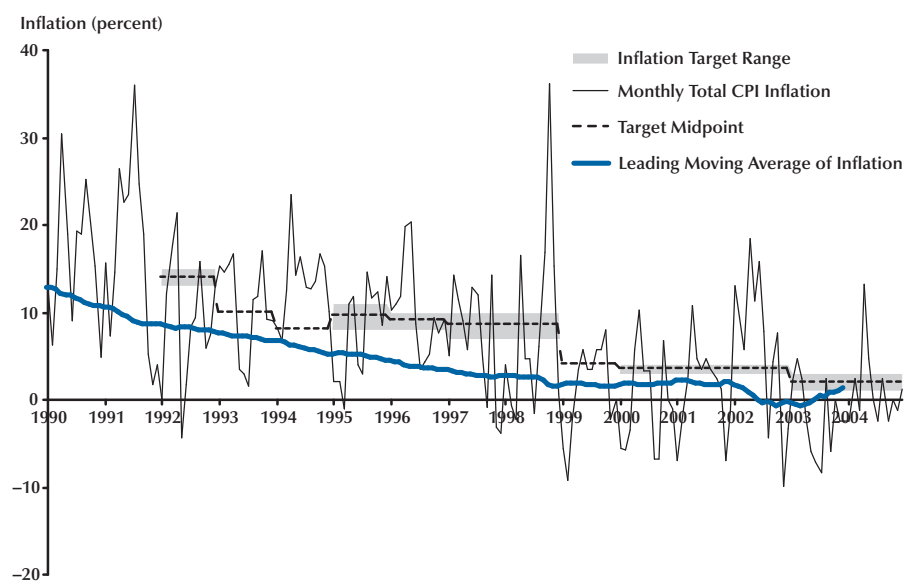
**Iceland: Moving Average of Inflation and Inflation Target Range**



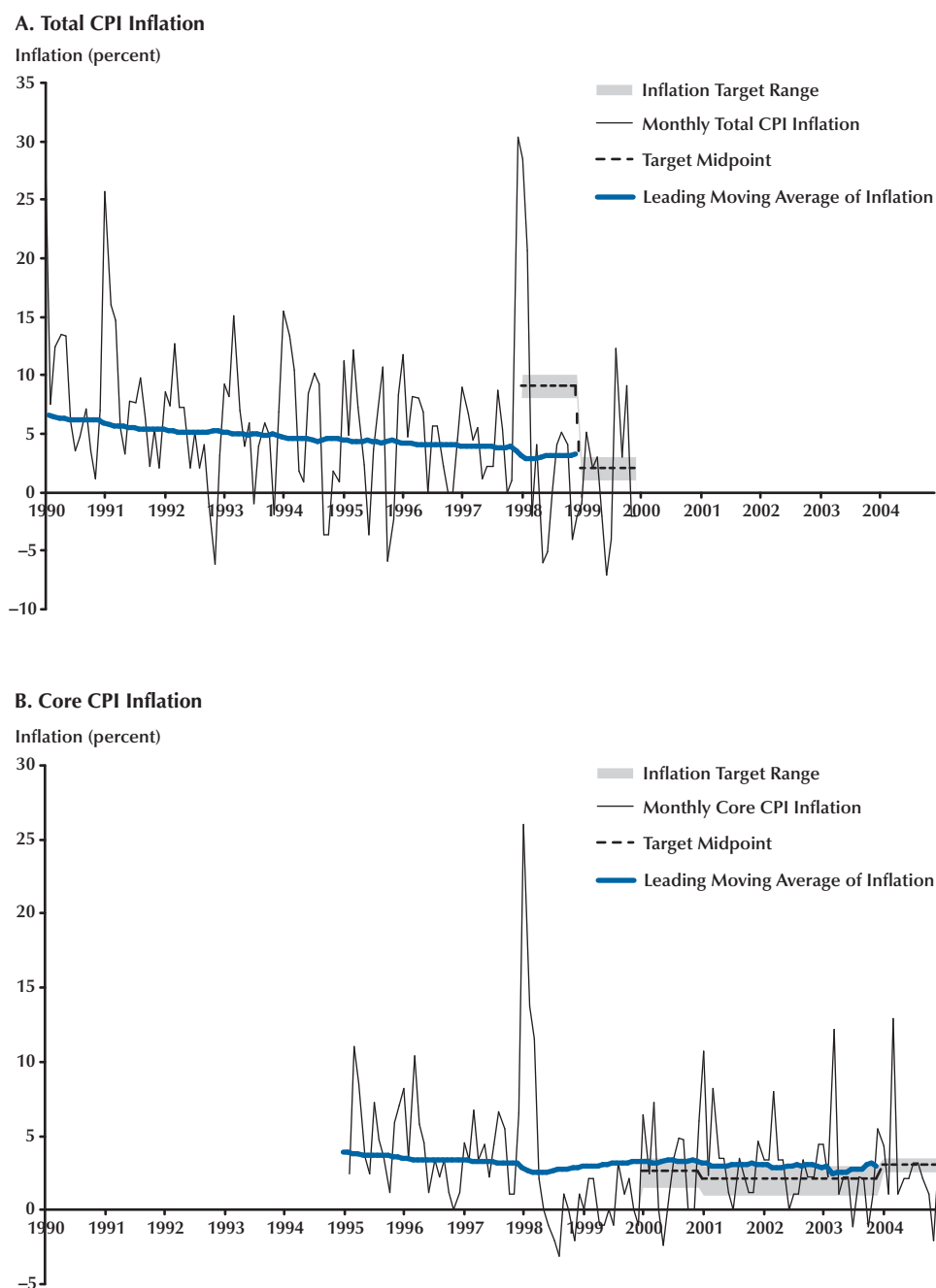
SOURCE: Statistics Iceland.

**Figure 10**

**Israel: Moving Average of Inflation and Inflation Target Range**



SOURCE: Central Bureau of Statistics, Israel.

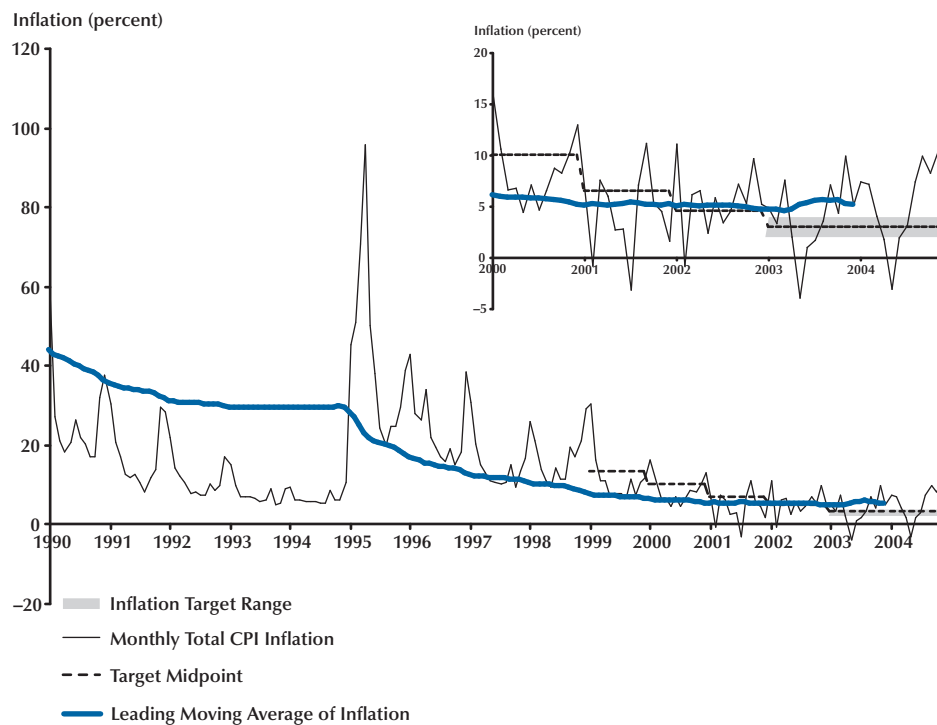
**Figure 11****Korea: Moving Average of Inflation and Inflation Target Range**

NOTE: Total CPI was targeted until 1999. Core inflation was targeted beginning in 2000.

SOURCE: Korea National Statistics Office and the Bank of Korea.

**Figure 12**

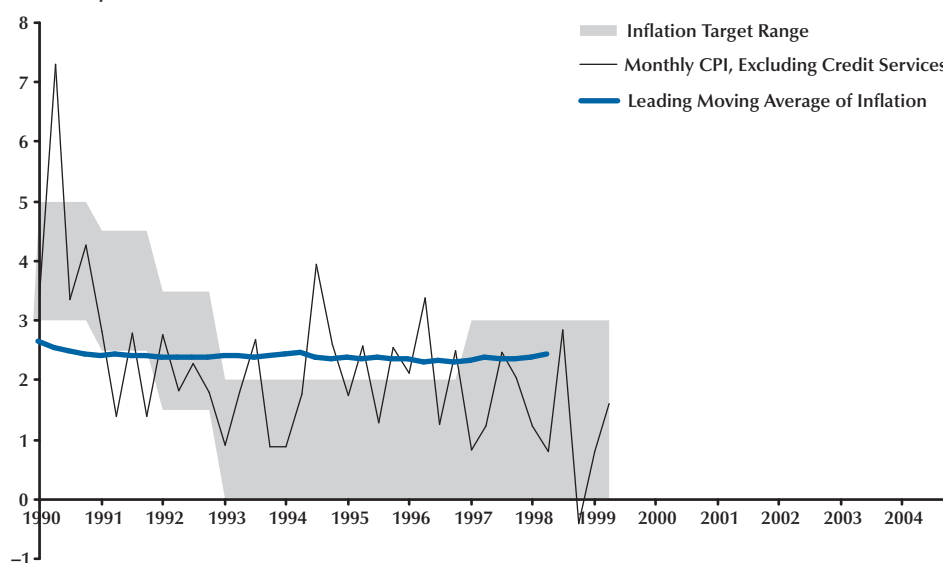
**Mexico: Moving Average of Inflation and Inflation Target Range**



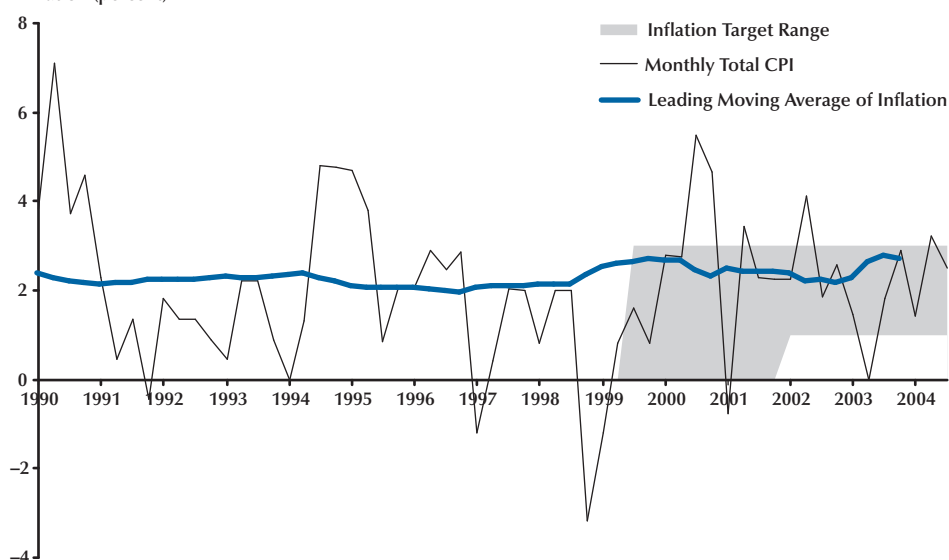
SOURCE: Banco de Mexico.

