

The Yen and Japan's Economy, 1985-2007*

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Introduction

In the late 1980s, Japan's economy embarked on a period of rapid escalation in the prices of shares and real estate. This "bubble economy" was followed by a collapse in asset prices, a reduced pace of real economic growth, banking problems, and deflation. Nearly two decades after the demise of the bubble economy, the prognosis for Japanese growth remains uncertain amid a turbulent global economic outlook. Japan's experience carries lessons for those hoping to understand and contain the current financial crisis originating in the United States housing market.

Some observers of Japan blame its monetary policy for failing to react promptly and aggressively enough, both as asset prices rose in the late 1980s and as they plummeted afterward. In these accounts, official concerns about the yen's foreign exchange rate and the competitiveness of the export sector were significant considerations for monetary policy. Indeed, the yen has experienced epic gyrations since the mid-1980s, starting with its rapid ascent after the March 1985 Plaza Accord of major industrial countries. Two distinct periods of *endaka fukyo*, or recession induced by a strong yen, occurred in the late 1980s and the early 1990s at critical phases of the monetary policy cycle. In general, Japan's real economic growth rate is rather strongly negatively correlated with the level of the yen's real effective exchange rate, as illustrated in Figure 1. Over 1978-2007, the correlation coefficient between the real exchange rate and real GDP growth is -0.38 .

Yet the determinants of the yen's short- and even longer-term movements remain mysterious in light of the development of Japan's macro economy. What factors, for example, can explain the yen's steady and dramatic appreciation against the dollar over

the early 1990s as Japan's real economy and its financial system deteriorated? In their prominent study of the Japanese economy through 1997, McKinnon and Ohno (1997, p. 2) go so far as to "treat the course of the yen-dollar exchange rate as a forcing variable for Japanese monetary policy, rather than assuming that monetary policy independently determines the exchange rate." While the U.S.-Japan trade tensions that McKinnon and Ohno view as the underlying determinant of yen/dollar movements undoubtedly influenced market expectations, their vision of yen fluctuations that are largely exogenous with respect to macro policies begs the question of just how policymakers were able to direct market-determined exchange rates toward politically expedient levels.¹

This paper explores the links between macroeconomic developments, especially monetary policy, and the exchange rate during the period of Japan's bubble economy and subsequent stagnation. My approach emphasizes the interaction of short-term developments driven by monetary factors (as they affect real interest rate differentials) and the longer-term determinants of the real exchange rate's path. While I believe this approach to be fruitful, it raises further questions for future research as I describe below. Hopefully this exploration will nonetheless throw light on the general question of how major currency misalignments emerge and recede. The approach is unabashedly macroeconomic in its primary focus, although there is no doubt that microeconomic factors affecting the health of the financial system are also important, in part through their effect on the monetary transmission mechanism.

¹ As McKinnon and Ohno (1997) express their thesis elsewhere, "The erratically appreciating yen has been an independent (or exogenous) source of disturbance. And since 1984, at least, it has imposed undue deflation on the Japanese economy" (p. 199).

The paper begins by reviewing the broad outlines of exchange rate behavior since the Plaza agreement of 1985.² It then sets out a simple framework relating real interest differentials to the exchange rate, and uses it to explore the role of monetary policies. The paper's second half focuses on the longer-term determination of the real exchange rate, which informs the exchange rate forecasts underlying international real interest rate differentials. Specifically, the paper considers the evolution of the yen's real exchange rate with reference to international and intersectoral productivity growth gaps, as posited by the Harrod-Balassa-Samuelson model, and fluctuations in relative international prices for traded goods. An important question is the extent to which sharp exchange rate movements have themselves affected productivity levels in Japanese industry.

Real Interest Differentials, Natural Real Rates, and the Real Exchange Rate

The open or uncovered interest rate parity theory of the exchange rate has received quite limited support from the empirical record of the modern floating exchange rate era. I will nonetheless rely upon it as a basic framework for thinking about the link between monetary policy and movements in the yen. Why could this be a reasonable approach?

There are three reasons:

² A complementary study exploring this ground is Hamada and Okada (2007). Hamada and Okada sometimes verge on language seeming to imply an exogenous yen real exchange rate, which on their p. 20 they “figuratively compare to an outside temperature that Japan faced during these 20 years” Elsewhere, however, they clarify their belief the yen exchange rate has reacted in part to domestic macro policies. Like McKinnon and Ohno they allude to trade conflict (through a theoretical analysis of current account targets), but place little emphasis on it in their detailed policy narrative.

1. Some framework is essential, and our knowledge of risk premia is rudimentary at best. It thus seems prudent to start with the simplest framework, even if it does not fit the data exactly, and then, if necessary, add additional conjectural factors such as risk premia.
2. If risk premia or other deviations from interest parity move slowly over time, a first-differenced relationship could be useful even if level deviations from interest parity are significant.
3. My focus will be on long-horizon interest parity, and the evidence (partial as it is) suggests that interest parity may hold more closely for long-term interest rates (see, for example, Alexius and Sellin 2002; Chinn 2006).

Modern discussions of monetary transmission – echoing the classic insights of Wicksell more than a century ago – stress the link between the real interest rate implied by the monetary policy stance and the natural, market-clearing real interest rate. The interest-parity relation suggests, moreover, that relative international discrepancies between natural and market real interest rates have consequences for real exchange rates. Thus, the interest-parity relationship, once reinterpreted, is a natural vehicle for linking the expansiveness or restrictiveness of monetary policy to the exchange rate. This approach is most likely to be informative when applied to long-term interest-parity,

If r_t is the long-term real rate of interest at home, r_t^* the long-term real rate abroad, and q_t the real exchange rate (defined as the domestic consumption cost of

foreign consumption), then if \bar{q}_t is the expected long-run real exchange rate as of date t , the (open) interest-parity condition is

$$r_t - r_t^* = \bar{q}_t - q_t. \quad (1)$$

Observe that in this notation, a rise in q is a real depreciation of the domestic currency. A rise in $r_t - r_t^*$, holding \bar{q}_t constant, elicits a real domestic appreciation.

Let a tilde over a variable denote its “natural” level: the level consistent with market clearing in a flexible-price world. In particular, \tilde{q}_t denotes the flex-price equilibrium real exchange rate and, $\bar{\tilde{q}}_t$ denotes the expected long-run “natural” real exchange rate, which – importantly – coincides with \bar{q}_t . In the flex-price equilibrium the analog of eq. (1) holds:

$$\tilde{r}_t - \tilde{r}_t^* = \bar{\tilde{q}}_t - \tilde{q}_t. \quad (2)$$

By subtracting (2) from (1), we obtain a simple relationship that ties the current deviation of the real exchange rate from its flex-price level to the relative expansiveness of domestic monetary policy, as represented by deviations of market from natural long-term real rates of interest:

$$q_t = \tilde{q}_t + (r_t^* - \tilde{r}_t^*) - (r_t - \tilde{r}_t). \quad (3)$$

If the domestic real rate of interest rises relative to its natural level, for example, then the domestic currency will appreciate in real terms relative to its own full-employment level (everything else equal). For example, a decline in economic growth prospects would naturally be associated with a fall in the natural long-term real interest rate, \tilde{r}_t , but if

monetary policy is expected to remain restrictive over the medium term, the result could well be a real currency appreciation and recession.

