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**Article**

## Explaining exchange rate behavior

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[7147] One conclusion from this literature is that optimal policy can often be written as a form of a “Taylor rule,” according to which the short-term interest rate set by the central bank responds to inflation and a measure of real economic activity, such as the deviation of output from its potential. [For a recent example, see 9149; for an opposing view, see 9421.]

Another conclusion from this literature is that optimal policy should

obey the “Taylor principle,” which states that the nominal interest rate should rise more than one-for-one with the inflation rate. In many standard models of the business cycle, this principle ensures that shocks to the economy do not induce inflation to get out of control. There is considerable evidence that the successes of monetary policy over the two decades, compared to the problems in the 1970s, can be explained by reference to the

Taylor principle. [6442, 6768, 8471, 8800] That is, the Fed has responded aggressively to changes in inflation when choosing its target interest rate during the recent period, whereas the Fed appears to have responded much less to inflation in the earlier period. This insufficient response to inflation may explain why inflation got out of hand in the United States in the 1970s.

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## Research Summaries

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### Explaining Exchange Rate Behavior

Menzie D. Chinn\*

In an era characterized by increasingly integrated national economies, the exchange rate is the key relative price in open economies. As such, a great deal of attention has been focused on characterizing its behavior. Unfortunately, it is unclear how much success there has been in predicting this critical relative price. As recently remarked, “There may be more forecasting of exchange rates, with less success, than almost any other economic variable.”<sup>1</sup> While this characterization may be quite apt — a point I will return to later — it should not prevent us from attempting to identify the empirical determinants of exchange

rates, an enterprise separate from forecasting exchange rates.

#### The Impact of Productivity Changes

The first major line of inquiry I’ve followed links changes in productivity to changes in nominal and real exchange rates. There is a long and venerable literature that links these two variables theoretically, most notably associated with Balassa and Samuelson.<sup>2</sup> In these models, differences in productivity levels between traded and nontraded sectors affect the relative prices of these goods. Further, with traded goods prices equalized in common currency terms, real exchange rates — which incorporate the prices of nontraded good — will be affected.

The post-War yen has been the traditional candidate for explanation by

this type of model.<sup>3</sup> In addition, the model typically is applied to economies experiencing rapid growth, since such growth often is associated with rapid productivity change in the tradable (manufacturing) sector. Hence, a natural application of the model is to the East Asian countries. Unfortunately, the data necessary for a direct test of the model do not readily exist. Instead, most analyses rely on observations on relative prices to infer the validity of the approach. In order to conduct a direct test, I compiled sector-specific employment and output data for China, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, and Thailand, and estimated the implied relationships. The time-series evidence did not support the model except in a few cases. Using panel regression techniques adapted to persistent time series,<sup>4</sup> I find that the model applies to the set of countries including Indonesia, Japan, Korea,

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Malaysia, and the Philippines.<sup>5</sup> Part of the reason for the limited extent of the finding may be that *measured* traded goods prices do not appear to be equalized, especially when the prices pertain to bundles of goods that are changing rapidly. After all, the composition of exports of Malaysia today bears little resemblance to that of forty years ago.

Interestingly, there is some evidence that the productivity effect applies even for more developed economies. Louis D. Johnston and I examined sector-specific productivity levels for 14 OECD countries. Using panel cointegration methods, we found that productivity levels did matter for dollar-based real exchange rate levels in the long run, although other factors mattered as well. These other factors included government spending and the terms of trade. In a closely related paper, we found that the same conclusions held for trade-weighted OECD real exchange rates.<sup>6</sup>