**Figure 13****New Zealand: Moving Average of Inflation and Inflation Target Range****A. CPI, Excluding Credit Services (CPIX)**

Inflation (percent)

**B. Headline CPI**

Inflation (percent)



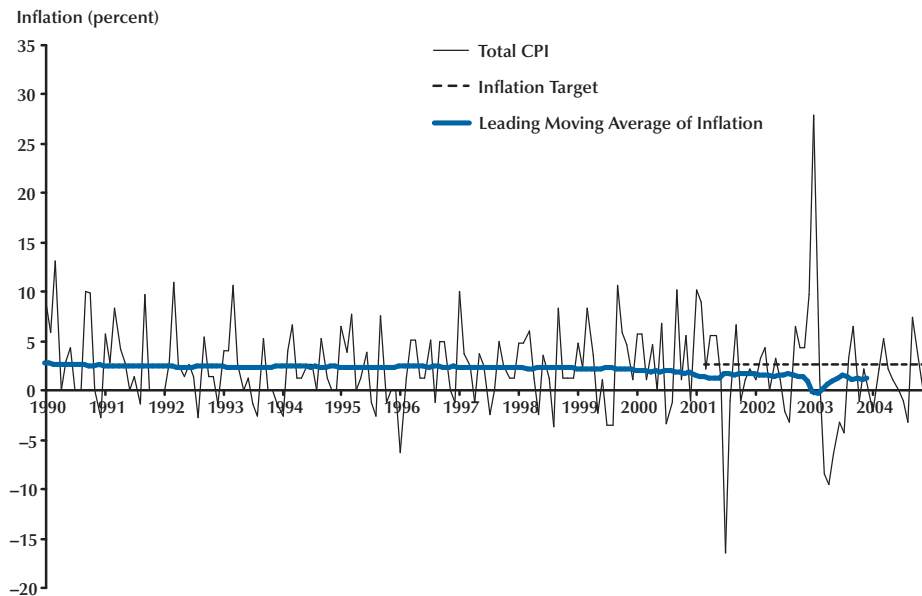
NOTE: The Reserve Bank of New Zealand targeted underlying inflation until the September 1997 quarter, CPIX inflation through to the June 1999 quarter, then CPI inflation from the September 1999 quarter.

SOURCE: Reserve Bank of New Zealand.



**Figure 14**

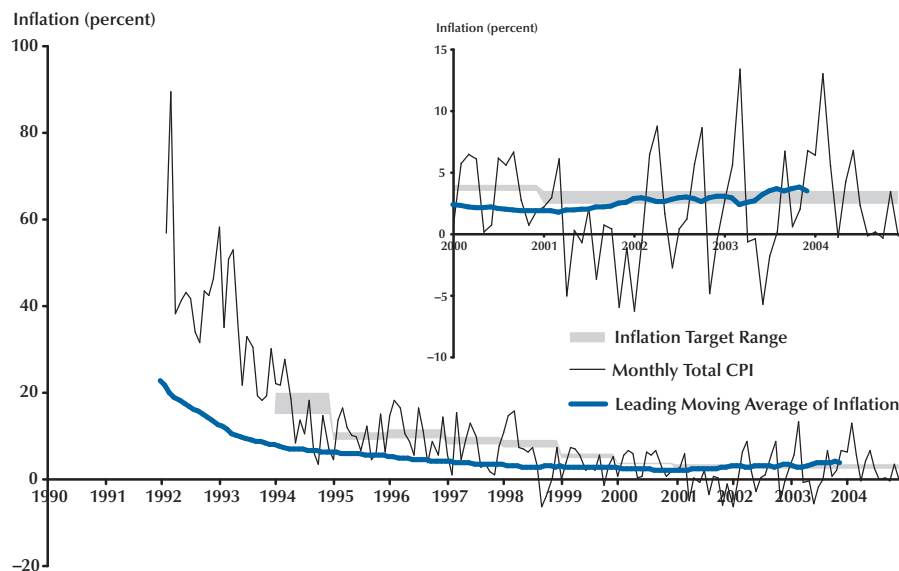
**Norway: Moving Average of Inflation and Inflation Target Range**



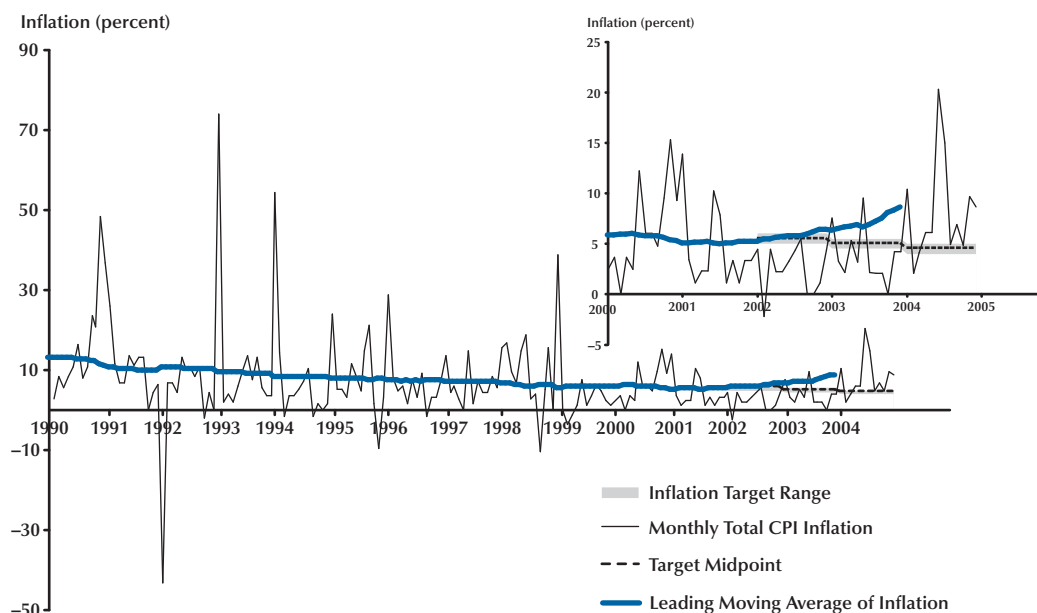
SOURCE: Statistics Norway.

**Figure 15**

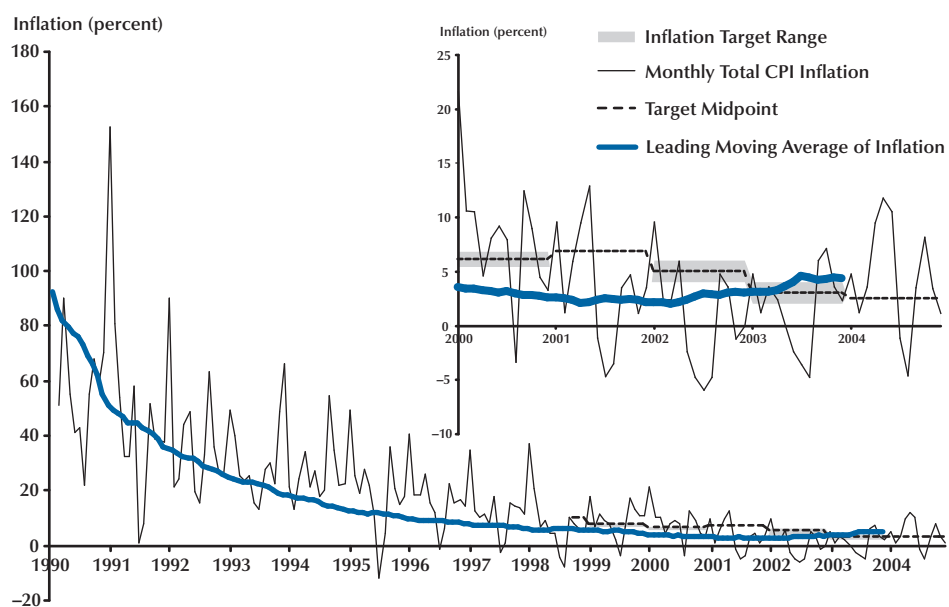
**Peru: Moving Average of Inflation and Inflation Target Range**



SOURCE: Central Reserve Bank of Peru.

**Figure 16****Philippines: Moving Average of Inflation and Inflation Target Range**

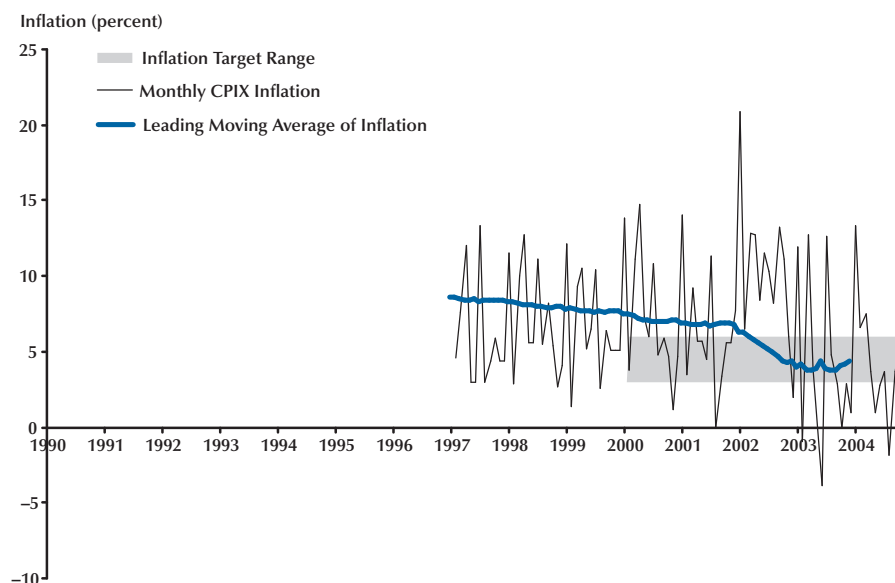
SOURCE: Central Bank of the Philippines.

