Federal Reserve Bank of Dallas

Economic & Financial Policy Review

Volume 3, Number 1, 2004

The Real Impact of Financial Crises

Elias Brandt, Scott Dressler, and Erwan Quintin

Output falls precipitously in most emerging nations that experience financial crises. The authors conjecture that a significant part of the real impact of financial crises is due to the fact that during turbulent times firms choose to leave a large fraction of productive resources idle until business conditions improve. In the case of Mexico's 1994–95 crisis, they calculate that capital utilization could account for as much as half the drop in standard measures of total factor productivity. Capital utilization matters much more during financial crises than during other periods, they argue, because crises create ideal conditions for large swings in utilization rates.

Brandt is an economic research assistant and Quintin is a senior economist at the Federal Reserve Bank of Dallas. Dressler is a Ph.D. student at the University of Texas at Austin.

Suggested Citation

Brandt, Elias, Scott Dressler, and Erwan Quintin (2004), "The Real Impact of Financial Crises," Federal Reserve Bank of Dallas *Economic and Financial Policy Review*, Vol. 3, No. 1, http://dallasfedreview.org/pdfs/v03_n01_a01.pdf.

Financial crises typically bring about precipitous falls in gross domestic product (GDP). After Mexico devalued its currency in December 1994, real output fell by more than 10 percent in two quarters. This episode (known as Mexico's Tequila Crisis) is not exceptional: Real output fell by similar magnitudes following sovereign debt crises in the early 1980s in Argentina, Chile, and Mexico and during recent currency crises in several Latin American and Asian nations. While much has been written on what causes financial crises (see, for example, Calvo 1998; Calvo and Mendoza 1996, 2000; Cole and Kehoe 1996; Sachs, Tornell, and Velasco 1996; Flood, Garber, and Kramer 1996), little is known about their real impact.

The output drops that follow financial crises are intriguing because of their unusual magnitude and because they often far exceed the concurrent drops in standard measures of physical capital and labor uses. In the standard neoclassical model, total factor productivity (TFP) has to fall by nearly 10 percent to account for the collapse in real GDP in Mexico in 1995. This is twice as large as any other movement in TFP in Mexico over the past twenty years. In this standard accounting exercise, the role of resource utilization rates is ignored. Our objective is to quantify the potential importance of utilization rates for the behavior of measured TFP during financial crises.

Specifically, we measure the impact of relaxing the assumption that physical capital is used at a constant rate over time. Mexico does not measure capital utilization rates, so we infer these rates from available data using two methods. First, under the assumption that the energy intensity of capital is inelastic in the short run, we note that utilization rates should be roughly proportional to the aggregate-energy-use-to-capital ratio in the short run. This ratio fell abruptly in 1995 in Mexico, which, barring a sudden change in the energy intensity of physical capital, constitutes strong evidence that big movements in utilization rates occurred during the Tequila Crisis.

In a second approach, we assume—as in Greenwood, Hercowitz, and Huffman (1988)—that higher capital utilization rates cause the capital stock to depreciate more quickly, and we infer utilization rates from the behavior of the capital–output ratio. Our main finding is that capital utilization could account for up to half the drop in TFP in Mexico in 1995. We also find that capital utilization matters little for TFP movements during other periods.

The fact that capital utilization only appears to matter for TFP during financial crises provides some support for the conventional view that utilization rates cannot account for secular trends in TFP. For instance, in their comparative study of Chile and Mexico, Bergoeing et al. (2002) write: "It seems farfetched…to argue that [utilization rates] can account for large differences in productivity movements between countries over a period of a decade or more, when firms are making new investments and hiring new workers." We agree: Capital utilization is unlikely to fall for decades. But financial crises do not last decades. In fact, they bring about ideal conditions for large swings in capital utilization. For typically short periods (one to two years), real interest rates are well above trend, while total factor productivity is well below trend.[1] This gives firms strong incentives to post-

[1] Rates on three-month Mexican Brady (U.S. dollar-denominated) bonds deflated by U.S. CPI rose from 2 percent to 4.5 percent in the first two quarters of 1995 but returned to their precrisis level by the end of 1997. See Meza and Quintin 2003.

pone the consumption of capital services (by, say, leaving plants or machines temporarily idle) and economize on variable expenditures such as wear and tear. Furthermore, in nations like Mexico where many prices are managed, sudden price changes may also lead firms to reallocate physical resources across competing uses. For instance, pressed by the International Monetary Fund to improve its fiscal situation, the Mexican government decided to raise energy prices in the first quarter of 1995, and some energy-intensive uses of capital may have become unprofitable. Our results suggest that attempts to measure resource utilization in countries prone to financial crises could prove well worth the effort.