Of course, equation (1) by itself also has implications for the real exchange rate.

Rewrite (1) as

$$q_t = \bar{q}_t - (r_t - r_t^*).$$

This relationship implies that if changes in the expected long-run real exchange rate \bar{q}_t are small and if risk premia changes are excluded, the currency will appreciate in real terms when the domestic-foreign real interest differential rises. This pattern is most likely when the main shocks hitting the economy are monetary, for pure monetary shocks do not alter the long-run real exchange rate. In reality, the implied relation between current real exchange rates and real interest differentials seems to be rather loose for most currencies. In the Japanese case, however, I will argue that monetary shocks were important and do provide some traction for understanding exchange rate movements. This approach still leaves most of short-term exchange rate movements unexplained, of course, so it is important to keep in mind that expected real interest rates are measured with some error (due to the use of inflation-expectations proxies), that variable risk premia indeed are relevant, and that changes in expectations of long-run real exchange rates are likely to have occurred at various points.

Figure 2 displays the monthly time series of Japan less United States real interest differentials and the real yen/dollar exchange rate index, calculated on the basis of CPIs (with an upward move in the exchange rate index being a real yen appreciation). The real interest rate is calculated as the 10-year government bond rate less the centered twelve-

month ex post inflation rate. For the period from June 1980 to July 2008, the correlation coefficient between the real interest differential and the log real exchange rate is +0.45. Evidently real interest differentials do not explain everything, but they are surprisingly highly correlated with real yen/dollar movements, and in the direction that a simplified interest parity theory would suggest.³

Patterns in Nominal and Real Exchange Rates

As the United States embarked on a program of disinflation and fiscal expansion in the early 1980s, the yen and other world currencies depreciated sharply against the United States dollar. After averaging below 220 yen per dollar over 1978-81 – that level itself a very sharp appreciation relative to the average of 288 over 1974-77 – the yen depreciated to about 250 in 1982, before assuming an average value of around 238 for 1983-85.

These annual averages in exchange rates disguise very high intra-year volatility, however. Between March 1984 and February 1985, for example, the yen depreciated from 225.40 to 260.24 against the dollar, a move of more than 14 percent (in log points). The dollar's renewed strength reinforced trade tensions between the U.S. and its trading partners, and eventually led to the September 1985 Plaza Accord. The U.S. and four major allies – the United Kingdom, France, Germany, and Japan – pledged concerted policy intervention to bring the dollar down.

³ The bilateral real exchange rate measure and the Japanese CPI inflation measure used in calculating the real interest rate are adjusted to remove the effects of the consumption tax increases of April 1, 1989 and April 1, 1997 (from 0 to 3 percent and from 3 to 5 percent, respectively).

The aftermath of the Plaza accord saw a dramatic move in the yen's dollar exchange rate, as illustrated in Figure 3. Having been around 260 yen per dollar in early 1985, the yen price of dollars had fallen to around 125 by early 1988, an appreciation of roughly 73 percent (in log points) over only three years. In its latter stages, the yen's rise was encouraged by somewhat easier U.S. monetary policy immediately following the October 1987 stock market crash. Estimates such as those reported by Ahearne and others (2002) suggest that Japan's GDP was below potential in 1986 and 1987 as exporters struggled.

At the same time, Japan's policy interest rates, having been raised abruptly late in 1985 to support the Plaza policy, were lowered sharply through 1986 and 1987. (See Figure 4.) From a high point above 8 percent in late 1985, the overnight call money rate fell to just above 3 percent in the first half of 1987. And early in 1986, the prices of equity and land began to rise sharply. Many observers, for example, Ahearne and others (2002), Ito and Mishkin (2006), and Hamada and Okada (2007), link the Japanese authorities' policy response to this emerging asset bubble to the macro landscape in the late 1980s. With the yen historically strong, output below potential, and inflation quiescent in 1986-88 during this first episode of *endaka fukyo*, there was no appetite to restrict monetary policy in the hope of moderating asset-price inflation. Such action would have risked further yen appreciation, and, as McKinnon and Ohno (1997) argue, the wealth effect of the bubble may have moderated the growth slowdown that otherwise would have occurred. The period was the first of several episodes in which Japan's macro policies, perhaps lagging "behind the curve," contributed to a sequence of destabilizing

exchange rate movements that ultimately worsened the bubble and its aftermath. These episodes will be discussed in greater detail below.

Figure 3 shows that, as far as the nominal exchange rate is concerned, the yen depreciated after late 1988 through mid-1990, then embarking upon a sharp appreciation trajectory that would culminate in a rate of 80 yen per dollar in April 1995. After depreciating again through late 1998, the yen reversed course and appreciated sharply through end-1999. Since then it has remained in a range of roughly 95 to 130 yen per dollar.

More relevant for assessing the competitiveness of Japan's exports is the yen's *real* exchange rate, shown in Figure 5 for the case of consumer-price deflators. (In this graph, as in Figure 2, a rise in the index is a real appreciation.) The cycles are similar to those for the nominal exchange rate, but some distinct trends are now apparent. Most importantly, after the April 1995 peak for the yen, there is a strong trend of real depreciation, whether the real exchange rate is measured in real effective terms or bilaterally against the dollar. The real depreciation trend is driven by the relatively higher inflation rates in Japan's trading partners over a period when Japan at times suffered from outright deflation. Our question is how these cycles and trends are driven by monetary policy actions as well as by the longer-run evolution of the Japanese economy.

Swings in the Real Yen Exchange Rate since 1988

Figure 5 suggests that the yen *real* exchange rate's history since 1988 can be divided into (at least) six periods, characterized by the following given changes in the extreme month-average *nominal* exchange rates against the dollar:

1. December 1988–April 1990: Depreciation (123 ¥/\$ – 158 ¥/\$).
2. April 1990–April 1995: Appreciation (158 ¥/\$ – 84 ¥/\$).
3. April 1995–August 1998: Depreciation (84 ¥/\$ – 145 ¥/\$).
4. August 1998–December 1999: Appreciation (145 ¥/\$ – 103¥/\$).
5. December 1999–July 2007: Depreciation (103¥/\$ – 122 ¥/\$).
6. July 2007–October 2008: Appreciation (122 ¥/\$ – 95¥/\$).

Taken in its entirety, the period after April 1995 has been one of distinct trend real depreciation. Between April 1995 and mid-2008, the yen depreciated in real effective terms (based on the CPI, and as a log difference) by 57 percent. For the bilateral yen/dollar rate, the corresponding real depreciation rate is 60 percent. As Figure 3 suggests, the yen's nominal value against the dollar has not changed greatly since mid-1996, yet the yen has depreciated markedly against the dollar in bilateral real terms as a result of the divergent inflationary trends in Japan and the United States.