**Figure 17****Poland: Moving Average of Inflation and Inflation Target Range**

SOURCE: Central Statistical Office, Poland.

**Figure 18**

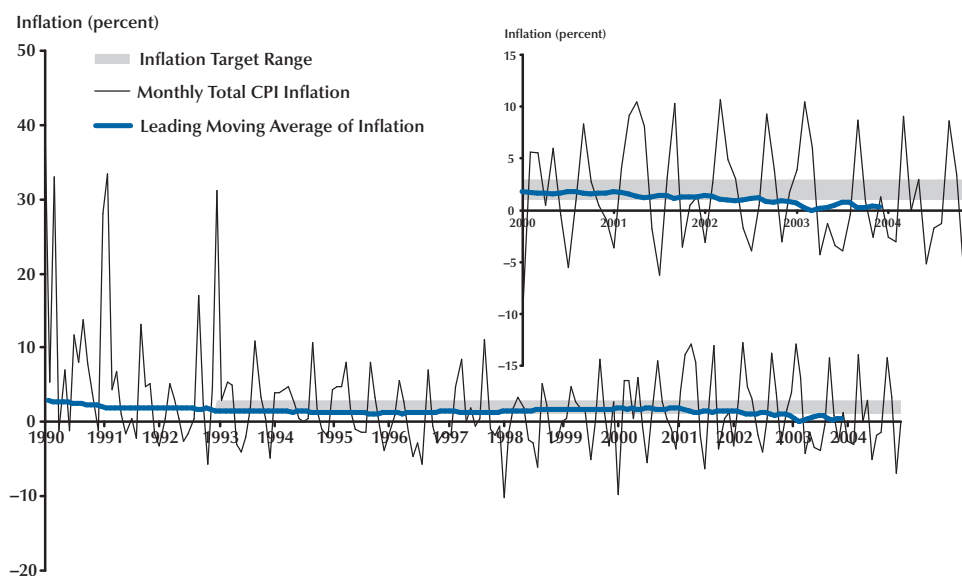
**South Africa: Moving Average of Inflation and Inflation Target Range**



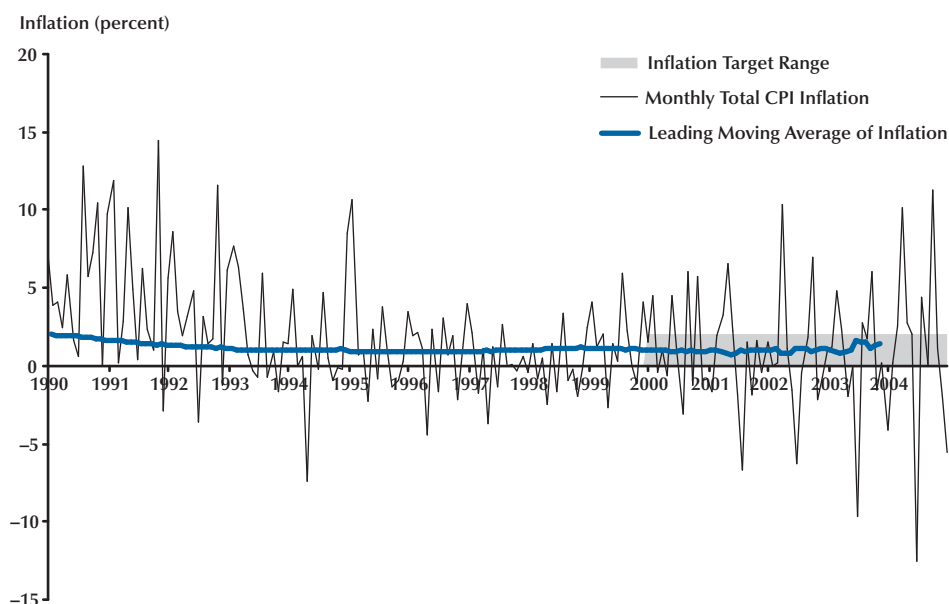
SOURCE: South African Reserve Bank.

**Figure 19**

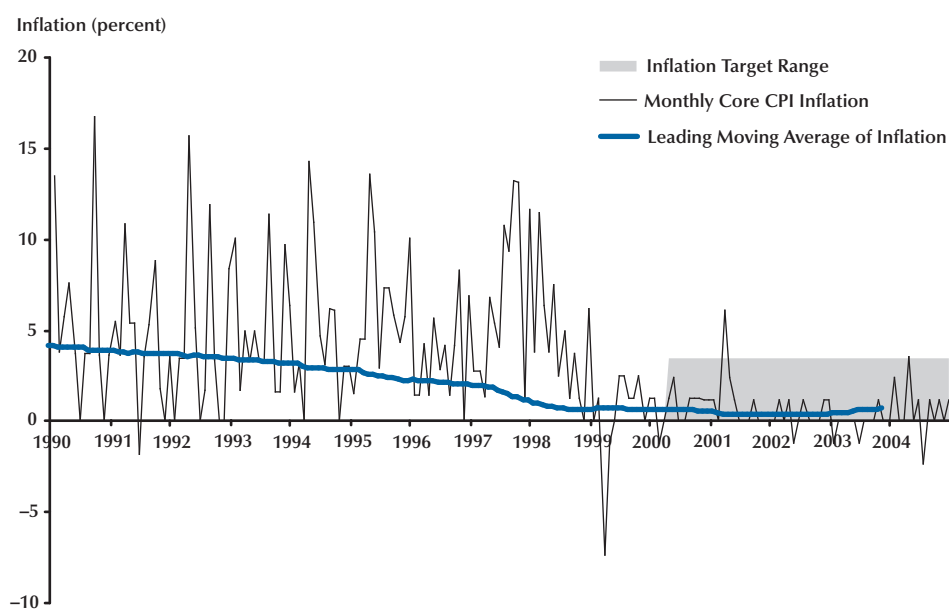
**Sweden: Moving Average of Inflation and Inflation Target Range**



SOURCE: Statistics Sweden.

**Figure 20**
**Switzerland: Moving Average of Inflation and Inflation Target Range**


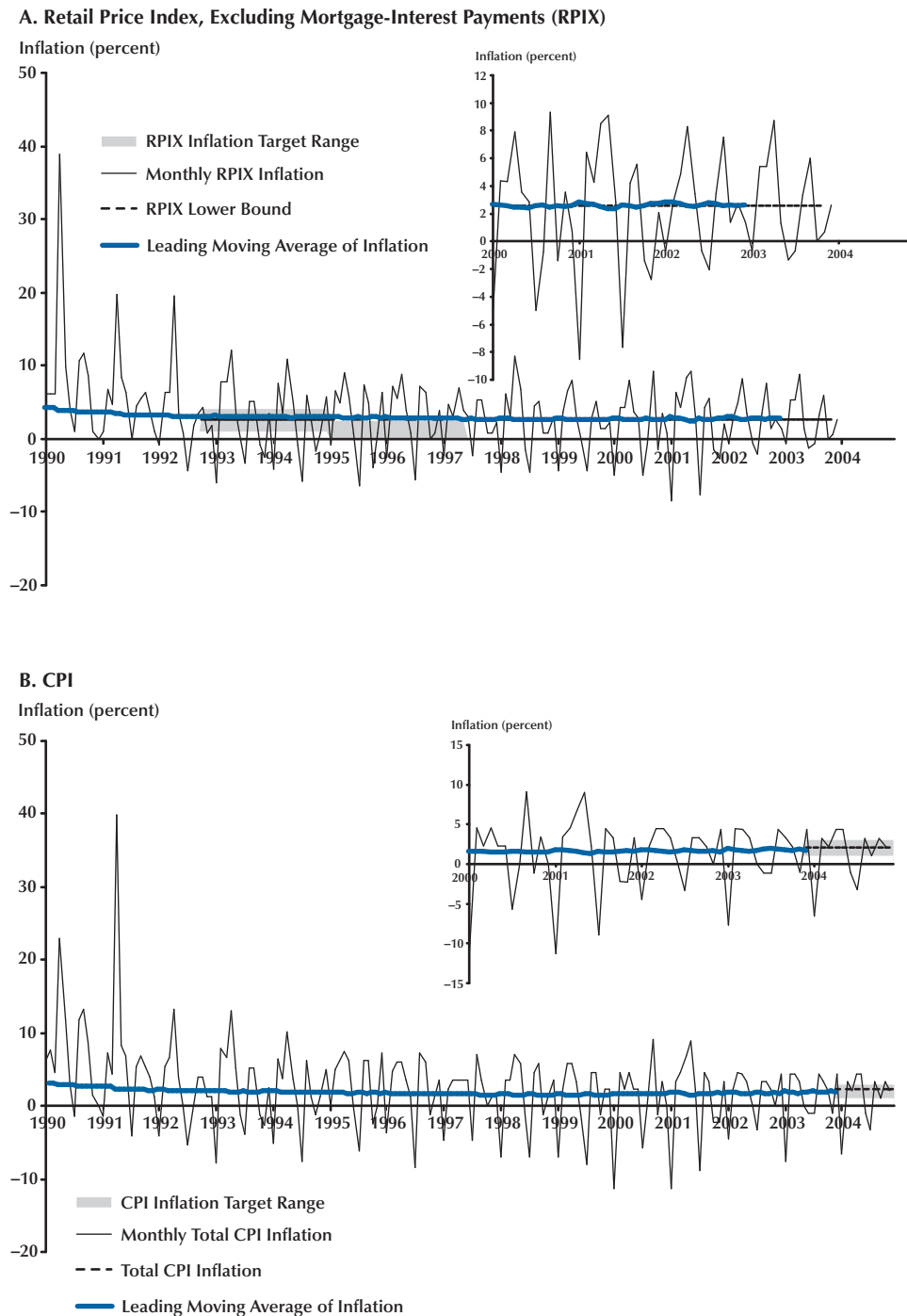
SOURCE: Swiss National Bank.

**Figure 21**
**Thailand: Moving Average of Inflation and Inflation Target Range**


SOURCE: Bureau of Trade and Economic Indices, Ministry of Commerce, Thailand.