FINANCIAL CRISES AND TFP

Mexico's GDP fell by 10 percent in real terms in the twelve months following the December 1994 devaluation. The magnitude of this drop in real output is all the more surprising because during the same period, aggregate resource use fell by no more than half that amount. This is best seen through a standard growth accounting exercise like that conducted by Kydland and Prescott (1982) in their analysis of the postwar U.S. economy. Standard growth accounting begins with the formal statement of a production function, an equation that expresses the link between the aggregate output of an economy and the aggregate inputs used to produce it. For consistency with the observation that capital and labor income shares are stable over time in most nations, it is common to posit that

$$Y_t = z_t K_t^{\alpha} N_t^{1-\alpha}, \tag{1}$$

where Y_t is net aggregate output in real terms, K_t is the aggregate capital stock, and N_t is the supply of labor services in quarter t. The parameter α (capital's share of output) is the average fraction of real national income that remunerates capital services. The final variable, z_t, denotes TFP, the aggregate state of technology in quarter t.

Quarterly time series for real output, capital, and labor can be constructed from readily available data. Appendix A describes in detail the way we constructed these data for Mexico's ex-energy business sector.[2] Figure 1 shows the resulting time series for the capital stock per capita and per capita hours worked.[3] In constructing our capital stock measure we assume, like Kydland and Prescott (1982), that new capital requires four quarters to build.[4] Because net aggregate capital formation was high in 1994, our capital stock measure rises in 1995. Per capita hours worked, meanwhile, fell in 1995, but by only 5 percent.

Figure 2 shows that even though aggregate resource use fell little, output fell by almost 10 percent in 1995. In the context of the standard neoclassical model, this means that TFP must have fallen precipitously.

[2] For consistency, throughout this article we consider Mexico's private sector excluding the energy-producing sector.

[3] The series are normalized so that the value of the variable in December 1994 is equal to 100. This normalization casts the data series into percentage terms relative to the value observed at the onset of the crisis.

[4] If one assumes instead that investment becomes capital after one period, the resulting capital stock measure falls by roughly 5 percent in 1995, which is half the size of the drop in output. That alternative approach, therefore, also leads to a considerable TFP drop.

Figure 1
Capital Stock and Labor, 1991–2000

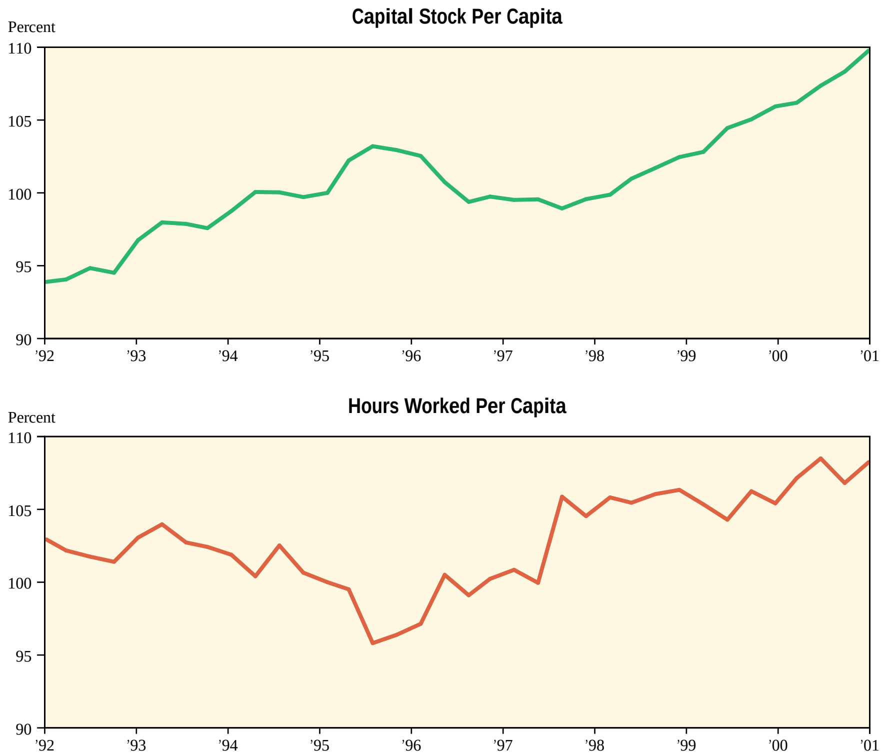
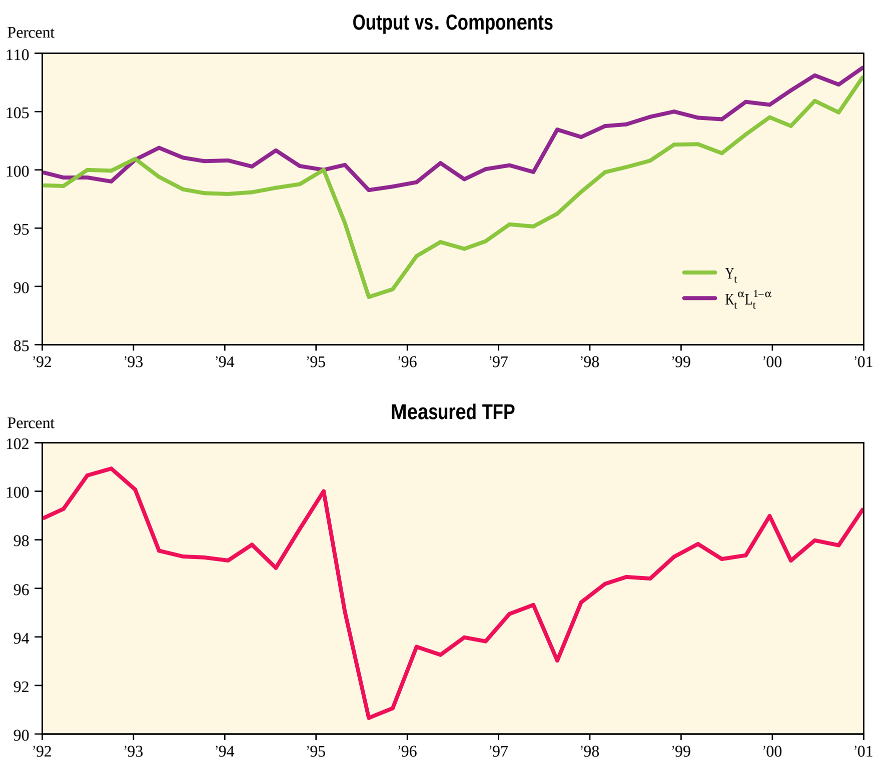