Period 1. After the protracted appreciation period that followed the Plaza agreement, the yen appeared to stabilize early in 1988. That development was welcome and boosted the economy. The asset-price boom continued, however, and inflationary forces, which remained muted after a period of yen strength, were in fact gathering. (See Figure 6, which shows Japanese and U.S. core inflation. In this Figure, Japan's CPI is not

adjusted to remove the effects of the April 1, 1989 and April 1, 1997 increases in consumption tax.) Apparently unwilling to risk renewed appreciation, however, the Japanese authorities did not aggressively raise target interest rates (see Figure 5). Inflationary pressures were evident earlier in the U.S., however, and the Fed did respond with a series of interest rate hikes starting in the second half of 1988 (Figure 7).⁴ The yen started to depreciate late in 1988.

The Bank of Japan began to raise short-term interest rates in mid-1989. Core inflation was significantly higher by the spring of 1990 – by which time the price-level effects of the April 1989 consumption tax increase are no longer distorting the data in Figure 6. Yen depreciation continued. Even after the stock market peaked late in 1989 and the yen hit bottom in April 1990, and with Japanese and U.S. long-term real interest rates close once again, the BOJ continued to tighten short rates. Around that time Japanese inflation also took a ratchet-step upward.

Why did the yen depreciate through April 1990 and not begin to appreciate sooner after Japanese monetary policy began to tighten? One possibility is that falling Japanese equity prices prompted an international portfolio shift out of yen. It may also be that the markets had some doubts about the willingness of the BOJ, not a formal inflation targeter, to do what was necessary to keep inflation down. As the policy interest rate continued to climb, however, markets became convinced that the BOJ meant to limit

⁴ The “Record of Policy Actions of the Federal Open Market Committee,” Meeting of May 17, 1988 (<http://www.federalreserve.gov/monetarypolicy/fomchistorical1988.htm>), noted that “consumer and producer prices have risen more rapidly recently. In addition, labor costs increased substantially in the first quarter.”

inflation. At this point, Japanese long-term real interest rates had generally been above U.S. rates for some time (Figure 2).⁵

Period 2. With long-term Japanese real interest rates exceeding those of the U.S. in the spring of 1990, and Japanese short-term rates continuing to rise, the yen began to appreciate sharply. In the last quarter of 1990 the Japanese long-term nominal interest rate fell below the overnight rate, which stood at better than 8 percent throughout the first quarter of 1991. The sharp reversal in interest-rate policy that began in the spring of 1991 moderated the pace of yen appreciation but did not induce depreciation. One reason was that the U.S. monetary tightening cycle had peaked in the fall of 1990, and U.S. policy rates were falling rapidly from the end of the year. The Fed's view was that, despite the possible inflationary effects of a rise in oil prices, U.S. real activity was slowing.⁶ By the final quarter of 1991, the Japanese economy was suffering the coincidence of a strengthening currency, uncomfortably high inflation, and asset-price collapse. In 1991, Japan's real GDP growth slowed whereas the U.S. entered a mild recession. As U.S. growth recovered in 1992, however, Japan's slowed further and it remained low in 1993. In 1994, Japanese growth turned sharply negative (Figure 8).

Contributing to poor growth performance was a sharp upward movement of the yen (roughly 25 percent) between mid-1992 and the last quarter 1993. This was the start of the second great episode of *endaka fukyo*. At this point U.S. inflation had largely stabilized but Japanese inflation was falling. Inflation expectations may therefore have played some role in the yen appreciation over 1992-93, but from a macro perspective the

⁵ Clarida and Waldman (2008) show that the response of exchange rates to inflation news has been quite different as between inflation-targeting central banks and non-targeters (such as the BOJ and the Fed).

appreciation remains puzzling. It seems likely, however, that U.S.-Japan trade tensions created expectations that the Japanese authorities would not allow the yen to depreciate far. This is the interpretation favored by McKinnon and Ohno (1997). In January 1992, President George H. W. Bush visited Japan and secured commitments to specified increases in imports of autos and auto parts from the U.S.⁷ The election of the Democratic Clinton administration in November 1992 may well have raised expectations of a more confrontational trade stance by the U.S. Coupled with Japan's slow growth, U.S. recovery was leading to an expansion in American imports from Japan, and this, paradoxically, added to the tense atmosphere regarding trade.

As Japan's short-term interest rate fell and the Fed kept short-term rates on hold, the yen stabilized, but a renewed appreciation episode started in mid-1994, just as the yen overnight interest rate stopped falling and began to inch upward. Between June 1994 and April 1995, when the yen reached its all-time peak, the yen appreciated by 12.5 percent (log points) in real effective terms and by 18 percent (log points) in real terms against the dollar. This episode has puzzled observers, as it occurred when the Japanese economy was already quite weak and about to fall into deflation.

As of early 1994, however, private and policy forecasts discerned signs of recovery, and indeed, at that point the long-term yen nominal interest rate began to move up. Ahearne and others (2002, p. 17) quote the BOJ *Quarterly Bulletins* for May and November 1994 as pointing, respectively, to stabilization of the economic growth rate and to strength in "all categories of spending...." Short-term interest rates remained on

⁶ See The "Record of Policy Actions of the Federal Open Market Committee," Meeting of November 13, 1990 (<http://www.federalreserve.gov/monetarypolicy/fomchistorical1990.htm>). The average price of crude petroleum doubled temporarily between the summer and fall of 1990 as Iraq invaded Kuwait in August.

hold, however, and with the fundamentals of the economy in reality deteriorating, it is possible, as Ahearne and others (2002, p. 18) suggest, that the market real interest rate rose above the natural rate, prompting the sharp yen appreciation of early 1995. This result is consistent with the prediction of equation (3). The sharp appreciation itself, coupled with the Kobe earthquake and falling equity prices, helped snuff out a possible of economic recovery. Early in 1995, headline CPI inflation, which had risen slightly toward the end of 1994, dropped to around zero. Core inflation also was low and declining (Figure 6).

Period 3. In April 1995, a series of dramatic policy interventions, carried out by both Japanese and foreign authorities, initiated a new, long-term weakening trend for the yen. The BOJ discount rate was slashed and the yen overnight interest rate fell dramatically, reaching a level of about 0.5 percent by the fall of 1995. As described by McKinnon and Ohno (1997, pp. 226-8), the U.S. eased mercantile pressures and Japan, while several countries carried out joint interventions to support the dollar in currency markets. The Japanese authorities had purchased dollars in unilateral official intervention operations on 21 days in March 1995 as the yen continued to rise. They intervened on eight more days between April 3 and 18, purchasing about \$500 billion for the month.