## Figure 22

### United Kingdom: Moving Average of Inflation and Inflation Target Range



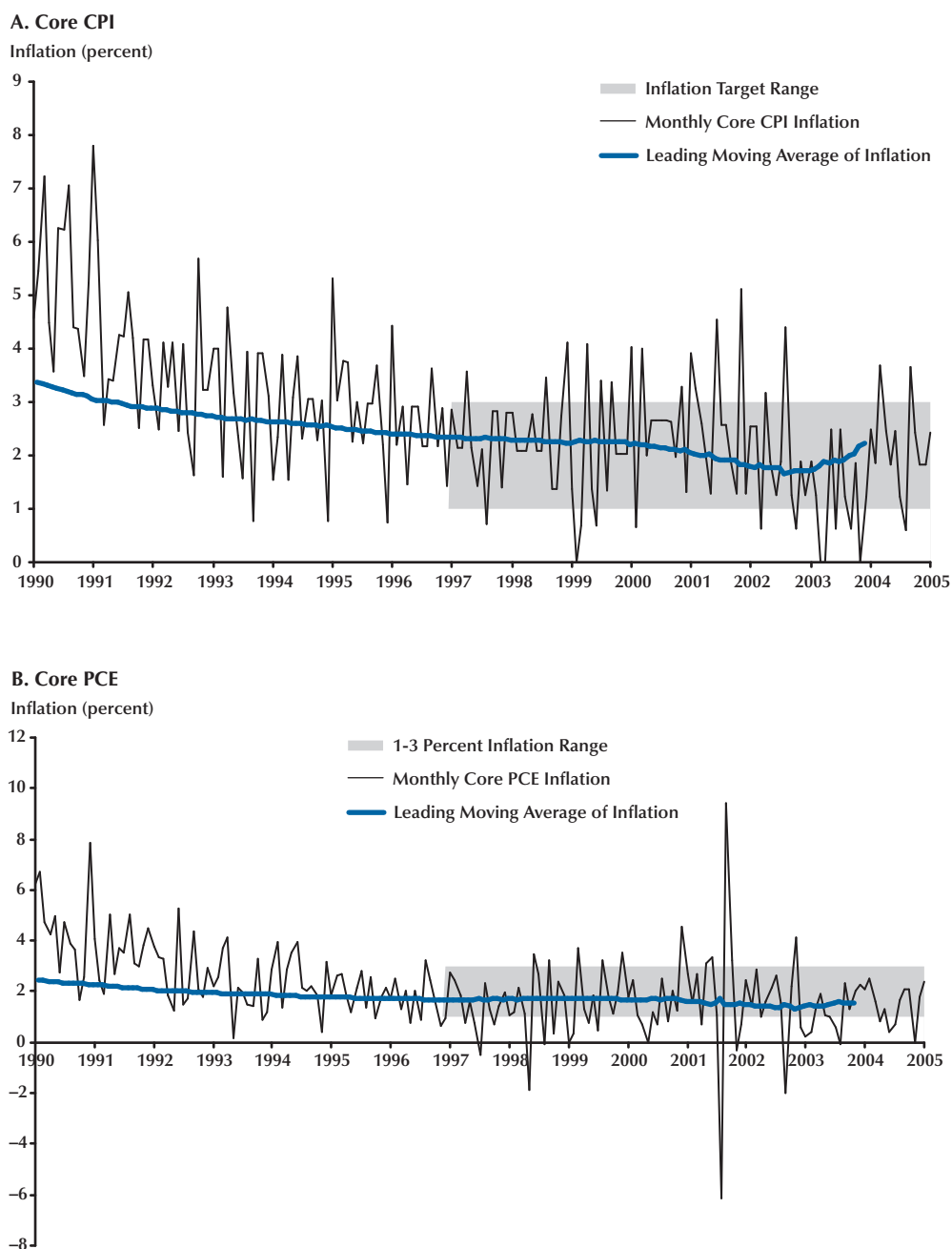
NOTE: Since December 2003, the United Kingdom's inflation target has been based on the CPI.

SOURCE: National Statistics, United Kingdom.



## Figure 23

### United States: Moving Average of Inflation and Inflation Target Range



NOTE: CPI for all urban consumers: All items less food and energy.

SOURCE: FRED®, Federal Reserve Bank of St. Louis.

**Table 2****Effectiveness of Explicit Numeric Inflation Targeting**

Country	Target range as of Dec. 2004 (%)	First date for which target range is not met	Number of periods within range	Moving average rate of inflation from Dec. 2002 to Dec. 2004 (%)	Standardized deviation from moving average
Australia	2-3	June 2000	17	2.51	0.02
Brazil	4.5 ± 2.5	Dec. 2003	12	8.80	1.72
Canada	2 ± 1	Nov. 1992	109	2.24	0.24
Chile	2-4	Nov. 2003	13	1.76	-1.24
Colombia	5-6	Dec. 2002	24	6.17	1.34
Czech Republic	1-3	Feb. 2002	34	1.93	-0.07
Hungary	3.5 ± 1	Dec. 2003	12	5.75	2.25
Iceland	2.5 ± 1.5	Aug. 2003 (next date is April 2001)	16	3.37	0.58
Israel	1-3	Nov. 2003	13	-0.35	-2.35
Korea	2.5-3.5	Nov. 2003 (next date is Nov. 2001)	13	2.87	-0.26
Mexico	2-4	Dec. 2003	12	4.69	1.69
New Zealand	1-3	Never <sup>1</sup>	59	2.15	0.15
Norway <sup>2</sup>	2.5	Never	45	0.85	—
Peru	2.5 ± 1	Nov. 2003	13	3.03	0.53
Philippines	4-5	Dec. 2003	12	6.38	3.76
Poland	2.5 ± 1.5	Dec. 2003	12	3.09	0.39
South Africa	3-6	Feb. 2002	34	4.25	-0.17
Sweden	2 ± 1	Dec. 2003	12	0.78	-1.22
Switzerland	<2	Never <sup>3</sup>	59	0.97	-0.03
Thailand	0-3.5	Never <sup>4</sup>	55	0.30	-0.83
United Kingdom	2 ± 1	Never <sup>5</sup>	146	1.46 <sup>6</sup>	-0.54

NOTE: <sup>1</sup>Average rate of inflation for New Zealand has never gone outside the range since inflation targeting was adopted (1990).

<sup>2</sup>No index numbers for CPI-ATE (CPI, adjusted for tax changes and excluding energy products) are available. Average rate of headline CPI inflation was used instead. Value for average rate of headline CPI inflation has never exceeded 2.5% since inflation targeting was adopted (2001). <sup>3</sup>Average rate of inflation for Switzerland has never gone outside the range since inflation targeting was adopted (2000). First date for which the average rate of inflation was outside the range was October 1989 at 2.09%. <sup>4</sup>Average rate of inflation for Thailand has never gone outside the range since inflation targeting was adopted (2000). The first date for which the average rate of inflation was outside the range was August 1992 at 3.52%. <sup>5</sup>First date for which the average rate of inflation was outside the range was March 1992 at 3.03% for average rate of RPIX inflation. <sup>6</sup>Note that in December 2002, the United Kingdom targeted RPIX and not headline CPI. The value for the average rate of inflation of RPIX at that time was 2.6%, still within the target range as of December 2004.

Australia also have maintained, for considerable periods, an average rate of inflation within the range currently in effect. (Note that for Australia and New Zealand, data are quarterly and not monthly.) None of these countries has a particularly wide target range. The Czech Republic and South Africa have shorter records of success by this metric, but nevertheless have moderately effective performances. The Czech Republic is notable because the inflation rate there was fairly high when the target was adopted and the moving average of the rate of inflation has fallen outside of the target range only on the low side. Nevertheless, the moving average of Czech headline inflation has been positive for the entire period since it fell below the lower bound of the current target range (in February 2002).

Israel, Peru, and Poland have experienced long-term average inflation below their current target ranges. The short-horizon moving averages for Hungary, Peru, and Poland have exceeded the current target ranges. In Israel, the moving average of the rate of inflation actually went negative in 2002 and 2003. Three countries—Chile, Colombia, and Hungary—have adjusted their targets downward over time, and generally the average inflation rate has fallen below the ranges, consistent with success in moving to the lower inflation targets. Deviations from the target ranges have been symmetric. Other countries, notably Brazil, Mexico, and the Philippines, have consistently missed their target ranges on the high side.

Although averages provide interesting insights into the sustainability of inflation performance, they obscure the marginal performance. A moving average could remain within the target range for a long period of time if, over time, the inflation rate converges toward the midpoint of the range. Alternatively, the same moving average could result if, early in the period, the inflation rate was close to one end point of the target range and, as time progressed, inflation moved close to the opposite edge of the target range. The latter situation could be characterized as “skating on thin ice.”

To examine this issue, Table 2 shows the value of the moving average over the two-year period 2003-04 and a standardized deviation of this two-

year moving average from the midpoint of the target range that prevailed at the end of 2004. The standardization is constructed by dividing the deviation of the moving average from the midpoint by one-half the difference between the upper and lower endpoints of the target range.

By this metric, the bulk of the inflation-targeting countries have been doing quite well over the past two years. The exceptions are Brazil, Colombia, Hungary, Mexico, and the Philippines (whose average inflation rate over the past two years fell above their target ranges) and Israel and Sweden (whose average inflation rate over the past two years fell below the target ranges).

Our conclusion from these data is that central banks that have announced explicit numeric inflation objectives have been quite effective in achieving the stated inflation stabilization objective.

The FOMC has not adopted this framework, though it is known that on at least three occasions the pros and cons of adopting this approach have been debated around the FOMC table.<sup>7</sup> Several current participants in the FOMC have stated on the record their preference for an explicit numeric target and given their preferred measures. Included are then-Governor Ben Bernanke, President Jeffrey Lacker of the Federal Reserve Bank of Richmond, President Janet Yellen of the Federal Reserve Bank of San Francisco, and former-President Anthony Santomero of the Federal Reserve Bank of Philadelphia.<sup>8</sup>

Then-Governor Bernanke indicated his preferred inflation target is 1 to 2 percent as measured by the core personal consumption price index.<sup>9</sup> President Lacker has indicated his preference for

<sup>7</sup> Transcripts of two of these debates, on January 31, 1995, and July 2, 1996, can be found on the web site of the Board of Governors of the Federal Reserve System: [www.federalreserve.gov/fomc/transcripts/transcripts\\_1995.htm](http://www.federalreserve.gov/fomc/transcripts/transcripts_1995.htm) and [www.federalreserve.gov/fomc/transcripts/transcripts\\_1996.htm](http://www.federalreserve.gov/fomc/transcripts/transcripts_1996.htm), respectively. A summary of the most recent debate at the February 1, 2005, FOMC meeting is also available on the Board's web site: [www.federalreserve.gov/fomc/minutes/20050202.htm](http://www.federalreserve.gov/fomc/minutes/20050202.htm).