More recently, Ron Alquist and I have examined the behavior of the euro/dollar exchange rate, drawing inspiration from the large literature that ascribed the strength of the dollar and the weakness of the euro to the differing prospects for accelerated productivity growth rates associated with the diffusion of the New Economy. Using aggregate productivity data from 1985 to 2001, we found that productivity was strongly related to the euro/dollar rate. One of the paradoxes of the results is that according to the estimates, each one percentage point increase in the productivity differential between the United States and the eurozone economies results in a real dollar appreciation of between 2 and 5 percent. While other studies have detected effects of a similar nature, the magnitude is somewhat larger than has been found previously. Furthermore, it is hard — although not impossible — to rationalize the magnitude of the effect theoretically. A combination of demand side effects and an increase in productivity, localized to the technologies used in the United States, is one interpretation.<sup>7</sup>

## Overvaluation

Models of purchasing power parity, or the Balassa-Samuelson hypothesis, naturally lend themselves to the exercise of determining whether a currency is “overvalued” or otherwise misaligned. Indeed, one implication of the Balassa-Samuelson hypothesis is that the standard practice of measuring misalignments as deviations from linear trends is likely to provide misleading conclusions. In work I conducted in the wake of the crises of 1997-8, I asked whether the East Asian currencies were overvalued, given the possibility that the standard practice was applied inappropriately.

A long-run relationship between exchange rates and relative prices exists for all currencies, with respect to at least one reference currency (dollar or yen) or price deflator (CPI or PPI). My results indicate that the Malaysian ringgit, Philippine peso, and Thai baht were overvalued a month before the baht devaluation in July 1997. On the other hand, the Indonesian rupiah, Korean won, and Singapore dollar appear to have been undervalued. Of these results, the implied undervaluations of the rupiah and won are the most counter-intuitive, since these two currencies suffered precipitous declines in value. Consequently, the widely held view that currency overvaluation was at the heart of each of the East Asian currency crises lacks credibility (although overvaluation probably did play some role).

## Real Exchange Rate Behavior and Market Characteristics

A large body of work has sought to characterize the adjustment of the real exchange rate toward its long-run value. Often, the long-run real exchange rate is thought to be what sets the price of identical baskets of goods to be equal, when expressed in common currency terms; this condition often is termed purchasing power parity. The mystery arises from the stylized fact that the adjustment takes longer than what can be rationalized by sticky prices.<sup>8</sup> Yin-Wong Cheung, Eiji Fujii, and I merge the literature on

real exchange rates with that on industrial organization factors suggested by the New Keynesian literature.<sup>9</sup> We calculate real exchange rates sector-by-sector (for example, for chemicals, or for fabricated metal products), and relate the pace at which these real exchange rates revert to their long-run values to the characteristics of those sectors, including the amount of intra-industry trade, size of price-cost margins (a proxy measure for the degree of substitutability of goods) and other factors thought to be important including distance, exchange rate volatility and inflation rates.

The econometric results reveal considerable evidence for the hypothesis that market imperfection is associated with high persistence in deviations from purchasing power parity. In general, the two measures of market imperfection — a price-cost margin and an index of intra-industry trade — are significant across different specifications and have a positive impact on real exchange rate persistence. The robustness of the market structure effects stands in stark contrast with the results pertaining to the macroeconomic variables, which can yield coefficient estimates that vary across model specifications, and occasionally have a sign different from what the theory predicts. Overall, our analysis uncovers positive evidence of market structure effects on real exchange rate persistence.

## Interest Rates, Exchange Rates and Expectations

A common method of predicting asset prices uses market-based indicators. For instance, futures prices often are cited as forecasts of commodities. Forward rates — agreements set today for a trade of currencies in the future — would seem to be an ideal indicator for the future exchange rate. Equivalently, according to a no-arbitrage profits condition, when financial capital is free to move, the forward rate equals the current exchange rate adjusted by the interest differential. In reality, forward rates for developed economy currencies typically are biased predictors of future spot rates;