Nominal long-term interest rates in Japan fell dramatically as expectations of low growth and low inflation took hold. As Figure 2 shows, Japan's long-term real interest rate fell far below that of the United States. From a level of around 4.2 percent per year in March 1995, the nominal 10-year JGB rate fell to a low of around 0.9 percent in the fall of 1998. Not only did Japanese nominal long-term rates rise after that point, but also,

⁷ This visit may best be remembered as the one in which President Bush, at a state dinner, vomited into Japanese Prime Minister Miyazawa's lap.

accelerating Japanese CPI deflation had started to cause the long-term *real* Japanese interest rate to start trending upward. Even before that point, U.S. short and real long-term rates had started to decline in the aftermath of the Asian financial crisis. Eventually those factors halted the yen's depreciation.

Because a number of East Asian countries pegged their currencies to the dollar as of 1995, the yen's depreciation from its height made those countries' export sectors less competitive. Some observers argued that this was a contributing factor behind the 1997-98 Asian crisis.

Period 4. It was in August 1998 that the yen's next phase, a real appreciation cycle, began. During this period, Japan's real long-term interest rate rose relative to that in the United States. In Japan the overnight interest rate stood at just under 0.5 percent and would fall effectively to zero within a year, but in the presence of deflation expectations, yen appreciation continued. At the point when the zero lower bound was reached late in February 1999, the BOJ had no further ability to lower the short-term nominal interest rate. By the end of 1999, Japanese and U.S. real long-term interest rates were again very close, and the upward trend in the (negative) Japan-U.S. differential had ceased (Figure 2), in part because U.S. headline inflation had moved upward.

Over the entire period from August 1998 to December 1999, the yen appreciated in real effective terms by 29.8 percent and in real bilateral terms against the dollar by 31.2 percent.

Period 5. In the subsequent long real depreciation phase, a falling yen price level reinforced the yen's nominal depreciation against the dollar. The yen fell sharply in real terms through the end of 2001 as Japan's relative real interest rate fell. From August 2000

to March 2001 the BOJ moved policy interest rates above zero, having perceived signs of recovery despite a core inflation rate that remained negative (Ito and Mishkin 2006, pp. 145-6). This move caused a small temporary strengthening of the yen, but economic activity slowed and deflation accelerated.

The yen stabilized and even rose (against the dollar) after early 2002 as Japan's real interest rate rose toward the U.S. level (Figure 2), but depreciation returned early in 2005 despite a relative Japanese real interest rate that continued to rise for several months (part of the Greenspan "conundrum" period).

Hamada and Okada (2007) argue that the yen would have appreciated far more in 2003-04, crippling Japanese recovery, if not for the energetic dollar purchases carried out by Japan's Ministry of Finance under Vice Minister Zembei Mizoguchi. Between January 2003 and the end of March 2004, the MOF sold ¥35,256.4 billion for dollars in the foreign exchange market.⁸ Ito (2004) discusses the rationale and context for these interventions in detail and suggests that while they could have had a weakening effect on the yen of up to 13 percent compared to the counterfactual of no intervention, it is also possible that their effects were mostly temporary. In any case, the Fed had begun to tighten U.S. monetary conditions in mid-2004 in the face of mounting inflation pressure (Figures 5 and 6). From April 2005 Japanese long-term real rates began to fall compared to the U.S., and yen depreciated accelerated.

On July 15, 2005, the BOJ definitively ended its zero-interest policy regime (Figure 5). Even with some signs of Japanese recovery and Japan's relative real long-

⁸ See Ministry of Finance Japan, "Foreign Exchange Intervention Operations," <http://www.mof.go.jp/english/e1c021.htm>.

term interest rate rising, yen depreciation continued through July 2007. It could be that markets perceived unusually high risks in a period of monetary policy transition.

Period 6. Yen behavior during this period is dominated by Japan's emergence as a relative safe haven in a period of global financial market crisis. Paradoxically, the weakness of Japan's financial system over prior years may have deterred Japanese institutions from overextending themselves during the 2000s, unlike institutions in Europe and especially the United States. Japanese institutions, unlike many in Western Europe, had relatively little exposure to eastern Europe and Latin America, so the yen strengthened sharply in the fall of 2008 as emerging markets and some industrial countries came under financial pressure.

Yen Movements over the Long Run

Movements in relative real long-term interest rates offer some insight into short-term exchange rate dynamics, but it is also likely that perceptions of long-run real exchange rates changed over the period following the collapse of Japan's asset bubble. We would like to understand whether and when such changes in long-term perceptions occurred, and a related challenge is to explain the observed long-term trends in the yen's real exchange rate. I now turn to the question of long-term changes in the yen and their relationship to underlying economic fundamentals.

The Harrod-Balassa-Samuelson Approach

Perhaps the most fundamental benchmark model for thinking about real exchange rates is the Harrod-Balassa-Samuelson (HBS) model (see Rogoff 1992; Asea and Mendoza 1994; or Obstfeld and Rogoff 1996, Chapter 4). The model posits economies with two sectors, tradable and nontradable goods. In essence, the real exchange rate depends on the international “difference in differences” between the economies’ tradable-sector and nontradable-sector productivity growth rates.

To understand the HBS approach, let P be Japan’s consumer price level and P^* that of the United States, with E the price of yen in terms of dollars. Then the real exchange rate of the yen against the dollar (defined so that an increase is a relative real depreciation of the yen) is $q = EP^*/P$. In this notation, a rise in E (nominal yen depreciation) or rise in P^*/P (fall in Japan’s relative money price level) lowers the price of consumer goods in Japan compared to the U.S.

Each country’s consumer price level, in turn, depends on the domestic price indexes for tradable and nontradable goods, denoted P_T and P_N for Japan and P_T^* and P_N^* for the United States. In general, as shown by Obstfeld and Rogoff (2007, p. 356), a useful approximation for the change in the log yen real exchange rate is

$$\Delta \log q \approx (1 - \gamma) \Delta \log \left(\frac{P_N^* / P_T^*}{P_N / P_T} \right) + \Delta \log \left(\frac{EP_T^*}{P_T} \right), \quad (4)$$

where γ is the share of tradables in the CPI (the same in the two countries). This equation discloses the two main determinants of the real exchange rate: the international ratio of relative nontradables prices, and the relative international price of tradables.

The HBS theory presumes that the law of one price holds for every tradable good and that consumers in the two countries have identical preferences over the tradable goods. Thus, $EP_T^* = P_T$, so that the HBS theory operates entirely through the determination of the relative price of nontradables in terms of tradables. There is considerable evidence, however, that relative international tradables prices vary greatly, at least for some country pairs and over some horizons. Moreover, they tend to covary positively and strongly with nominal exchange rates, so that nominal yen depreciation, for example, raises the price level of tradables in Japan relative to tradable price levels abroad. For Japan, the terms of trade broadly mirror the evolution of the exchange rate, with nominal (and real) yen depreciation generally associated with deterioration in Japan's terms of trade – a rise in import price relative to export prices. I tentatively put this evidence aside to focus on the HBS predictions about relative nontraded-goods prices, predictions that are broadly consistent with data from many countries.