Figure 2
Output and TFP, 1991–2000



TFP is not directly observed, but given the production function we assume in Equation 1, it must satisfy

$$(2) \qquad z_t = \frac{Y_t}{K_t^{\alpha} N_t^{1-\alpha}}.$$

The path for TFP inferred from this accounting identity is shown in the bottom panel of Figure 2. The top panel plots the data series for Mexican per capita output and compares it with the measured output series calculated from Equation 1, with TFP arbitrarily held to one throughout the sample period. For these calculations, the value of α is 0.3.[5] Output falls by almost 11 percent in the first two quarters of 1995, while aggregate resource use falls by only 2 percent. Measured TFP must drop by more than 9 percent between December 1994 and June 1995 to account for this difference, which is twice as large as any other TFP drop in the past twenty years in Mexico.

While this article focuses on the Tequila Crisis, measured TFP falls by unusual amounts in most emerging nations struck by financial crises. Bergoeing et al. (2002) show this for Mexico and Chile during their 1982 debt crises, as do Kydland and Zarazaga (2002) for Argentina in 1995. Calculations, available upon request, also show unusual drops in TFP in Thailand, Korea, and Taiwan during the 1997–98 Asian crisis.

NEEDED: A THEORY OF TFP FOR CRISIS-PRONE COUNTRIES

Most of the literature on financial crises focuses on what triggers the collapse in the first place. The Tequila Crisis appears to have surprised many observers because the period leading up to it was marked by relative fiscal and monetary stability, low inflation, and record high levels of foreign reserves (see Lustig 1998). In a special issue of the *Journal of International Economics* devoted to understanding the causes of the Tequila Crisis, Flood, Garber, and Kramer (1996) and Calvo and Mendoza (1996) discuss the role played by flow imbalances (for instance, liquid financial assets versus broad monetary aggregates or short-run debt versus gross foreign reserves). In the same issue, Cole and Kehoe (1996) and Sachs, Tornell, and Velasco (1996) conjecture that Mexico's large stock of short-term debt may have given rise to self-fulfilling speculative attacks against peso-denominated bonds. These and many related articles have shed some light on what caused the financial collapse in Mexico, but they do not help us understand the sharp drop in output that followed. Calvo (1998) and Calvo and Mendoza (2000) argue that financial insolvency combined with highly interdependent capital markets or informational frictions can render factors of production prohibitively expensive, but these theories have yet to be tested quantitatively.

We believe that as a first step toward understanding the real impact of financial crises, one should ask what part of the fall in output is attributable to changes in capital utilization. As we argue in the introduction, capital utilization is likely to play a particularly important role during financial crises. Furthermore, this first step is relatively simple, and similar efforts have proven fruitful in other areas of economic research. For example, Bils and Cho (1994), King and Rebelo (1999), Burnside and Eichenbaum

[5] Bergoeing et al. (2002) and Meza and Quintin (2003) argue that this value for the capital share is appropriate for Mexico.

(1996), and Hornstein (2002) show that making labor and capital utilization rates endogenous can improve the ability of standard models to mimic the behavior of macroeconomic variables over the U.S. business cycle.

QUANTIFYING THE EFFECTS OF VARIABLE CAPITAL UTILIZATION

The standard growth accounting framework can easily be altered to accommodate variable capital utilization. One simply needs to amend the production function in Equation 1 by writing

$$Y_t = \tilde{z}_t (u_t K_t)^{\alpha} N_t^{1-\alpha}, \tag{3}$$

where u_t denotes the utilization of the capital stock, and $\tilde{z}_t$ is the *true* level of TFP. Note that true TFP is now different from *measured* TFP ($\tilde{z}_t u_t^{\alpha}$), the TFP level one would infer from the data if one ignored movements in capital utilization. Utilization is not directly observable, however, and one needs to infer those rates from available data. To that end, we will now lay out two simple models.