indeed, when interest differentials point to a dollar depreciation, the dollar on average appreciates. This well known fact led Jeffrey Frankel and Kenneth Froot to use survey data to assess whether, for the major currencies, this bias was attributable to the existence of a risk premium or to biased expectations. In two important works, they conclude that the expectations of market participants were biased, and further that there was little evidence that the bias in the forward rate was caused by the presence of an exchange risk premium.<sup>10</sup> Frankel and I examined a larger number of currencies and once again found evidence of biased expectations for 25 currencies over a three-year period.<sup>11</sup> Interestingly, in examining forward rate bias in a larger set of currencies (17), we find somewhat more evidence in favor of an exchange risk premium.<sup>12</sup> To the extent that one believes that such risk premiums arise from the differentiated nature of the bonds issued by separate governments, the result makes sense. For instance, U.S. and German bonds may be more substitutable than U.S. and Swedish bonds.

Guy Meredith and I<sup>13</sup> investigate whether interest rate differentials point in the wrong direction for exchange rate changes for horizons much longer than typically studied: five and ten years, versus the one month or one year used in earlier studies. We find that at these horizons, this perverse correlation largely disappears. While this finding appears robust to a number of variations, its statistical significance has been disputed, given the small number of independent observations in the post-Bretton Woods era (for example, five non-overlapping five-year horizons). Hence, we use panel regressions and confirm the finding.

The interpretation of these results is complicated by the lack of agreement on the origins of the forward rate bias. We propose a model wherein shocks to the interest rate parity relationship (perhaps because of noise traders) spur a central bank reaction function that serves to make exchange changes correlated negatively with interest differentials. Because central banks only can control short-term

interest rates, the effect is most pronounced at short horizons. Since long-term interest rates are a weighted average of short-term interest rates, the effect is muted at longer horizons. Further research may illuminate alternative explanations.

## What Do Market Participants Think?

The work previously recounted uses empirical methods to discern the determinants of exchange rate movements. Taking a different tack, Cheung and I conduct a survey study of foreign exchange traders in the United States.<sup>14</sup> Our results indicate that: more than half of market respondents believe that large players dominate in the dollar-pound and dollar-Swiss franc markets, and technical trading best characterizes about 30 percent of traders, with this proportion rising from five years ago. The responses also suggest that news about macroeconomic variables is incorporated rapidly into exchange rates, although the relative importance of individual macroeconomic variables shifts over time. Finally, economic fundamentals appear to be more important at longer horizons, while short-run deviations of exchange rates from their fundamentals are attributed to excess speculation and institutional customer/hedge fund manipulation.

Perhaps, unsurprisingly given the mixed findings regarding purchasing power parity, traders do not view the parity condition as a useful concept, even though a significant proportion of them believe that it affects exchange rates at horizons of over six months. Interestingly, these particular findings do not appear to be location-specific. Ian W. Marsh, Cheung, and I conducted a similar survey of U.K.-based foreign exchange dealers in 1998.<sup>15</sup> We confirm that many of these characteristics also pertain to that market. Moreover, we find that there is clear heterogeneity of traders' beliefs, but it is not possible to explain the source of these disagreements in terms of institutional detail, rank, or trading technique (for example, technical analysts versus fundamentalists).

## Are Exchange Rates Predictable?

One of the key issues dominating the empirical literature is whether exchange rates can be predicted. Previous assessments of nominal exchange rate determination have focused on a narrow set of models typically of the 1970s vintage. The canonical papers in this literature are by Meese and Rogoff, who examined monetary and portfolio balance models.<sup>16</sup> These papers established the stylized fact that it is extremely difficult to beat a random walk on a consistent basis. Succeeding works by Mark and by Chinn and Meese overturned these results, but only at long (three or four year) horizons.<sup>17</sup>

More recently, several studies have re-evaluated the long-horizon results. Faust, Rogers, and Wright argue that the success of long-horizon regressions is specific to the particular time period examined by Mark and Chinn and Meese.<sup>18</sup> In work co-authored with Cheung and Pascual,<sup>19</sup> I also re-assess exchange rate prediction. Using a wider set of models that have been proposed in the last decade — interest rate parity, productivity based models, and a composite specification incorporating sticky-price, productivity, and portfolio balance models — we compare these models against a benchmark, the Dornbusch-Frankel sticky price monetary model.