<sup>8</sup> During the July 1996 FOMC debate on inflation targets, President Gary Stern of the Federal Reserve Bank of Minneapolis indicated that a 2 percent target (in terms of the CPI) would be acceptable to him (FOMC Transcripts, July 2-3, 1996, p. 56). The discussion at that time was not framed in terms of a target point or a target range.

<sup>9</sup> See, for instance, Derby (2005).

a target of 2 percent as measured by the core CPI or 1.5 as measured by the core personal consumption price index; he has also indicated a preference that inflation be kept above 1 percent (Lacker, 2005). President Yellen has indicated a preference for a target of 1.5 percent as measured by the core personal consumption price index, with a range of about  $\pm 1$  percent (Reuters News, 2005). Former-President Santomero indicated his preference for a target range of 1 to 3 percent as measured by a 12-month moving-average rate of change in the core personal consumption price index (AFX Asia, 2004). Other current participants at FOMC meetings, including Vice Chairman Donald Kohn (2005), have indicated that they do not prefer an explicit numeric inflation objective. President William Poole has stated that he believes “ambiguity with respect to the Fed’s inflation and employment objectives is not large and is not the main problem the Fed faces with its communication policies” (Poole, 2005b).

Differences of opinion among FOMC participants notwithstanding, in May 2003 the press release following the FOMC meeting indicated that “the probability of an unwelcome substantial fall in inflation, though minor, exceeds that of a pickup in inflation from its already low level.”<sup>10</sup> The minutes of that FOMC meeting (FOMC Minutes, May 6, 2003) indicate the rationale for this statement:

Members commented that substantial additional disinflation would be unwelcome because of the likely negative effects on economic activity and the functioning of financial institutions and markets, and the increased difficulty of conducting an effective monetary policy, at least potentially in the event the economy was subjected to adverse shocks. Members also agreed that there was only a remote possibility that the process of disinflation would cumulate to the point of a decline for an extended period in the general price level.<sup>11</sup>

At that time, core personal consumption inflation was measured in the neighborhood of

1 percent. Although the FOMC has never stated a numeric inflation objective, individual FOMC participants have expressed preferences for both the core CPI and core personal consumption price index; they have typically indicated values for core CPI inflation one-half percent above those for the core personal consumption inflation rate. It seems reasonable to conclude that the FOMC has a lower bound of an acceptable medium-term rate of inflation in the neighborhood of 1 percent for the core personal consumption inflation rate and perhaps 1.5 percent for the core CPI inflation rate.

Former-Governor Larry Meyer (2004) is also on record in favor of an explicit numeric inflation objective. However, his position is that the “dual mandate” inherent in the Federal Reserve Act differentiates the U.S. environment from that of other inflation-targeting central banks that operate under a “hierarchical mandate.” Meyer defines a hierarchical mandate as an environment “in which price stability is identified as the principal objective, and central banks are restricted from pursuing other objectives unless price stability has been achieved” (p. 151). He contrasts this with the “dual mandate,” where “monetary policy is directed at promoting both full employment and price stability with no priority expressed, and with the central bank responsible for balancing these objectives in the short run” (p. 151). It is our opinion that Meyer’s view does not allow for the effectiveness of monetary policy to vary in the long and short runs. In terms of long-run objectives, central banks must necessarily operate under a hierarchical mandate, given the consensus view of monetary policy that policymakers are not presented a long-run tradeoff between inflation and real output. Indeed, in specifying a policy rule, whether an instrument or target rule, the exercise of determining how much weight to place on short-run movements in inflation versus short-run movements in real output is conditioned on the prespecification of the long-run inflation target ( $\pi^*$ ). In this sense, any central bank seeking to operate in such a monetary policy framework has to be hierarchical: First it must specify its long-run inflation objective and then, and only then, can it set its preferred (or optimal) weights

<sup>10</sup> See [www.federalreserve.gov/boarddocs/press/monetary/2003/20030506/default.htm](http://www.federalreserve.gov/boarddocs/press/monetary/2003/20030506/default.htm).

<sup>11</sup> See [www.federalreserve.gov/fomc/minutes/20030506/htm](http://www.federalreserve.gov/fomc/minutes/20030506/htm).

for short-run fluctuations.<sup>12</sup> The choice of weights could be such that the central bank follows a hierarchical mandate in both the long and short runs; however, there is nothing to preclude pursuing a dual goal, with a short-run mandate nested within a hierarchical long-run mandate. It is likely that most, if not all, central banks that have adopted an explicit inflation target pursue that objective within a nested hierarchical/dual structure.

Panels A and B of Figure 23 show the core CPI inflation and core personal consumption price inflation for the United States; the leading moving average from each of the dates since January 1990 until the end of 2004 are also shown.<sup>13</sup> The shaded area, from 1 to 3 percent in core CPI inflation, appears to encompass the preferences of the FOMC participants who have spoken out in favor of an explicit numeric inflation objective. The leading moving-average rate of core CPI inflation in the United States bottomed out in August 2002 at a value of 1.64 percent (annual rate). The corresponding date and value for core personal consumption price inflation are December 2002 and 1.28 percent, which appear to be close to the bottom of the FOMC's implicit acceptable range of inflation. On the other end of the scale, the leading moving-average rate of core CPI inflation has been below the 3 percent level since March 1991, whereas that for personal consumption price inflation has been below the 3 percent level since March 1987. These are comparable to the best performance of the inflation-targeting central banks against their announced targets. Accordingly, it cannot be claimed that an explicit numeric inflation target is a necessary condition to produce low and stable rates of inflation for an extended period. The question, which will not be answered unless inflation pressures build in the future, is whether in the absence of a public numeric inflation objective the institutional commitment exists to take potentially unpopular policy actions to resist upward creep in inflation.

<sup>12</sup> See also Svensson (2004).

<sup>13</sup> Relative to the end of 2004, the line indicates a trailing moving average of inflation back to the date indicated.

## HOW EFFECTIVE ARE CENTRAL BANKS AT SHORT-RUN (OUTPUT) STABILIZATION?

The evidence on the effectiveness of monetary policy as a short-run stabilization device is problematic. As Poole (2005b) has noted,

[t]he only certainty is that the effect of policy actions on real variables eventually dissipates. "Eventually" may cover a period of several years, and may be longer in some circumstances than others. It is worth noting that these hedges on my part reflect ignorance—mine and the profession's—and not obfuscations. We just don't have precise estimates of the magnitudes and durations of effects of monetary policy on real variables.

Our objective here is to examine why a definitive answer to this question remains so illusive. On one hand there is "case study" evidence supporting the idea that monetary policy does affect output fluctuations in the short run. The most prominent evidence from such studies highlights the contractionary effects of monetary policy. On the other hand, there are volumes of VAR analyses that fail to determine a major role for monetary policy in short-run stabilization.

The best known, though not uncontested, case-study analysis of the short-run response of real activity to monetary policy is Friedman and Schwartz's (1963) monetary history. They argue that the Federal Reserve put the "great" in the Great Contraction:

The monetary character of the contraction changed drastically in late 1930, when several large bank failures led to the first of what were to prove a series of liquidity crises involving runs on banks and bank failures on a scale unprecedented in our history...

The drastic decline in the stock of money and the occurrence of a banking panic of unprecedented severity did not reflect the absence of power on the part of the Reserve System to prevent them. Throughout the contraction, the System had ample powers to cut short the tragic process of monetary deflation and banking collapse. Had it used those powers effectively in late 1930 or even in early or mid-1931,



the successive liquidity crises that in retrospect are the distinctive feature of the contraction could almost certainly have been prevented and the stock of money kept from declining, or indeed, increased to any desired extent. Such action would have eased the severity of the contraction and very likely would have brought it to an end at a much earlier date. (pp. 10-11)

Romer and Romer (1989) construct case studies of six episodes from World War II through 1979 in which they believe that the Fed deliberately took action to induce a recession to reduce inflation. They conclude that the evidence supports the hypothesis that the monetary policy actions had a significant negative effect on real output in all of these instances. Case studies such as these address the qualitative question of whether monetary policy has an effect on real output; they do not address the question of the magnitude of the output response to a change in policy.

The final experience that is widely cited as evidence of a contractionary effect of monetary policy is the U.S. experience in 1979-83: the so-called "Volcker disinflation." This period is marked by two separate recessions: January-July 1980 and July 1981-November 1982. The first recession followed closely the introduction of the "new operating procedures" in October 1979 and an increase of 6 percent in the federal funds rate.<sup>14</sup> Note that the increase in the funds rate was not directly targeted by the Fed under the "new operating procedures." Furthermore, the impact of the monetary policy action in 1980 is confounded with the introduction of credit controls by the Carter administration in March 1980.<sup>15</sup>

Goodfriend (2005) maintains that the recession of 1981-82 was the direct consequence of monetary policy directed at disinflation:

The lesson of 1980 was that the Fed could not restore credibility for low inflation if it continued to utilize interest rate policy to stabilize

the output gap...As measured by personal consumption expenditures (PCE) inflation, which was about 10 percent in Q1 1981, real short-term interest rates were then a very high 9 percent. Not surprisingly, the aggressive policy tightening began to take hold by mid-year. (pp. 316-17)

Certainly, the home building industry in the United States regarded the collapse of housing construction during both recessions as the direct responsibility of the Volcker Fed, as evidenced by the numerous complaints delivered to the Board of Governors written on 2 × 4s. The housing construction industry in the United States showed highly cyclical fluctuations through the recession of 1990-91 (see Figure 24), and concerns about the sensitivity of this industry to monetary policy actions had been the focus of discussion at least since the early 1960s.<sup>16</sup>

Housing starts and housing construction behaved very differently in the 2001 recession than in prior postwar recessions: No slowdown is obvious. Admittedly, this cyclical slowdown was very mild, at least as measured in terms of real output growth. Yet this raises the question of whether cyclical fluctuations in housing should be cited as universal evidence of an impact of monetary policy on short-run fluctuations.<sup>17</sup>

One legacy of the Great Depression in the United States has been the use of price controls on bank deposits—so-called Reg Q ceilings. In 1966 these controls were extended to liabilities of thrift institutions that, at the time, were the principal source of mortgage financing. Cyclical fluctuations in interest rates had a major impact on the availability of mortgage financing during this period. By the mid-1980s these price controls had been removed, but by that time (economic) insolvency was widespread among thrift institutions. The resolution of the crisis in the housing finance industry continued through the recession of 1990-91. Hence, it may be more appropriate to argue that the interaction of monetary policy with

<sup>14</sup> For an analysis of the environment that led to the introduction of the "new operating procedures" and the objectives that the Volcker Fed sought to achieve with this innovation, see Lindsey, Orphanides, and Rasche (2005).