Method 1: Energy Use

Most empirical attempts to measure the importance of capital utilization in the United States use electricity consumption by the business sector as a proxy for utilization rates (see, for example, Burnside, Eichenbaum, and Rebelo 1995). However, using electricity consumption for that purpose in the case of Mexico would not be wise because of the structural shortage of electricity Mexican businesses must confront. (See the box titled “Electricity Consumption in Mexico.”)

Given the state of the Mexican electricity industry, we will use overall energy consumption as a proxy for capital utilization. That variable, unlike electricity consumption, is procyclical. To identify capital utilization, note that capital goods such as productive machinery do not require energy when they are idle. Therefore, energy consumption can reasonably be assumed to increase when capital is used more. In other words, there is a positive relationship between energy usage and the utilization of the capital stock. This reasoning gives rise to a second equation relating the capital stock, its utilization rate, and energy use by the ex-energy business sector,

$$E_t = \bar{e} u_t K_t, \tag{4}$$

where E_t is energy consumption in quarter t and $\bar{e}$ is the (unobserved) energy intensity of capital. The assumption that the energy intensity of capital is fixed is extreme, but the evidence discussed by Atkeson and Kehoe (1999) suggests that the elasticity of energy use is low in the short run.[6]

Normalized data on total energy usage by the ex-energy business sector in Mexico are shown in the top panel of Figure 3. Energy consumption fell by more than 12 percent during 1995. Given these data, the level of capital utilization can be inferred, using

$$u_t = \frac{E_t}{\bar{e} K_t}. \tag{5}$$

[6] Meza and Quintin (2003) relax the assumption that the energy intensity of capital is permanently fixed and obtain results similar to ours.

We normalize $\bar{e}$ so that Equation 5 implies that 80 percent of the capital stock was utilized in the last quarter of 1994. The behavior of utilization rates implied by Equation 5 during other periods is shown in the bottom panel of Figure 3. According to Equation 5, capital utilization fell by about 15 percent with the Tequila Crisis. This is evidence that a large fraction of the capital stock was left idle in the months following the financial collapse.

Method 2: Greenwood, Hercowitz, and Huffman (1988)

In the second model, we consider the profit-maximization problem of a stand-in, representative firm that must optimally choose its level of capital utilization. By increasing its capital utilization rate (u_t) in a given period, the firm raises its current output, but it loses more capital to wear-and-tear, or depreciation. Specifically, we assume—as in Greenwood, Hercowitz, and Huffman (1988) or Burnside and Eichenbaum (1996)—that the depreciation rate in quarter t is

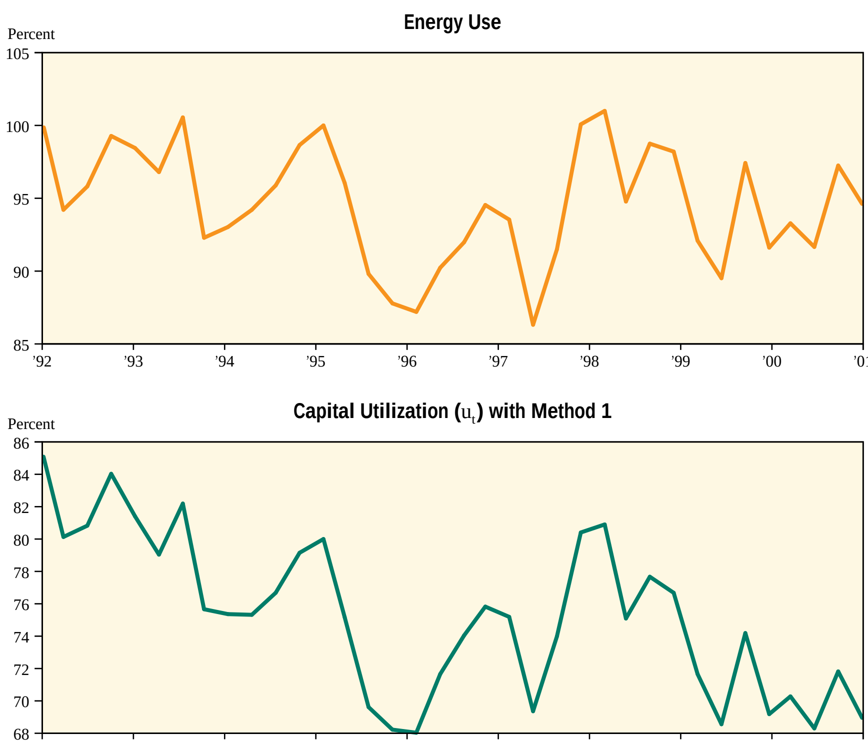
$$\delta_t = \frac{\phi}{\omega} u_t^{\omega}, \tag{6}$$

where $\omega > 1$ and $\phi > 0$ is a scaling parameter. As shown in Appendix B, first order conditions for profit maximization at the firm level imply

$$u_t = \left(\frac{\alpha Y_t}{\phi K_t} \right)^{\frac{1}{\omega}}, \tag{7}$$

where α, as before, is the income share of capital. As explained in Appendix B, we set $\omega = 2.18$ and $\phi = 0.086$ so that, on average, the utilization rate inferred from precrisis Mexican data is 80 percent, while the average