Over a sufficiently long horizon – one in which goods prices are flexible and domestic factor markets can adjust to ensure the equality of factor rewards across sectors of the economy – relative productivity growth is a prime determinant of the first term on the right-hand side of equation (4). To see this, assume that outputs in the tradable and nontradable sectors are given by the constant-returns production functions of capital and labor:

$$Y_T = A_T F(K_T, L_T),$$

$$Y_N = A_N G(K_N, L_N),$$

where A_T and A_N measure total factor productivity (TFP).⁹ Let μ_{LT} denote labor's income share in tradables, μ_{LN} its share in nontradables, and \hat{x} the proportional rate of change of variable x . Furthermore, define the relative price of nontradables as $p \equiv P_N / P_T$. Proceeding as in Obstfeld and Rogoff (1996, Section 4.2.1), but allowing for the possibility that both the real (tradable) wage w and the real (tradable) return to capital r can change, log differentiation of zero-profit conditions, assuming firm optimization and free domestic factor mobility, yields

$$\begin{aligned}\hat{A}_T &= \mu_{LT} (\hat{w} - \hat{r}) + \hat{r}, \\ \hat{p} + \hat{A}_N &= \mu_{LN} (\hat{w} - \hat{r}) + \hat{r}.\end{aligned}\tag{5}$$

Combining these results in a relationship linking the change in the real exchange rate to relative TFP growth,

$$\hat{p} = \hat{A}_T - \hat{A}_N + (\mu_{LN} - \mu_{LT})(\hat{w} - \hat{r}).\tag{6}$$

In general, the change in p depends not only on the sectoral difference in TFP growth, but also on the evolution of the wage-rental ratio, with a rise in the latter raising p when nontradables are relatively labor intensive.¹⁰ If there are significant movements in relative factor rewards over time and intersectoral differences in functional income shares, then

⁹ It would be simple to include nontraded goods as an input to tradables (think of retailing services required to deliver tradables to final consumers). That change would not alter the main qualitative predictions concerning relative sectoral TFP and the relative price of nontradables, but it would place a wedge between different countries' price indexes for tradable consumption. That additional wedge would, however, depend mainly on relative nontradables prices.

¹⁰ One could solve for the endogenous wage-rental ratio in terms of exogenous variables by imposing further structure on the consumption side and assuming a balanced growth path, as Asea and Mendoza (1994) do, but at the cost of restricting generality. For my purposes it is not necessary to follow that route. In the context of a growth model, and assuming a balanced growth path with a constant marginal product of

capital r , equation (5) would imply that $\hat{w} = \hat{A}_T / \mu_{LT}$. Accordingly, (6) implies $\hat{p} = \left(\frac{\mu_{LN}}{\mu_{LT}} \right) \hat{A}_T - \hat{A}_N$. This is the formula in Obstfeld and Rogoff (1996, Chapter 4) for the case of a constant world real interest rate.

the relation between the relative price of tradables and sectoral TFP growth rates may not be straightforward. Evolution in the relative price of nontradables will depend exclusively on differential TFP growth only in very special cases, for example, when sectoral factor shares are the same.

One way to circumvent the problem is to focus on labor productivity rather than total factor productivity, as Canzoneri, Cumby, and Diba (1999) do. That approach potentially confounds exogenous long-term TFP movements with demand-side factors, but it has a number of countervailing advantages, as Canzoneri, Cumby, and Diba show.

To understand their approach, observe that along the economy's long-run production possibilities frontier, p equals the ratio of labor's marginal physical productivity in tradables to its marginal physical productivity in nontradables. Let $f(k_T) \equiv F(K_T/L_T, 1)$ and $g(k_N) \equiv G(K_N/L_N, 1)$. Under the tentative assumption that *marginal* labor products are proportional to *average* labor products, one can therefore write

$$p = \frac{A_T [f(k_T) - f'(k_T)k_T]}{A_N [g(k_N) - g'(k_N)k_N]} = \frac{\varphi A_T f(k_T)}{\psi A_N g(k_N)}$$

for suitable constants φ and ψ . Log-differentiating this expression, one finds that

$$\hat{p} = \hat{A}_T + (1 - \mu_{LT}) \hat{k}_T - [\hat{A}_N - (1 - \mu_{LN}) \hat{k}_N].$$

Here, $\hat{A}_T + (1 - \mu_{LT})\hat{k}_T$ is the growth rate of (average) labor productivity in tradables (in contrast to TFP in tradables), whereas $\hat{A}_N + (1 - \mu_{LN})\hat{k}_N$ is the growth rate of labor productivity in nontradables. (In general, labor productivity growth rates exceed TFP growth rates when there is capital deepening over time.)

The earlier tentative assumption that marginal and average labor products coincide can hold true only if the last equation is the same as equation (6). Let σ_T and σ_N be the elasticities of factor substitution in the traded and nontraded goods sectors. Then one can express the last equation in terms of factor-price changes as

$$\hat{p} = \hat{A}_T + (1 - \mu_{LT})\sigma_T(\hat{w} - \hat{r}) - \left[\hat{A}_N - (1 - \mu_{LN})\sigma_N(\hat{w} - \hat{r}) \right].$$

This equation is valid – that is, it agrees with equation (6) – when (and only when) $\sigma_T = \sigma_N = 1$. Thus, for Cobb-Douglas production functions, the long-run relative price of nontradables depends exclusively on differential labor-productivity growth in nontradables and tradables. I will assume that Cobb-Douglas production functions adequately represent Japanese industry.

Below I explore the relationship between the preceding labor productivity differential and the yen's real exchange rate. One point to notice, however, is that for the tradable and nontradable sectors, short-term movements in labor productivity and TFP are very highly positively correlated. The six panels of Figure 9 (a through f) illustrate this correlation for the tradable and nontradable sectors of Japan, the United States, and Germany. Productivity growth rate data are from the EU KLEMS database (<http://www.euklems.net/>, March 2008), and sectoral productivity figures are constructed

from less aggregated industry figures using a Törnqvist index with value-added weights.¹¹ As an example, for Japanese tradables the contemporaneous correlation coefficient between labor productivity and TFP growth rates is 0.95; for Japanese nontradables the corresponding correlation coefficient is 0.94. Note that, as the HBS literature suggests, productivity growth in tradables is generally higher than that in nontradables, with the implication that the relative price of services should rise secularly.