<sup>15</sup> See Schreft (1990).

<sup>16</sup> See, for example, Federal Reserve Bank of Boston (1970) and Grebler and Maisel (1963).

<sup>17</sup> Stock and Watson (2003) note the large decline in the volatility of residential construction (though not nonresidential construction) in the United States since the mid-1980s (p. 39).

## Figure 24

### U.S. Housing Starts: Annual Rates



NOTE: Shaded bars indicate recessions.

the system of deposit price controls produced a unique environment that supported a cyclical response of the economy to monetary policy actions. In the current U.S. environment, where mortgage securitization has become the rule and specialized deposit intermediaries have ceased to be significant players in mortgage finance, a traditional argument for the transmission of monetary policy may be more tenuous.

Econometric models provide alternative evidence on the effectiveness of monetary policy in influencing the short-run behavior of real output. Over the past 25 years, since the publication of Sims's (1980) classic article, literally hundreds, perhaps thousands, of econometric studies in vector autocorrelation (VAR) frameworks have sought to address this question. We believe that few people would argue that research in this framework has provided conclusive evidence to support the hypothesis that monetary policy has strong short-run effects on real output fluctuations. Christiano, Eichenbaum, and Evans (1999) summarize their extensive overview of this literature:

“[V]iewed across both sets of identification strategies that we have discussed, there is a great deal of uncertainty about the importance of monetary policy shocks in aggregate fluctuations” (p. 127) and “there is agreement that monetary policy shocks account for only a very modest percentage of the volatility of aggregate output; they account for even less of the movements in the aggregate price level” (p. 71). But if a consensus from case studies of historical episodes is that there are substantial effects, the question is how to reconcile the apparently conflicting evidence. An early assessment of the VAR type of study is provided by Cagan (1989):

If we accept the bulk of historical evidence as confirming the important monetary effects on the real economy, contrary findings cannot be fully valid. And, if such contrary evidence is not valid, what kind of evidence in monetary research is acceptable and convincing? (p. 119)

The VAR seems to me to be hopelessly unreliable and low in power to detect monetary effects of the kind we are looking for and

believe, from other kinds of evidence, to exist.  
(p. 127)

In the approximately 15 years since Cagan posed this question, analysts have become much more aware of the limitations of VAR analyses. It is now well understood that the VAR approach does not solve the fundamental econometric problem of identification. The VARs that are readily estimated using standard econometric software are no more than reduced-form models.<sup>18</sup> Indeed, there is substantial risk of misspecification as a result of omitted variables, given the limits on the dimensionality of the typical VAR that is imposed by the available time span of macroeconomic data series.

In the formative years of VAR analysis (say 1980-86) the typical approach was to “rotate and orthogonalize shocks” by computing a Cholesky decomposition of the covariance matrix of the estimated VAR residuals and to assume that one of the resulting “shocks,” frequently that associated with a short-term interest rate, represented the monetary policy innovation—the unpredictable component of monetary policy. Analyses of the effectiveness of monetary policy were constructed from impulse response functions and variance decompositions with respect to this “monetary shock.”

Gradually, it became recognized that “recursiveness and orthogonalization” is the imposition of a particular set of identifying restrictions—a triangular Wold causal chain structure.<sup>19</sup> This approach to identification was widely rejected by the econometrics establishment when initially proposed in the 1960s. Starting in the mid-1980s, alternative restrictions for identification of “structural VARs” (SVARs) appeared in the literature.<sup>20</sup> Generally the SVAR framework has maintained the identifying restrictions that the shocks in the “economic model” are independent and has found the additional required restrictions among the only available alternatives: constraints on impact or steady-state multipliers of the SVAR

or exclusion restrictions on the slope coefficients among contemporaneous variables or steady-state relationships in the SVAR.

Steady-state identifying restrictions are those for which accepted theory provides the most insight. Such restrictions may provide information on the dynamics of a real output response to a monetary policy shock that produces a permanent change in the inflation rate (assuming that inflation is approximately a nonstationary variable during the sample period). This is facilitated by received macroeconomic theories that suggest only monetary shocks can produce sustained changes in inflation. In an economy where the central bank focuses on a rule for an interest rate target that responds to deviations from a desired rate of inflation and other variables such as output gaps, such monetary shocks occur only when there is a change in the inflation target.<sup>21</sup> This does not get to the question of the effectiveness of monetary policy for short-run output stabilization. Here, the issue is how real output responds to monetary shocks that cause transitory fluctuations in the inflation rate (i.e., changes in the price level).

Unfortunately, received macroeconomic theories suggest that shocks from many nonmonetary sources can have a permanent effect on the price level. Examples include fiscal policy shocks, energy price shocks, productivity shocks, and terms-of-trade shocks. In such economic structures, restrictions on impact multipliers are hard to justify and sufficient restrictions on slope coefficients among the contemporaneous variables in the VAR to identify the desired monetary shock are problematic. This concern is echoed in Romer and Romer (1989, p. 121):

The reason that purely statistical tests, such as regressions of output on money, studies of the effects of “anticipated” and “unanticipated” money, and vector autoregressions, probably have not played a crucial role in forming most economists’ views about the real effects of monetary disturbances is that such procedures cannot persuasively identify the direction of causation.

<sup>18</sup> For an extensive discussion of the identification problem in VAR models, see Christiano, Eichenbaum, and Evans (1999, Section 2).

<sup>19</sup> See Wold (1954 and 1960).

<sup>20</sup> See, for example, Sims (1986) and Bernanke (1986).

<sup>21</sup> This conclusion should hold regardless of whether the central bank pursues an instrument rule or a target rule.

Identification of the effectiveness of monetary policy to stabilize output fluctuation is further complicated by a lack of transparency and likely a lack of stationarity in the rule-like behavior of central banks. There is an ongoing debate about whether FOMC behavior over a long period can be characterized by a common rule-like specification. Romer and Romer (2002a,b) argue that the actions of the FOMC in the 1950s and in the 1980-90s were similar in their rule-like characteristics, but that during the 1960s and 70s a different “regime” was in place. Orphanides (2001 and 2002) and Orphanides and van Norden (2002) argue that, when judged in terms of real-time data, the rule-like behavior of the FOMC in the 1960s and 1970s is consistent with behavior in the 1980s and 1990s. They conclude that the Great Inflation did not result from bad policy, but from applying reasonable policy without recognition of and adjustment for biased measurements of “potential output.” Either view of the 1960 and 1970s poses a challenge to the standard approach of identifying monetary shocks in SVAR structures.

Beyond the arguments about the specification of monetary policy during the Great Inflation, there are other concerns that at least occasionally dominate central bankers’ discussions of policy objectives. Such concerns at a minimum contaminate efforts to identify policy rules with measurement error and likely also contaminate the assumed identifying restrictions.

For the FOMC, there are at least four incidents in the past 20 years (documented in the published record of FOMC minutes and transcripts) in which concerns about financial stability dominated policy decisions and policy actions were driven by issues in addition to inflation or output stabilization. These incidents include the stock market collapse in October 1987, the Asian crisis/Russian default in August-October 1998, Y2K in late 1999, and the 9/11 tragedy in September 2001. Some analysts add the credit crunch/financial headwinds concern in 1990-93 to this list.<sup>22</sup>

According to the unofficial staff interpretations of FOMC policy changes compiled by Thornton and Wheelock (2000), the expected funds rate was

decreased by 37.5 basis points on October 23, 1987, and by an additional 12.5 to 25 basis points on October 28, 1987, in response to the stock market crash. This interrupted the succession of increases in the expected funds rate that had started on January 15, 1987. Increases in the expected funds rate were not resumed until March 29, 1988, roughly six months after the crash. During a conference call on October 20, 1987, Chairman Greenspan noted,

I think we’re playing it on a day-to-day basis. And in a crisis environment. I suspect we shouldn’t really focus on longer-term policy questions until we get beyond this immediate period of chaos. (FOMC Transcripts, conference call, October 20, 1987, p. 1)

On September 29, 1998, the FOMC reduced the funds rate target by 25 basis points. This was followed by a two additional reductions of 25 basis points on October 15 and November 17. Chairman Greenspan noted the following at the February 1999 FOMC meeting:

I have not heard it argued specifically, but our 75 basis point action last fall was directed at countering a freezing-up of financial markets, which constituted a demonstrable threat to the stability of our economy, and arguably we have largely succeeded. It is true that one can still observe some residual impact of the liquidity problems that we have experienced, with yields on junk bonds remaining significantly above Treasuries and even obligations rated A and AA still running spreads against Treasuries that we haven’t seen for a very long time. If it is correct that we have succeeded, then one could argue that we ought to reverse at least part of our easing moves. (FOMC Transcripts, February 2-3, 1999, p. 104)

The funds rate target established in November was maintained until the FOMC meeting in June 1999, though no argument was made that financial markets remained unsettled after November.

On December 21, 1999, the FOMC press release noted that the funds rate target was kept unchanged, in spite of

the possibility that over time increases in demand will continue to exceed the growth in potential supply, even after taking account

<sup>22</sup> See, for example, Romer and Romer (2002b, p. 68).



of the remarkable rise in productivity growth.  
(FOMC Press Release, December 21, 1999)

The maintenance of the existing target funds rate was explained by concerns about the century date change:

Nonetheless, in light of market uncertainties associated with the century date change, the Committee decided to adopt a symmetric directive in order to indicate that the focus of policy in the intermeeting period must be ensuring a smooth transition into the Year 2000. (FOMC Press Release, December 21, 1999)

On September 17, 2001, the FOMC press release noted that the funds rate target was reduced 50 basis points in response to the uncertainty about financial market conditions in light of the terrorist attack on the World Trade Center:

The Federal Reserve will continue to supply unusually large volumes of liquidity to the financial markets, as needed, until more normal market functioning is restored. (FOMC Press Release, September 17, 2001)

On the same date, Chairman Greenspan noted:

It's clear that the events of last week, at a minimum, have created a heightened degree of fear and uncertainty that is placing considerable downward pressure on asset prices, increasing the probability of an asset price deflation, with its obvious impact on the economy. (FOMC Transcripts, conference call, September 17, 2001)

It is worth noting that, while in real time FOMC participants were concerned about significant weakness in economic activity in the fourth quarter of 2001, the current estimate is that gross domestic product (GDP) grew at a positive 1.6 percent annual rate in that quarter.