Figure 3
Energy Consumption and Utilization Rates



Electricity Consumption in Mexico

A casual study of electricity consumption data for Mexico would lead to the conclusion that capital utilization cannot account for any part of the drop in measured TFP during the Tequila Crisis. Electricity consumption by the business sector actually rose in Mexico in 1995. But electricity consumption is not an appropriate proxy for capital utilization in Mexico because the government sets electricity prices below market-clearing levels. As a result, electricity consumption in Mexico tends to rise with capacity. It is, in fact, barely procyclical, in sharp contrast to what occurs in the United States.

The electricity industry in Mexico was nationalized in 1960. Today it is a state-owned, vertically integrated monopoly made up of two separate organizations. The Comisión Federal de Electricidad (CFE) was established in 1937 in response to spotty service by private companies. It provides service for much of the country, while Luz y Fuerza del Centro (LFC) serves the Federal District and several surrounding states. Signs that electricity demand routinely exceeds the available supply are ubiquitous. A typical U.S. user can expect about 120 minutes of power interruption in a year. By comparison, a CFE user in 1999 experienced 230 minutes of downtime and an LFC user 331 (see Carreón and Jimenez 2003).

To meet the growing demand for electricity and reduce blackouts, the government has taken steps to get the private sector involved in electricity production, but progress has been slow. In 1992, a law was passed that allows businesses to generate their own power and then sell the excess to the CFE. The private sector is now responsible for 4 percent of Mexico's production capacity. In 1999, President Zedillo proposed legislation that would have opened up the industry to even more private capital, but this proposal never gained congressional approval. In 2001, President Fox attempted to liberalize the 1992 law, with comparable results. Congress appealed to the Supreme Court, claiming that the executive branch was overstepping its bounds in attempting to push the modifications through. The Supreme Court not only agreed but also questioned the practice of businesses producing their own electricity for sale to the CFE, creating even more uncertainty.

Many manufacturers, fearing worsening shortages in the future, are taking matters into their own hands by building power plants and taking steps to conserve energy. For example, Vitro, Grupo Imsa, and Apasco have built a $190 million cogeneration plant near Monterrey so their power supply will not be interrupted. Cemex is working on several of its own power plants to save money and ensure supply, and it is taking steps to conserve electricity. In 2000, Cemex saved 160,000 megawatts of electricity, in part by burning its own waste products for power.

precrisis depreciation rate is 10 percent. Because the depreciation rate now varies from period to period, our capital stock measures must be altered. We do this inductively: Given the capital stock and output in our first period of data, Equation 7 enables us to calculate the utilization rate, hence the effective depreciation rate and the undepreciated stock of capital at the start of the next period. Additions to this existing stock of capital are imputed from investment flows, as before, assuming that building new capital requires four periods. The resulting measure of capital utilization is illustrated in Figure 4, along with the measure we obtained with the first approach.

The model of Greenwood, Hercowitz, and Huffman (1988) yields a time series for capital utilization that is smoother than the series implied by the energy-use approach. However, both measures show a very large drop in capital utilization during the crisis period (15 percent with the energy-use approach versus 6 percent with the model of Greenwood, Hercowitz, and Huffman 1988).

UTILIZATION AND TFP

Using the two models, we can now determine the share of measured TFP that is attributable to a change in capital utilization. With either measure of capital utilization, true TFP can be calculated in the same way as in the standard growth accounting exercise above.

$$\tilde{z}_t = \frac{Y_t}{(u_t K_t)^{\alpha} N_t^{1-\alpha}}. \tag{8}$$

Figure 5 compares measured TFP with true TFP obtained using the two methods outlined above. Using method 1, the volatility in the utilization rate (illustrated in Figure 4) results in large discrepancies between true TFP and measured TFP. With this approach, true TFP only falls by 5 percent, which is half the size of the drop in measured TFP. In other words, almost 50 percent of measured TFP is attributable to capital utilization under this measure. Using the second approach, true TFP drops by slightly more than 6 percent, which is about two-thirds of the drop in meas-