Evidence on HBS and Its Component Sub-theories

For much of its postwar history Japan was a poster-child for the HBS theory. In an early study, Hsieh (1982) derived a one-factor version of the HBS theory and tested it on labor productivity data for Japan and Germany versus aggregates of major trading partners. For his study, tradables were defined as manufacturing and nontradables as nonmanufacturing. The theory received support for both countries, but over a sample period (1954-1976) containing very few observations from the post-1973 floating exchange rate era. As I argue below, however, deviations from the HBS model are likely to be larger and more persistent under floating exchange rates.¹²

Marston (1987) offered the first detailed study of Japan based on a substantial span of data from the floating exchange rate period (1973-1983). Marston found that in the U.S. over that period, tradables productivity growth exceeded that in nontradables by 13.2 percent. For Japan, he found that the same cumulative differential was 73.2 percent.

¹¹ Tradables consist of agriculture, hunting, forestry, and fishing; mining and quarrying; total manufacturing; and electricity, gas, and water supply. Nontradables consist of construction; wholesale and retail trade; hotels and restaurants; transport, storage, and communication; finance, insurance, real estate, and business services; public administration and defense; compulsory social security; education, health, and social work; and other community, social, and personal services.

¹² Hsieh's findings in support of HBS went against previous negative cross-section work reported by Officer (1976).

Japanese relative nontradables prices rose by 56.9 percent as opposed to only 12.3 percent in the U.S. The yen appreciated significantly against the U.S. dollar in real terms. These results seemed strikingly to confirm the HBS approach.¹³

Subsequent research has focused on larger samples of countries. De Gregorio, Giovannini, and Wolf (1994), using the newly assembled OECD sectoral database for 1970-85, showed a strong relationship between differential sectoral TFP growth and the growth of relative nontradables prices for a sample of 14 countries including Japan. They did not look explicitly at real exchange rates. Asea and Mendoza (1994) reached similar conclusions regarding relative sectoral prices levels within the OECD sample, but found that TFP differentials were much less useful in understanding even low-frequency movements in real exchange rates.

That failure is not surprising in view of equation (4), as a major role in movements of the real exchange rate, alongside that of relative sectoral prices, is played by the relative international price of tradables. Under floating exchange rates, the latter relative price is highly correlated with the nominal exchange rate in the short run, and hence is much more volatile than either of the relative prices p and p^* that enter the first right-hand term in (4). The volatility in relative international tradables prices, to some degree, reflects widespread violations of the law of one price; it also reflects terms of trade changes (given international differences in consumer preferences) as well as the nontradable content of final “tradable” consumption goods. Engel (1999) argues that even

¹³ In a related vein, Yoshikawa (1990) claimed an important role for relative labor productivities in determining the long-run nominal yen/dollar exchange rate over 1973-87. Yoshikawa’s model assumed an average law-of-one-price relationship for tradables, and allowed for changes in the relative price of energy inputs. Rather than focusing on relative productivity in nontraded and traded sectors, however, Yoshikawa’s model focuses on the relative importance of labor and energy in producing export goods. I do not consider energy costs below. Energy costs in effect work like a global technology shock for energy

over longer horizons, variation in the relative international prices of *tradables* dominates real exchange rate movements of the United States dollar. Were Hsieh's (1982) tests to be carried out over post-1973 data, it seems certain that any measured effects of intersectoral productivity differentials would be swamped by the influence of nominal exchange rate movements.¹⁴

Many recent studies employ error-correction models to look for cointegrating relationships among real exchange rates and the other variables that underlie the HBS model. The basic presumption of these models is that real exchange rates contain unit roots. While the unit-root hypothesis has proved difficult to reject in the spans of data that are typically used, the question of mean reversion in real exchange rates in fact remains quite open, with many researchers believing in some degree of slow mean reversion, a belief derived in part from the analysis of longer time series samples. Thus, Taylor and Taylor (2004, p. 154) describe as a "consensus view" the propositions "that short-run PPP does not hold, that long-run PPP may hold in the sense that there is significant mean reversion of the real exchange rate, although there may be factors impinging on the equilibrium exchange rate through time" It should be kept in mind that the statistical tests described next all rely on the hypothesis that real exchange rates and their determinants are $I(1)$ random variables,

Retaining a focus on the OECD sectoral data but working in terms of labor productivity as noted above, Canzoneri, Cumby, and Diba (1999) looked separately at the two components of the HBS model: the ability of sectoral productivity differences to

importers, and can influence long-term real exchange rates to the extent that energy input shares differ across sectors and countries.

¹⁴ Park and Ogaki (2007) caution, however, against drawing long-run implications from data samples of the size that Engel uses.

explain the relative price of nontradables in terms of tradables, and the validity of purchasing power parity (PPP) with respect to indexes of tradables prices. Using 1970-1993 data, carry out a panel cointegration analysis aimed at ascertaining long-run dynamic features of the data record. They found that relative sectoral prices and relative productivities were cointegrated with a coefficient near 1.0.¹⁵ However, nominal exchange rates against the U.S. dollar were not cointegrated with tradables prices relative to those of the U.S. Interestingly, the hypothesis of PPP for tradables fared much better when Germany rather than the United States was used as the comparison country. Kakkar and Ogaki (1999), also using cointegration techniques, explicitly studied long-run comovements in real exchange rates and relative nontradables prices. Their long data sample, ranging from as early as 1929 to the late 1980s, contained several spans with fixed exchange rates. Particularly in floating-rate data, they found mixed support for a close long-run relationship between relative nontradables prices and real exchange rates.¹⁶ This is consistent, once again, with a large role for nominal exchange rate movements in driving deviations from PPP for tradable goods.

A number of studies focus explicitly on real exchange rates of East Asian countries. Some authors, such as Chinn (2000, p. 20), argue that “The East Asian economies are exactly the type for which Balassa posited the relevance of the HBS effect: economies characterized by rapid growth, presumably due to rapid manufacturing—and hence traded—sector productivity growth.” Ito, Isard, and Symansky (1999), Drine and Rault (2003), and Thomas and King (2004), however, all find mixed evidence concerning the HBS theory. Chinn (2000) himself studies the bilateral real exchange rates of a group

¹⁵ Kakkar (2003) established the same result for a model based on TFP measures.

of nine East Asian countries, including Japan and China, against the U.S. dollar. He finds that for Japan, Malaysia, and the Philippines, the real exchange rate is cointegrated with relative sectoral labor productivities based on a 1970-93 sample. He notes, however, that real exchange rates display protracted swings away from the levels predicted either by relative nontradables prices or by relative productivity levels. Kakkar and Yan (2006) assemble a disaggregated data set of TFPs for Hong Kong, Indonesia, Korea, Malaysia, Singapore, and Thailand. They find that in panel data, real exchange rates appear cointegrated with relative sectoral productivity differentials, but whereas long-run PPP for tradables appears reasonable when East Asian currencies are compared to the yen, it fails when the dollar is the comparison currency. This difference could result from the closer trading linkages among the East Asian countries, including Japan.¹⁷ Choudhri and Khan (2005) present a panel study of 16 emerging market countries, including some in East Asia, over 1976-94. They find that bilateral real exchange rates against the dollar are related to relative nontraded goods prices and that the latter are, in turn, related to relative labor productivity as the HBS theory suggests, but they do not test directly for a link between real exchange rates and relative sectoral productivity differences. They also find a role for the terms of trade in determining real exchange rates.