We examine the model's performance at various forecast horizons (1 quarter, 4 quarters, 20 quarters) using differing metrics (mean squared error, direction of change), as well as the "consistency" test proposed in Cheung and Chinn.<sup>20</sup> About half of the estimates are based upon specifications that use contemporaneous information (that is, the forecast of December 2000 uses December 2000 data on the right-hand side variables), while half use only lagged information (that is the December 2000 forecast uses data either one quarter, one year, or 5 years prior.) Consequently, half of our specifications are at a great informational disadvantage.

We find that no model consistently outperforms a random walk, by the

conventionally adopted mean squared error measure. However, along a direction-of-change dimension, certain structural models do outperform a random walk with statistical significance. We also find that interest rates predict quite well, although only at the longest horizon.

These forecasts are tied to the actual values of exchange rates in the long run, although in a large number of cases the elasticity of the forecasts with respect to the actual values is different from unity. Overall, we find that model/specification/currency combinations that work well in one period do not necessarily work well in another period.<sup>21</sup>

While the results are not very positive, they do suggest that along some dimensions, structural models have predictive power. And, it is important to recognize that we have stacked the deck against these models having good predictive power, in that half of our estimates do not rely upon contemporaneous information. So, while useful forecasting models remain elusive, the identification of key empirical factors remains a productive, albeit challenging, enterprise.

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<sup>1</sup> Alan Greenspan, *Testimony of the Federal Reserve Board's semiannual monetary policy report to the Congress, before the Committee on Banking, Housing, and Urban Affairs, U.S. Senate, July 16, 2002.*

<sup>2</sup> B. A. Balassa, "The Purchasing Power Parity Doctrine: A Reappraisal," *Journal of Political Economy*, 72 (1964), pp. 584-96; and P. A. Samuelson, "Theoretical Notes on Trade Problems," *Review of Economics and Statistics*, 46 (1964), pp. 145-54.

<sup>3</sup> See M. D. Chinn, "Whither the Yen? Implications of an Intertemporal Model of the Yen/Dollar Rate," *Journal of the Japanese and International Economies*, 11 (2) (June 1997), pp. 228-46.

<sup>4</sup> These are panel regression techniques adapted to data that appear to follow unit root processes. See for instance P. Pedroni, "Purchasing Power Parity in Cointegrated Panels," *Review of Economics and Statistics*, 83 (4) (2001), pp. 727-31.

<sup>5</sup> M. D. Chinn, "The Usual Suspects? Productivity and Demand Shocks and Asia-Pacific Real Exchange Rates," NBER

*Working Paper No. 6108, July 1997, and in Review of International Economics*, 8 (1) (February 2000), pp. 20-43.

<sup>6</sup> M. D. Chinn and L. D. Johnston, "Real Exchange Rate Levels, Productivity and Demand Shocks: Evidence from a Panel of 14 Countries," NBER Working Paper No. 5709, August 1996; and M. D. Chinn, "Sectoral Productivity, Government Spending and Real Exchange Rates: Empirical Evidence for OECD Countries," NBER Working Paper No. 5943, February 1997, and in *Equilibrium Exchange Rates*, R. MacDonald and J. L. Stein, eds., Boston: Kluwer Academic Publishers, 1999, pp. 163-90.

<sup>7</sup> R. Alquist and M. D. Chinn, "Productivity and the Euro-Dollar Exchange Rate Puzzle," NBER Working Paper No. 8824, March 2002.

<sup>8</sup> See K. A. Froot and K. S. Rogoff, "Perspectives on PPP and Long-Run Real Exchange Rates," in G. M. Grossman and K. S. Rogoff, eds., *Handbook of International Economics*, Vol. III, Amsterdam: North-Holland, 1995.