Figure 4
Utilization Rates Inferred with Method 2

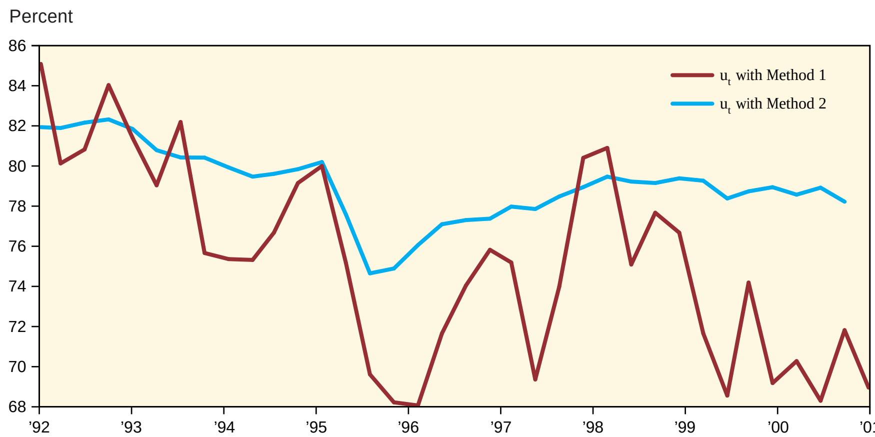
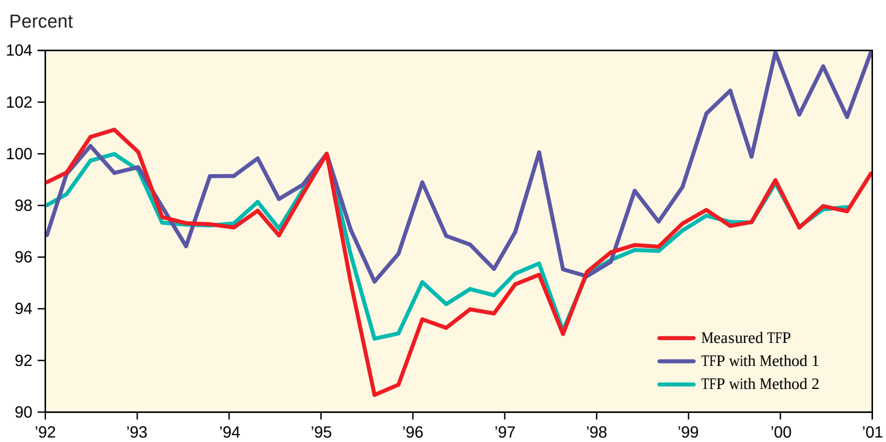


Figure 5
True vs. Measured TFP



ured TFP. Figure 5 also shows that while capital utilization matters a great deal during the 1995 crisis, it matters much less during other periods, especially using the second approach. True and measured TFP behave similarly in Mexico during other periods.

TESTING MODELS OF CAPITAL UTILIZATION

In the standard growth accounting exercise, the functional form adopted for the production function is motivated by the fact that the share of labor income in national income fluctuates little over time in Mexico. The models we have outlined above continue to predict constant factor income shares, but are they appropriate vehicles for inferring the behavior of capital utilization from Mexican data? Meza and Quintin (2003) argue that the answer is yes on the following grounds.

As we mention above, all evidence is that the energy intensity of capital is inelastic in the short run. This implies that utilization rates are roughly proportional to the aggregate-energy-use-to-capital ratio. Therefore, a satisfactory model of capital utilization should predict a path for the energy-use-to-capital ratio that is near its empirical counterpart. In a model that merges the two models we describe above, Meza and Quintin find that the predicted path for the energy-use-to-capital ratio does track the data well. In particular, and critically for the purpose of this article, this is true during the 1995 financial crisis.

Meza and Quintin calculate that capital utilization can account for about one-third of the 1995 drop in measured TFP in Mexico, which is within the range we obtain here via simpler methods. They also find that this ratio is robust to reasonable changes in exogenous parameters. Finally, they study the sensitivity of this estimate to the assumption that capital is homogenous. The assumption that capital is equally productive in all its possible uses is questionable in the standard growth accounting exercise, but it becomes particularly so when one makes capital utilization endogenous. Indeed, when the productivity of capital differs across its competing uses, it is the least productive units of capital that are idled first. This means that even large swings in capital utilization could have very little impact on aggregate TFP.

To address this concern, Meza and Quintin introduce capital heterogeneity—as in Cooley, Hansen, and Prescott (1995)—and find that doing so can halve the importance of capital utilization for the behavior of TFP in 1995. However, they also find that introducing heterogeneity yields counterfactual predictions for the path of the energy-to-capital ratio. (It predicts incorrectly that this ratio should not fall much in 1995.) This is because introducing heterogeneity drastically reduces the sensitivity of energy consumption to changes in capital utilization rates. Therefore, the homogenous capital model is more consistent with the Mexican evidence than the heterogenous capital model.

Meza and Quintin also report that all the models we have outlined so far, like the standard neoclassical model, predict that the aggregate labor input should have fallen much more than it did in 1995. This suggests that labor mismeasurement (labor hoarding, say, as in Burnside and Eichenbaum 1996) also played a role in the drop in measured TFP in Mexico in 1995. Accounting for this other source of measurement error may help us account for the remaining share of the 1995 output puzzle.

CONCLUSION

We calculate that capital utilization could account for as much as half the precipitous drop in measured TFP in Mexico during the Tequila Crisis. This is not surprising. Financial crises create perfect conditions for large drops in utilization rates because interest rates rise suddenly and sharply, while aggregate productivity falls. This induces firms to leave large quantities of capital idle until business conditions improve. It is our view, therefore, that models with endogenous factor utilization will enhance our understanding of the real impact of financial crises.