The body of evidence on the HBS theory indicates a definite connection between international differences in relative sectoral productivity levels and international differences in the price of nontraded in terms of traded goods. The connection seems

¹⁶ Similarly mixed evidence is found by DeLoach (1997), who uses CPI/WPI ratios to proxy relative nontradables prices.

¹⁷ Kakkar and Yan (2006) combine the equations in (5) by eliminating $\hat{w} - \hat{r}$ rather than \hat{r} . The result is

$$\hat{p} = \frac{\mu_{LN}}{\mu_{LT}} \hat{A}_T - \hat{A}_N + \left(\frac{\mu_{LT} - \mu_{LN}}{\mu_{LT}} \right) \hat{r},$$

rather than equation (6). The authors then work with the level form of

valid whether productivity is measured by output-labor ratios or by TFP. Direct linkages between productivity variables or relative price variables and real exchange rates is more tenuous, especially under floating nominal exchange rates, because of large and persistent deviations from purchasing power parity for tradables; see equation (4). These deviations may limit the usefulness of the HBS theory for explaining or predicting real exchange rates over all but the longest horizons. PPP for tradables – and therefore the HBS connection between relative productivity levels and real exchange rates – may hold more closely for pairs of countries with relatively extensive mutual trading links.

Sectoral Productivity and the Yen's Real Exchange Rate

A real yen appreciation caused by high productivity growth in tradables would not undermine the competitive position of Japanese exporters. The available evidence indicates, however, that at least in the short run, episodes of sharp yen appreciation have indeed harmed the fortunes of Japan's manufacturing exporters, with negative implications for overall Japanese economic growth (as suggested by Figure 1). Dekle and Fukao (2008) document how the yen's 1985-95 appreciation raised average costs levels in Japanese industries relative to those in the United States.

A first regularity to examine is the short-run relationship between real exchange rate movements and changes in the HBS relative productivity variable, which I define in terms of relative labor productivity as $\hat{Y}_T - \hat{L}_T - (\hat{Y}_N - \hat{L}_N) - [\hat{Y}_T^* - \hat{L}_T^* - (\hat{Y}_N^* - \hat{L}_N^*)]$. In practice, I take the “starred” foreign country to be either the U.S. or Germany. Figures 10a and 10b plot the data, which show no evidence of short-run positive correlation.

this equation under the hypothesis that the real return to capital, r , is an $I(0)$ random variable. Their

Indeed the sample correlation coefficients are slightly negative, equal to -0.14 for the comparison with the U.S. and to -0.16 for the comparison with Germany. These short-term comovements are the opposite of what the HBS theory predicts as a longer-term correlation.

In the short term, when prices are sticky and factors are immobile between sectors, real yen appreciation reduces the demand for Japanese exports and puts downward pressure on exporters' profit margins. This account is consistent with the evidence in Dekle and Fukao (2008). The appreciation could result from monetary factors as discussed earlier, from changed perceptions of the long-run equilibrium real exchange rate, or from shifting risk premia. Faced with reduced demand, Japanese exporters react immediately by reducing levels of capacity utilization and working existing labor pool less intensely. These adjustments, in turn, lower measured productivity, whether measured as TFP or as labor productivity.

For the United States, Basu (1996) has made a compelling case that procyclical rates of factor utilization play the main role in explaining the observed high degree of procyclical overall productivity.¹⁸ His analysis uses data on material inputs effectively to track firms' use of capital and labor inputs. It would be interesting to use methods like Basu's to more closely isolate the exogenous technological shocks driving observed productivity movements in traded and nontraded sectors. The resulting data would deliver a sharper test of the HBS theory.

methodology obviously obliges them to supply labor-income shares in tradables and nontradables.

¹⁸ For a related analysis using Japanese data, see Vecchi (2000).

In Figures 10a and 10b, real exchange rate movements are more volatile than the contemporaneous movements in international relative productivity ratios. The latter are, however, still surprisingly large. A yen appreciation lowers demand for tradable goods and may raise the demand for nontradables. To the extent that slow growth in the export sector depresses overall demand, however, any resulting rise in the cyclical component of nontraded-sector productivity may be dampened. In fact, over 1978-2005, the correlation between changes in Japanese tradable and nontradable productivity is only 0.05, effectively zero.

An analysis of longer-term changes in productivity *levels* and real exchange rates gives a sense of whether the historical trends are consonant with the HBS theory. For this purpose, I use the log levels version of equation (4), taking $\gamma = 0.25$ and identifying the relative prices p and p^* with the tradables-to-nontradables labor productivity ratios. Figures 11a and 11b present the data for the comparison of Japan against the U.S. and Germany, respectively, over the nearly three decades from 1978-2005. Against the U.S., over this entire period, Japan experiences a small real depreciation and a small decline in the HBS relative intersectoral productivity variable. In the interim, however, the swings away from “Harrod-Balassa-Samuelson” parity are huge and persistent. On this metric, the yen was about 50 percent “undervalued” during the strong dollar of the Reagan years, and about 40 percent “overvalued” during the height of the mid-1990s appreciation, which pushed Japan into protracted deflation. The “overvaluation” of the first *endaka fukyo* of the late 1980s is comparatively small and briefer, as is the “overvaluation” that emerges after the Asian crisis (August 1998–December 1999, described as Period 4 above). In all of these episodes, often identified as misalignments, sharp movements in

the yen's nominal exchange rate were associated with commensurately sharp movements in relative international tradables prices. As in equation (4), those developments helped to drive the real exchange rate far from the HBS benchmark.

In most of the subperiods of the 1978-2007 span, the yen's evolution is in fact the opposite of what the HBS theory would imply. Furthermore, the relevant productivity trends seem quite minor in magnitude compared to the long swings in the exchange rate. Changes in real exchange rates are more volatile than changes in productivity, yet are quite persistent.

The bilateral real exchange rate of the yen against Germany puts the HBS theory in a better light. The real exchange rate still fluctuates about the HBS trend, but the departures are much smaller and less persistent than in the yen/dollar case. Notable examples of "misalignment" – in the narrow sense of a significant departure from the HBS trend – are the yen's real depreciation against the deutsche mark at the time of the second oil shock of the late 1970s, real appreciation in the mid-1990s (less pronounced than that against the United States), and a substantial real appreciation around the launch date of the euro in 1999.

An interesting question is why HBS seems to be more successful in explaining swings of the Japanese currency against Germany than against the United States. Canzoneri, Cumby, and Diba (1999) likewise found that convergence to PPP for tradables held more closely when they compared OECD countries to Germany, rather than the U.S. As the world's premier exporter, Germany's integration into global markets exceeds that of the larger and more insular United States economy. This may explain the greater apparent coherence between world and German tradables prices, which, in turn,

might reduce the size and persistence of departures from an HBS benchmark. An interesting general question is whether predictions of the HBS theory holds more closely for economies that are more open to international trade.