Our conclusion from these questions is that considerable care and additional research is required to ensure that a valid identified model of the economy is constructed to enable us to draw inferences about the effectiveness of monetary policy as a tool for short-run stabilization of an economy. The number of issues that remain to be addressed suggests that we are a long way from a definitive answer.

If the objective of a well-identified model is achieved, then how should it be used to address the question of the effectiveness of monetary policy? Impulse response functions and variance decompositions that investigate the response to a monetary shock may not be the most informative analyses. These address only how the economy responds to the unpredictable component of monetary policy—the deviations from rule-like behavior. Cagan (1989, p. 135) complained that in the VAR analysis available at the time, the impact of such residuals was so small as to be implausible:

By removing all serial and cross correlations from economic series, VAR reduces them to exogenous movements and looks for correlation between these movements in each pair of series. But these exogenous movements are little more than isolated blips in the series, which in monetary growth have little effect on GNP. The financial system filters out the effect on monetary blips. Only changes in monetary growth that are maintained for an extended period of time affect business activity. These extended changes in monetary growth, however, exhibit serial correlation and, despite their variable lags in affecting output and prices, tend to be correlated with cyclical movements in other economic variables. The VAR accordingly eliminates the correlated movements in money as endogenous to the economic system. Thus does this technique give new meaning to the old cliché of “throwing the baby out with the bathwater.”

An alternative investigation is to vary the parameters in the equation of the identified economic model that characterize the rule-like behavior of the monetary authorities. The question then becomes not how effective monetary policy has been in stabilizing the economy under the historical characterization of policy, but how effective it could be with alternative rule-like behaviors. Christiano, Eichenbaum, and Evans (1999, pp. 134-46) argue that with VAR models this type of analysis may be difficult, because identification of monetary policy shocks is not sufficient to identify the historical policy rule pursued by the central bank. The answer to the question of how effective monetary policy could be in short-run



stabilization likely depends on the nature of the shocks that are assumed to hit the economy and, at least for some shocks, the relative tolerance for short-run inflation volatility versus output volatility.

Finally, has increased transparency and accountability of monetary authorities led to increased economic stability? This question has been raised in several contexts. First, some analysts have argued that the “Great Moderation” since approximately 1983 is substantially due to better monetary policy and improved transparency. Stock and Watson (2003, p. 29) use three different econometric models of the U.S. economy and replace their estimate of a post-1984 monetary policy rule with their estimate of a pre-1979 monetary policy rule. They conclude from these experiments that the models “all suggest that improved monetary control brought inflation under control, but accounts for only a small fraction—among the models fit to the United States data, less than 10 percent—of the reduction in output volatility.”

Other analysts argue that improved transparency and accountability of central banks anchor long-term inflation expectations more firmly, thus giving central banks more latitude to pursue short-run stabilization objectives. Support for this argument requires two kinds of research: (i) What evidence would support the hypothesis that long-term inflation expectations are less variable and (ii) has the rule-like behavior of any central bank become more aggressive in reacting to short-term fluctuations of output? Levin, Natalucci, and Piger (2004) provide some evidence on both of these issues by comparing inflation-targeting industrial countries with industrial countries that do not announce inflation targets; they conclude (p. 75) that inflation targeting in these countries has “played a role in anchoring inflation expectations and in reducing inflation persistence.”

Chairman Greenspan early on argued that a low and stable inflation environment contributed to the higher rate of productivity growth in the United States after 1995:

Given these real-world uncertainties, it is important for policymakers to be as explicit

as possible about not only the central bank’s long-run inflation objective but also about its short-run policy objectives. The more ambiguous policymakers are about these objectives, the more difficult it will be for the public to differentiate policy actions that may reflect a change in the central bank’s long-run inflation objective from actions intended only to offset the effects of real shocks on economic activity ...Implicit in that argument, if we are to move toward price stability, is that the process in and of itself induces an acceleration of productivity. (FOMC Transcripts, July 2-3, 1996, p. 47)

It is not that low or stable prices are an environment that is conducive to capital investment to reduce costs, but rather that it is an environment that forces productivity enhancements. It forces people who want to stay in business to take those actions—such as cutting down the size of the cafeteria, reducing overtime, and taking away managers’ drivers—that they did not want to take before in the ordinary course of business in a modest inflationary environment because it was easier then just to raise prices to maintain margins. If you force the price level down, you induce real reallocations of resources because to stay in business firms have to achieve real as distinct from nominal efficiencies. (FOMC Transcripts, July 2-3, 1996, p. 67)

This is an intriguing hypothesis that is difficult to investigate, given the limited understanding and theory of the determinants of productivity growth. Unfortunately, it is difficult to reconcile this hypothesis with the apparent uniqueness of the U.S. experience with the “productivity boom” in the face of almost worldwide low and stable inflation over the past decade.

## PROBLEMS IN THE IMPLEMENTATION OF SHORT-RUN STABILIZATION POLICY

One important issue for the implementation of short-run stabilization policy that did not receive much attention for a considerable period of time is the inherent uncertainty of the environment in which central bankers make decisions.

There are several dimensions to this uncertainty: (i) lack of accurate information about the contemporary state of the economy, (ii) inability to forecast accurately the future path of the economy, and (iii) lack of accurate information about how policy actions affect the economy.

Two problems face central bankers (and policymakers in general) in assessing the need for a short-run stabilization action: lags in the availability of data and measurement error in preliminary data.

In the United States, major economic statistics are available at either monthly or quarterly frequency, usually with an initial publication lag of a month or two. In other countries, comparable data may be measured at lower frequency and with longer publication lags. Consequently, most formal statistical data that are available for policy deliberations are “stale.” In the FOMC process, such data are supplemented by anecdotal data from the various Federal Reserve Districts.<sup>23</sup> The latter data are not collected from scientific surveys, and the number of respondents surveyed is small. Hence, there is a danger of inappropriately extrapolating from the small environment to the macroeconomy. Nevertheless, such reports can give insights into and reduce, though not eliminate, uncertainty about emerging trends.

The second problem, measurement error, is well known; but until recently, it did not receive much attention, probably because it has been regarded as a mundane problem and research into it is unlikely to receive much attention. In appears that, recently, attitudes have been changing. Research using real-time data has become more fashionable. Some of this research (Orphanides, 2001 and 2002) alleges that the principal culprit in the Great Inflation in the United States was systematic bias in the real-time assessment of “potential output” and the “output gap” in FOMC deliberations. Nevertheless, formal consideration of measurement error in forecasting models, whether constructed by private sector entities or by the staff of policy agencies, remains underdeveloped, even though the econometric methodology is well understood. The paucity of

readily accessible vintage data may contribute to this problem.<sup>24</sup>

An additional issue is the limited accuracy in the forecasts or projections that are available to monetary policymakers. Absent instantaneous reaction of the economy to policy actions, effective stabilization actions require an assessment of the future state of the economy. Gavin and Mandal (2001) found the accuracy of the forecasts by FOMC participants as recorded in monetary policy reports from 1983 through 1994 for real output growth are comparable to those of private forecasters (e.g., Blue Chip forecasters).<sup>25</sup> However, the root-mean-squared forecast error at 12- and 18-month horizons was roughly 1 percent (at annualized rates.) At a 6-month horizon the forecast error was 0.75 percent. In a subsequent analysis, Gavin and Mandal (2003) extended the sample of forecasts to 1979-2001. For this longer sample, they found that the root-mean-squared forecast errors at the 12- and 18-month horizons were 1.32 and 1.59 percent, respectively. The same statistic at a 6-month forecast horizon was only slightly less than 1 percent.<sup>26</sup> This forecast (in)accuracy suggests that variations in real output growth, from recessions to rapid expansions, cannot be reliably distinguished on a horizon as short as a year.

The projection accuracy for real output of the Reserve Bank of New Zealand (RBNZ) appears to be comparable to that of the participants in the FOMC.<sup>27</sup> Root-mean-squared projection errors of

<sup>24</sup> For the United States, a limited amount of vintage data has been reconstructed by the research staff of the Federal Reserve Bank of Philadelphia. Complete archives of the FRED® data base have been preserved since the web version of this service was introduced in 1996 at least at monthly intervals and since 1999 at weekly intervals. A new data service (Archival FRED, i.e., ALFRED®) has been implemented by the Research Division of the Federal Reserve Bank of St. Louis. ALFRED allows the user to retrieve a data list that is indexed with an “as of” vintage date. Over time, vintage data that was preserved on hard copy of *National Economic Trends* and *Monetary Trends* will be added to this archive.

<sup>25</sup> Gavin and Mandal (2001, Table 2): Forecasts are fourth-quarter over fourth-quarter growth rates.

<sup>26</sup> Gavin and Mandal (2003, Table 1): Forecasts are fourth-quarter over fourth-quarter growth rates.

<sup>27</sup> See Reserve Bank of New Zealand’s “The Projection Process and Accuracy of the RBNZ Projections”; [www.rbnz.govt.nz/monopol/review/0096577.html](http://www.rbnz.govt.nz/monopol/review/0096577.html).

<sup>23</sup> See, for example, Poole (2002).

the RBNZ are reported as 1 percent at a 1-quarter horizon and 1.5 percent at a 1-year horizon.

The Bank of England publishes estimates of the “uncertainty associated with its numeric projections of inflation and GDP growth” with each of its *Inflation Reports*.<sup>28</sup> At the 1-year projection horizon conditioned on market interest rate expectations, the reported uncertainty measure is 0.76 percent; at the 2-year horizon it is 1.0 percent; and at the 3-year horizon it is 1.10 percent. These values are on the order of 50 percent of the root-mean-squared error of the RBNZ and FOMC projections at comparable horizons, but still suggest substantial uncertainty relative to business cycle fluctuations in real GDP. Other inflation targeting central banks also make public projections of real output growth, though this information does not appear to have a long history and we have not found any other analyses of the performance of these projections.<sup>29</sup>

The final problem is the paucity of accurate information about the dynamic effects of policy actions. Specifically, received macroeconomic theories generally provide little insight into dynamic structures. This is reflected in the VAR paradigm that eschews any restrictions on dynamics.

One perspective, associated with Milton Friedman, is that lags in the impact of monetary policy are “long and variable.” Another perspective is derived from impulse response functions of econometric models, including VAR specifications. In many such models, the effect of a shock to the monetary policy variable is constrained to be zero as part of the identifying restrictions imposed on the data. In such models, a typical response pattern is that several quarters elapse before a significant response of real output builds

up, and then this response dissipates over 12 to 18 months.<sup>30</sup> In general, estimated confidence intervals around the impulse response functions are quite wide. This leaves a policymaker interested in short-run stabilization with a difficult and unfortunate dilemma: The impact of a policy action at any horizon is highly uncertain, and the horizon over which any policy action is most likely to have a major impact is one where the future is not predicted with any precision.