<sup>9</sup> Y. Cheung, M. D. Chinn, and E. Fujii, "Market Structure and the Persistence of Sectoral Real Exchange Rates," NBER Working Paper No. 7408, October 1999; also "Market Structure and the Persistence of Sectoral Deviations from Purchasing Power Parity," *International Journal of Finance and Economics*, 6 (2) (April 2001), pp. 95-114.

<sup>10</sup> J. A. Frankel and K. A. Froot, "Using Survey Data to Test Standard Propositions Regarding Exchange Rate Expectations," *American Economic Review*, 77 (1) (March 1987), pp. 133-53; and "Forward Discount Bias: Is It an Exchange Risk Premium?" *Quarterly Journal of Economics*, 104 (1) (February 1989), pp. 139-61.

<sup>11</sup> M. D. Chinn and J. A. Frankel, "Patterns in Exchange Rate Forecasts for 25 Currencies," NBER Working Paper No. 3807, December 1994, and "Are Exchange Rate Expectations Biased? Tests for a Cross-Section of 25 Currencies," *Journal of Money, Credit and Banking*, 26 (4) (November 1994), pp. 759-70.

<sup>12</sup> J. A. Frankel and M. D. Chinn, "Exchange Rate Expectations and the Risk Premium: Tests for a Cross-Section of 17 Currencies," NBER Working Paper No. 3806, August 1991, and *Review of International Economics*, 1 (2) (June

1993), pp. 136-44. Some of these results are updated in M. D. Chinn and J. A. Frankel, "Survey Data on Exchange Rate Expectations: More Currencies, More Horizons, More Tests," in W. Allen and D. Dickinson, eds., *Monetary Policy, Capital Flows and Financial Market Developments in the Era of Financial Globalisation: Essays in Honour of Max Fry*, London: Routledge, 2002, pp. 145-67.

<sup>13</sup> G. Meredith and M. D. Chinn, "Long-Horizon Uncovered Interest Rate Parity," NBER Working Paper No. 6797, November 1998.

<sup>14</sup> Y. Cheung and M. D. Chinn, "Macroeconomic Implications of the Beliefs and Behavior of Foreign Exchange Traders," NBER Working Paper No. 7417, November 1999; and "Traders, Market Microstructure and Exchange Rate Dynamics," NBER Working Paper No. 7416, November 1999, published as "Traders and Exchange Rate Dynamics: A Survey of the U.S. Market," *Journal of International Money and Finance*, 20 (4) (August 2001), pp. 439-71.

<sup>15</sup> Y. Cheung, M. D. Chinn and I. W. Marsh, "How Do UK-Based Foreign Exchange Dealers Think Their Market Operates?" NBER Working Paper No. 7524, February 2000.

<sup>16</sup> R. Meese and K. S. Rogoff, "Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample?" *Journal of International Economics*, 14 (1983), pp. 3-24; and "The Out-of-Sample Failure of Empirical Exchange Rate Models: Sampling Error or Misspecification?" in J. A. Frenkel, ed., *Exchange Rates and International Macroeconomics*, Chicago: University of Chicago Press, 1983, pp. 67-105.

<sup>17</sup> N. C. Mark, "Exchange Rates and Fundamentals: Evidence on Long Horizon Predictability," *American Economic Review*, 85 (1995), pp. 201-18; and M. Chinn and R. Meese, "Banking on Currency Forecasts: How Predictable Is Change in Money?" *Journal of International Economics*, 38 (1-2) (1995), pp. 161-78.

<sup>18</sup> J. Faust, J. Rogers and J. Wright, "Exchange Rate Forecasting: The Errors We've Really Made," paper presented at conference on "Empirical Exchange Rate Models," University of Wisconsin, September 28-29, 2001. Forthcoming in *Journal of International Economics*. The long horizon finding has been re-established in a panel context; see N. C. Mark

and D. Sul, "Nominal Exchange Rates and Monetary Fundamentals: Evidence from a Small Post-Bretton Woods Panel," *Journal of International Economics*, 53 (1) February 2001, pp. 29-52.