ACKNOWLEDGMENTS

The authors are grateful to Felipe Meza for suggesting the topic. They would also like to thank Tim Kehoe, Russ Cooper, Mark Wynne, Mark Guzman, and Carlos Zarazaga for their comments.

REFERENCES

Atkeson, A., and P. J. Kehoe (1999), "Models of Energy Use: Putty-Putty Versus Putty-Clay," *American Economic Review* 89 (September): 1028–43.

Bergoeing, R., P. J. Kehoe, T. J. Kehoe, and R. Soto (2002), "A Decade Lost and Found: Mexico and Chile in the 1980s," *Review of Economic Dynamics* 5 (January): 166–205.

Bils, M., and J. O. Cho (1994), "Cyclical Factor Utilization," *Journal of Monetary Economics* 33 (April): 319–54.

Burnside, C., and M. Eichenbaum (1996), "Factor-Hoarding and the Propagation of Business-Cycle Shocks," *American Economic Review* 86 (December): 1154–74.

Burnside, C., M. Eichenbaum, and S. Rebelo (1995), "Capital Utilization and Returns to Scale," NBER Working Paper Series, no. 5125 (Cambridge, Mass.: National Bureau of Economic Research, May).

Calvo, G. A. (1998), "Balance-of-Payments Crises in Emerging Markets: Large Capital Inflows and Sovereign Governments (University of Maryland, photocopy).

Calvo, G. A., and E. G. Mendoza (1996), "Mexico's Balance-of-Payments Crisis: A Chronicle of Death Foretold," *Journal of International Economics* 41 (November): 235–64.

——— (2000), "Capital-Markets Crises and Economic Collapse in Emerging Markets: an Informational-Frictions Approach," *American Economic Review* 90 (May): 59–64.

Carreón, V., and A. Jimenez (2003), "The Mexican Electricity Sector: Economic, Legal, and Political Issues," Political Economy of Power Market Reform Conference Proceedings, Stanford, Calif., February 19–20, http://pesd.stanford.edu/docs/2003mtg_mrkt_rfm/Mexico.pdf.

Cole, H. L., and T. J. Kehoe (1996), "A Self-Fulfilling Model of Mexico's 1994–1995 Debt Crisis," *Journal of International Economics* 41 (November): 309–30.

Cooley, T. F., G. D. Hansen, and E. C. Prescott (1995), "Equilibrium Business Cycles with Idle Resources and Variable Capacity Utilization," *Economic Theory* 6 (June): 35–49.

Flood, R. P., P. M. Garber, and C. Kramer (1996), "Collapsing Exchange Rate Regimes: Another Linear Example," *Journal of International Economics* 41 (November): 223–34.

Greenwood, J., Z. Hercowitz, and G. W. Huffman (1988), "Investment, Capacity Utilization, and the Real Business Cycle," *American Economic Review* 78 (June): 402–17.

Hornstein, A. (2002), "Towards a Theory of Capital Utilization: Shiftwork and the Workweek of Capital," Federal Reserve Bank of Richmond *Economic Quarterly*, Spring, 65–86.

King, R. G., and S. T. Rebelo (1999), "Resuscitating Real Business Cycles," in *Handbook of Macroeconomics*, vol. 1B, ed. J. B. Taylor and M. Woodford (Amsterdam: North-Holland), 927–1007.

Kydland, F. E., and E. C. Prescott (1982), "Time to Build and Aggregate Fluctuations," *Econometrica* 50 (November): 1345–70.

Kydland, F. E., and C. E. J. M. Zarazaga (2002), "Argentina's Lost Decade," *Review of Economic Dynamics* 5 (January): 152–65.

Lustig, N. (1998), *Mexico, the Remaking of an Economy*, 2nd ed. (Washington, D.C.: The Brookings Institution).

Meza, F., and E. Quintin (2003), "Financial Crises and Total Factor Productivity," unpublished manuscript.

Sachs, J., A. Tornell, and A. Velasco (1996), "The Mexican Peso Crisis: Sudden Death or Death Foretold?" *Journal of International Economics* 41 (November): 265–84.

Appendix A
Data Sources

In this appendix we construct data series for output and capital, labor, and energy inputs that are consistent with the energy-use model we describe in the text. Like Atkeson and Kehoe (1999), our model covers all sectors of the Mexican economy except the energy sector. Therefore, the major difference between national accounts variables and those in our model is the role of energy. Most data come from Mexico's Instituto Nacional de Estadística, Geografía y Informática (INEGI); all exceptions are mentioned below. GDP and capital formation data are in 1993 pesos.

Output

To obtain an output measure consistent with our model, we subtract the output of the energy sector from total GDP:

$$\widehat{GDP} = GDP_{Total} - GDP_{Energy}\,.$$

Next, in national accounts, GDP measures value added after accounting for all intermediate goods, including energy. In our model, output is the sum of payments to capital, labor, and energy. To make the national accounts data compatible with our model, we add the intermediate consumption of energy to $\widehat{GDP}$ to obtain

$$\overline{GDP} = \widehat{GDP} + \textit{Intermediate consumption of energy}.$$

This is the empirical counterpart for Y we use.