## CONCLUSION

Several conclusions seem warranted. First, inflation-targeting central banks appear to have an admirable record of consistently hitting targets on a medium-run horizon. However, it is not clear what the marginal contribution of inflation targeting beyond a credible commitment to price stability is, because the Federal Reserve, which eschews an inflation-targeting framework, has accumulated a comparable record of low and stable inflation.

Second, it is not clear what will happen to low and stable inflation if “bad shocks” are realized and the going gets tough. “Good luck” in the form of a decade or two of relatively mild shocks cannot be ruled out as a significant environmental factor during the inflation-targeting period (see Stock and Watson, 2003, pp. 46-47.)

Finally, the case for consistently effective short-run monetary stabilization policies is problematic—there are just too many dimensions to uncertainty in the environment in which central banks operate.

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<sup>28</sup> The recent estimates are in the “Numerical Parameters of Inflation Report Probability Distributions, February 2005”; [www.bankofengland.co.uk/publications/inflationreport/index.htm](http://www.bankofengland.co.uk/publications/inflationreport/index.htm). This report indicates that the uncertainty measure is the standard deviation of the forecast error in those cases where the distribution of forecast errors is symmetric.

<sup>29</sup> We have found quantitative projections/forecasts of real output in published inflation/monetary reports of the central banks of Chile, Hungary, Iceland, Israel, Korea, Mexico, Norway, Peru, Sweden, and the United Kingdom. Undoubtedly, we have missed some reports and we have not completed a tabulation of all published estimates.

<sup>30</sup> Impulse response functions that are typical of those derived from VAR analysis can be found in Christiano, Eichenbaum, and Evans (1999, Figures 2 and 4).

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## APPENDIX

### Characteristics of Inflation-Targeting Regimes of Countries

Country	Inflation measure	Current target value (%)	Inflation targets (%)
Australia	Headline CPI	2-3	2-3 Treasury underlying CPI until 1998 and CPI thereafter
Brazil	Headline CPI	4.5 ± 2.5	1999: 8 ± 2 2000: 6 ± 2 2001: 4 ± 2 2002: 3.5 ± 2. 2003: 4 ± 2.5 <sup>2</sup> 2004: 4.5 ± 2.5
Canada	CPI and core CPI <sup>3</sup>	2 ± 1	1991: 3-5 (for 22 months) 1992: 2-4 (multiyear) June 1994: 1.5-3.5 1995-2004: 1-3
Chile	Headline CPI	2-4	1991: 15-20 1992: 13-16 1993: 10-12 1994: 9-11 1995: 8 1996: 6.5 1997: 5.5 1998: 4.5 1999: 4.3 2000: ±3.5 2001 onward: 2-4
Colombia	CPI	6	1999: 15 2000: 10 2001: 8 2002: 6 2003: 4-6 2004: 5-6 2005: 4.5-5.5 2006: 3.5-5.5

NOTE: <sup>1</sup>Reserve Bank of Australia (RBA). Although the first formal agreement on the conduct of monetary policy between the RBA and the government was made in 1996, the RBA effectively adopted inflation targeting in 1993. <sup>2</sup>Bank of Brazil Open Letter 2002, 2003, 2004; [www.bcb.gov.br/ingles/relinf/OpenLetter2003.pdf](http://www.bcb.gov.br/ingles/relinf/OpenLetter2003.pdf). <sup>3</sup>Canada's core CPI excludes food, energy, and the effect of indirect taxes.

Adoption date	Who sets the target?	Separate inflation report	Published inflation forecast
June 1993 <sup>1</sup>	Government and central bank jointly	No: statements on monetary policy contain prospects for inflation growth	Yes: monetary policy report
June 1999	Government in consultation with central bank	Yes	Yes
February 1991	Government and central bank jointly	No	Yes: monetary policy report
September 1990	Central bank in consultation with government	Yes	Yes
September 1999	Jointly by government and central bank	Yes	Yes

**APPENDIX, cont'd****Characteristics of Inflation-Targeting Regimes of Countries**

Country	Inflation measure	Current target value (%)	Inflation targets (%)
Czech Republic	Net inflation through 2001 <sup>4</sup> ; headline CPI thereafter	1-3	Net inflation 1998: 5.5-6.5 1999: 4-5 2000: 3.5-5.5 2001: 2-4 Headline CPI band starts Jan. 2002: 3-5; band ends Dec. 2005: 2-4; from 2006 <sup>5</sup> : 3
Finland <sup>6</sup>	Core CPI	NA	Since 1993: 2
Hungary	CPI	4 ± 1	2001: 7.5 ± 1 2002: 4.5 ± 1 2003: 3.5 ± 1 2004: 3.5 ± 1 2005: 4 ± 1 2006: 3.5 ± 1
Iceland	CPI	2.5 ± 1.5	Since 2001: 2.5 ± 1.5
Israel	Headline CPI	1-3	1992: 14-15 1993: 10 1994: 8 1995: 8-11 1996: 8-10 1997: 7-10 1998: 7-10 1999: 4 2000: 3-4 2001: 3-4 2002: 3-4 2003: 1-3 2004: 1-3

NOTE: <sup>4</sup>Net inflation is calculated by the Czech Statistical Office as the growth of prices in the unregulated part of the consumer basket adjusted for changes in indirect taxes and for abolition of subsidies. <sup>5</sup>The 3 percent inflation target had been announced for the period from January 2006 until the Czech Republic's accession to the euro area. <sup>6</sup>Since 1998, Finland has been a member of the European System of Central Banks and the Eurosystem.



Adoption date	Who sets the target?	Separate inflation report	Published inflation forecast
January 1998	Central bank	Yes	Yes
February 1993 to June 1998	Central bank	No	No
July 2001	Central bank	Yes	Yes
March 2001	Central bank and government jointly	No: monetary bulletin contains prospects for inflation growth	Yes
December 1991	Central bank	Yes	Yes

**APPENDIX, cont'd****Characteristics of Inflation-Targeting Regimes of Countries**

Country	Inflation measure	Current target value (%)	Inflation targets (%)
Korea	CPI (1998) core inflation (after 1999)	2.5-3.5	1998: $9 \pm 1$ 1999: $3 \pm 1$ 2000: $2.5 \pm 1$ 2001: $2.5 \pm 1$ 2002: $3 \pm 1$ 2003: $3 \pm 1$ Jan. 2004: change to medium-term (instead of annual) targeting system; target for 2004-06: 2.5-3.5
Mexico	Headline CPI	$3 \pm 1$	1999: 13 2000: <10 2001: 6.5 2002: 4.5 2003: $3 \pm 1$ (in line with trading partners)
New Zealand	Headline CPI <sup>7</sup>	1-3	1990: 3-5 1991: 2.5-4.5 1992: 1.5-3.5 1993-1996: 0-2 1997-2001: 0-3 2002-present: 1-3
Norway	CPI-ATE <sup>8</sup>	2.5	2001-present: 2.5
Peru	Headline CPI	$2.5 \pm 1$	1994: 15-20 1995: 9-11 1996: 9.5-11.5 1997: 8-10 1998: 7.5-9 1999: 5-6 2000: 3.5-4 2001: 2.5-3.5 2002: $2.5 \pm 1$ 2003: $2.5 \pm 1$ 2004: $2.5 \pm 1$
Philippines	CPI (they monitor core CPI measures also)	4.5-5.5	2002: 5-6 2003: 4.5-5.5 2004: 4-5 2005: 4-5

NOTE: <sup>7</sup>Officially CPI, but the Reserve Bank of New Zealand targets "underlying" or "core" inflation. (CPI: Since December 1997, the CPI excluding credit services was used; before then, overall CPI was used. In late 1999, mortgage interest rates were removed from the index.) <sup>8</sup>CPI inflation adjusted for tax changes and excluding energy products.

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Adoption date	Who sets the target?	Separate inflation report	Published inflation forecast
April 1998	Government in consultation with central bank	Yes	Yes
January 1999	Central bank	Yes	Yes
March 1990	Government and central bank jointly	Yes	Yes
March 2001	Government	Yes	Yes
January 1994	Central bank in consultation with government	Yes	Yes
January 2002	Jointly by central bank and government	Yes	Yes

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**APPENDIX, cont'd****Characteristics of Inflation-Targeting Regimes of Countries**

Country	Inflation measure	Current target value (%)	Inflation targets (%)
Poland	Headline CPI	2.5 ± 1	1998: <9.5 1999: 6.6-7.8 2000: 5.4-6.8 2001: <6-8, 3 by 2003 2002: 5 ± 1, <4 by 2003 2003: 3 ± 1 2004: 2.5 ± 1
South Africa	CPIX <sup>9</sup>	3-6	2003: 3-6
Spain <sup>10</sup>	Headline CPI	NA	1996: 3.5-4 1997: 2.5 1998: 2
Sweden	Headline CPI	2 ± 1	Since 1995: 2 ± 1
Switzerland	Headline CPI	<2	Since 2000: <2
Thailand	Core CPI (excludes raw food and energy prices)	0-3.5	Since 2000: 0-3.5
United Kingdom	Headline CPI <sup>11</sup>	2	1992: RPIX inflation 1-4 1995: "2.5 or less" 1997: 2.5 Dec. 2003: CPI inflation 2 ± 1

NOTE: <sup>9</sup>The CPI for metropolitan and other urban areas excluding the interest cost of mortgage bonds. <sup>10</sup>Since 1998, Spain is a member of the European System of Central Banks and the Eurosystem. <sup>11</sup>Since December 2003, CPI inflation became the target, formerly known as the harmonized index of consumer prices. Prior to that, RPIX inflation was targeted.

SOURCE: Authors' compilations based on each central banks' web site discussions on monetary policy, individual monetary policy and inflation reports of each country, Mishkin and Schmidt-Hebbel (2002), and Morande (2002).

Adoption date	Who sets the target?	Separate inflation report	Published inflation forecast
October 1998	Central bank	Yes	Yes
February 2000	Government after consultation with the reserve bank and the national treasury	Yes	No
November 1994 to June 1998	Central bank	Yes	Yes
January 1993	Central bank	Yes	Yes
January 2000	Central bank	No: monetary policy report, monetary policy assessment, and inflation forecast published quarterly	Yes
May 2000	Government in consultation with central bank	Yes	Yes
October 1992	Government	Yes	Yes







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