<sup>19</sup> Y. Cheung, M. D. Chinn and A. G. Pascual, "Empirical Exchange Rate Models of the Nineties: Are Any Fit to Survive?" NBER Working Paper No. 9393,

December 2002.

<sup>20</sup> Y. Cheung and M. D. Chinn, "Integration, Cointegration, and the Forecast Consistency of Structural Exchange Rate Models," *Journal of International Money and Finance*, 17 (5) (1998), pp. 813-30.

<sup>21</sup> These results are confirmed in a related paper which also assesses in-sample fit. See Y. Cheung, M. D. Chinn and A. G. Pascual,

"What Do We Know about Recent Exchange Rate Models? In-Sample Fit and Out-of-Sample Performance Evaluated," mimeo (October 2002), forthcoming in P. DeGrauwe, ed., *Exchange Rate Economics: Where Do We Stand?* Cambridge: MIT Press for CESifo.

## Health, Income, and Inequality

Angus Deaton\*

Richer, better-educated people live longer than poorer, less-educated people. According to calculations from the National Longitudinal Mortality Survey which tracks the mortality of people originally interviewed in the CPS and other surveys, people whose family income in 1980 was greater than \$50,000, putting them in the top 5 percent of incomes, had a life-expectancy at all ages that was about 25 percent longer than those in the bottom 5 percent, whose family income was less than \$5,000. Lower mortality and morbidity is associated with almost any positive indicator of socioeconomic status, a relationship that has come to be known as "the gradient." African-Americans have higher but Hispanic Americans lower mortality rates than whites; the latter is known as the "Hispanic paradox," so strong is the presumption that socioeconomic status is protective of health. Not only are wealth, income, education, and occupational grade protective, but so are several more exotic indicators. One study found that life-spans were longer on larger gravestones, another that winners of Oscars live nearly four years longer than those who were

nominated but did not win.

Many economists have attributed these correlations to the effects of education, arguing that more educated people are better able to understand and use health information, and are better placed to benefit from the healthcare system. Economists also have emphasized the negative correlation between socioeconomic status and various risky behaviors, such as smoking, binge drinking, obesity, and lack of exercise. They have also pointed to mechanisms that run from health to earnings, education, and labor force participation, and to the role of potential third factors, such as discount rates, that affect both education and health.

Epidemiologists argue that the economists' explanations at best can explain only a small part of the gradient; they argue that socioeconomic status is a *fundamental cause* of health. They frequently endorse measures to improve health through manipulating socioeconomic status, not only by improving education but also by increasing or redistributing incomes. Fiscal policy is seen as an instrument of *public health*, an argument that is reinforced by ideas, particularly associated with Richard Wilkinson, that income inequality, like air pollution or toxic radiation, is itself a health hazard. Even if economic policy has no direct effect on health, the positive correlation between health and economic status implies that social inequalities in

wellbeing are wider than would be recognized by looking at income alone.<sup>1</sup>

### Income and Education among Cohorts and Individuals

Christina Paxson and I<sup>2</sup> looked at the relationship between health and economic status among American birth cohorts. We focused on the idea that health is determined by an individual's income relative to other members of a reference group whose membership typically is unobserved by the analyst. Even if income inequality has no direct effect on health, the fact that the reference groups are not observed means that the slope of the relationship between health and income depends on the ratio of the between-to-within group components of income inequality. For example, if doctors' health depends on the income of other doctors, and economists' health on the income of other economists, then the health-to-income relationship in the pooled data will flatten if the average incomes of the two groups pulls apart.<sup>3</sup>

Among birth cohorts there is a strong protective effect of income on mortality; the elasticity of mortality rates with respect to income is approximately -0.5. These estimates are consistent with estimates from the individual data in the National Longitudinal

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