Physical Capital

On the product side of the national accounts, we subtract investment in the energy sector from total investment. We thus define investment as the sum of fixed capital formation and purchases of durable goods, excluding investment in the energy sector. Using the resulting investment series and the perpetual inventory method with four periods to build yields a measure of the capital stock K consistent with our model. In doing so, we assume that investment in a given year is divided equally among new machines in the following four years (as investment would be in deterministic steady state). We assume an annual depreciation rate of 10 percent, except in the model with varying depreciation rate, where we use the effective depreciation rate in every period in building our capital stock measure.

Labor

The variable consistent with the neoclassical growth model is discretionary time allocated to work. We measure it as a fraction of total discretionary time available. This fraction is defined as the ratio of total hours worked in the economy to total working-age population, relative to total discretionary time available. However, in Mexico there are no data available on hours worked for the whole economy. To measure the labor input, we calculate average hours worked in the manufacturing sector from the Manufacturing Sector Survey.[1] We then assume that average hours behave similarly in both the manufacturing sector and the rest of the economy.[2] We obtain the ratio of workers to population twelve years of age and older from the Urban Employment Survey.[3] We only consider workers who report strictly positive hours worked. To make the labor input consistent with the model, we exclude from the aforementioned ratio the workers in the mining industry. Total employment in the oil and electricity industries in Mexico is available, but not total employment in the energy sector. We then multiply average hours by the ratio of workers to population. Finally, we divide this series by 1,300, the total discretionary time available in a quarter, under the assumption that a working-age person has 100 hours of discretionary time per week.

(continued)

Appendix A (continued)
Data Sources

Energy

Annual energy consumption data for the business sector (total consumption less residential and public consumption) is available from the Secretaría de Energía (SENER). Quarterly consumption data come from INEGI. Consumption numbers for the nonenergy sector for gas licuado (LPG), combustóleo (fuel oil), diesel, and gasolinas (gasoline) are based on internal sales (ventas internas) plus imports. Since this approximates consumption by all sectors other than the energy-producing sector, the residential and public sectors were removed using weights inferred from the annual consumption data from SENER. The quarterly electricity data from INEGI include only the industrial sector, so we use annual industrial electricity consumption as a percentage of total business sector consumption from SENER to account for the rest of the business sector. All the series were converted into megajoules.

NOTES

[1] See documentation available at INEGI web site http://dgcnesyp.inegi.gob.mx/BDINE/C10/MTD/C1000002.HTM.

[2] Alternatively, one could use employment as the labor input. Doing this has little impact on our quantitative findings.

[3] For documentation on the Urban Employment Survey, see www.inegi.gob.mx/est/contenidos/espanol/metodologias/detalladas/encuestas/hogares/metodeneu.pdf.

Appendix B
Greenwood, Hercowitz, and Huffman 1988

Equation 7 enables us to identify capital utilization rates using profit-maximizing incentives for a stand-in, representative firm. To derive this condition, consider a firm with a production process given by Equation 3. The objective of the firm is to maximize

$$\tilde{z}_t (u_t K_t)^{\alpha} N_t^{1-\alpha} - (\delta(u_t) + R_t) K_t - N_t w_t, \tag{B.1}$$

where R_t is the net rental rate of capital in quarter t, w_t is the price of labor and $\delta(u_t)$ is a function that relates the rate of capital utilization to the rate of capital depreciation. As in Greenwood, Hercowitz, and Huffman (1988), we assume that for all possible utilization rates $u \in [0,1]$,

$$\delta(u) = \frac{\phi}{\omega} u^{\omega}, \tag{B.2}$$

where $\omega > 1$ and ϕ is a scaling parameter. In any given period, the firm raises u until the additional capital lost to depreciation exceeds the output gain. Therefore, a necessary condition for profit maximization is

$$\alpha \tilde{z}_t (u_t K_t)^{\alpha-1} N_t^{1-\alpha} - \phi u_t^{\omega-1} = 0, \tag{B.3}$$

or

$$\alpha Y_t - \phi u_t^{\omega} K_t = 0, \tag{B.4}$$

which is Equation 7. We choose parameters ω and ϕ so that the average precrisis utilization rate u^* is 80 percent, while the average precrisis depreciation rate $\delta(u^*)$ is 10 percent. To do this, observe that Equation 7 implies

$$\omega = \frac{\alpha Y_t}{\delta(u_t) K_t}. \tag{B.5}$$

Based on this relationship, and letting Y^* and K^* denote the average output and capital stock levels in our precrisis data, we set

$$\omega = \frac{\alpha Y^*}{0.1 K^*} \approx 2.18. \tag{B.6}$$

Then, the scaling parameter ϕ must equal

$$\left(\frac{0.1\omega}{\phi}\right)^{\frac{1}{\omega}} \approx 0.086. \tag{B.7}$$