Conclusion

The recent history of the yen suggests prolonged departures from longer-run trends, especially with respect to the U.S. dollar. These departures cannot be explained reliably even after the fact, but they appear to be related to macroeconomic policy actions, both in Japan and abroad, and to market expectations of future policies.

In Japan's economic history after the generation and collapse of the great asset price bubble, the yen's strong real appreciation in 1990-95 stands out as a pivotal episode. From the point of view of the Harrod-Balassa-Samuelson theory, prior sectoral growth trends changed around this time, and it is doubtful that foreign exchange market participants were able to foresee these structural shifts. Against the United States, relative tradables productivity growth actually went into decline, whereas against Germany it leveled off, as Figures 11a and 11b show. To the extent that foreign exchange markets were mistakenly expecting a return to previous growth trends, the yen's real exchange rate could have been artificially high. Short-term monetary developments may have reinforced the latter stages of this appreciation, and trade tensions with the United States certainly played a role, as discussed above. In any case, the strong yen appreciation helped propel the Japanese economy into stagnation and deflation.

The yen's trend depreciation since early 1995 is more easily justifiable in terms of the underlying evolution of sectoral productivity growth and of overall growth in Japan and its trading partners. Real yen depreciation after 1995 has to some degree bolstered the economy through export promotion, though renewed trade friction with the United States remains a threat.

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Figure 1: Yen real exchange rate and Japan's growth

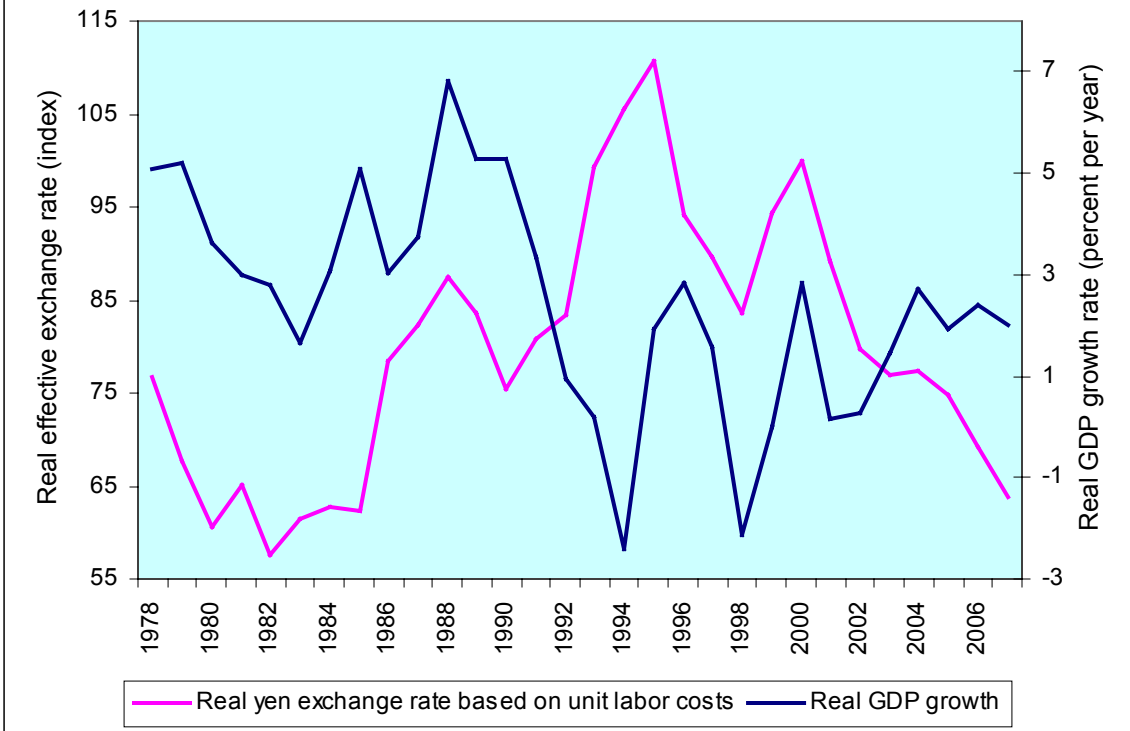


Figure 2: Japan less US: real long-term interest differential

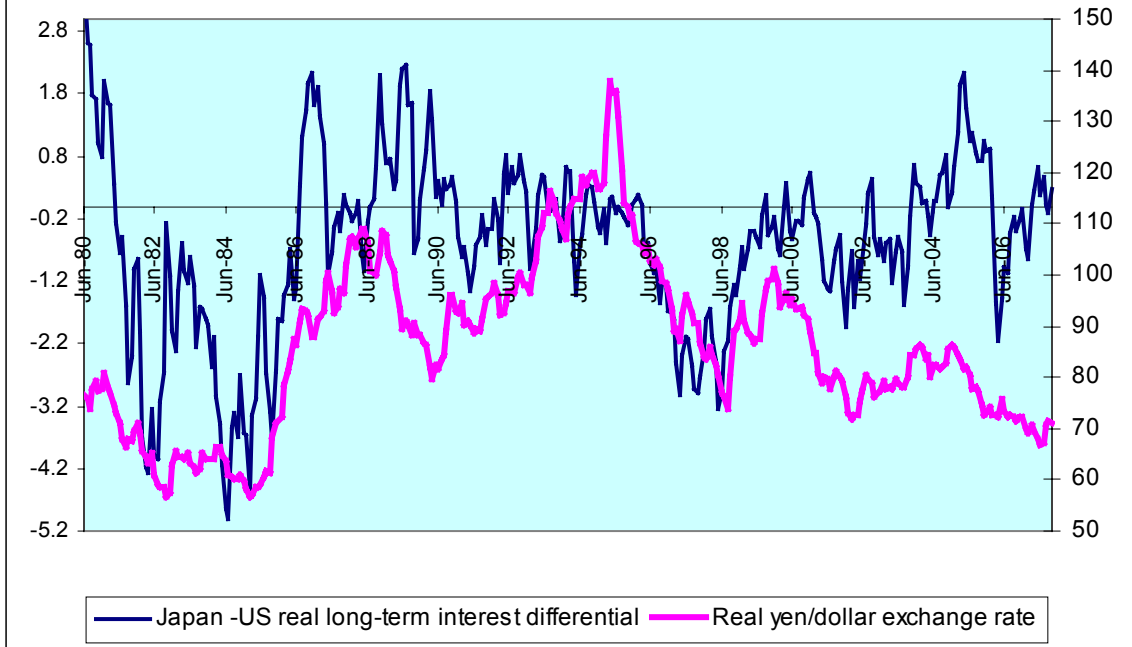


Figure 3: Yen/dollar nominal exchange rate



Figure 4: Yen nominal short-term interest and nominal exchange rate

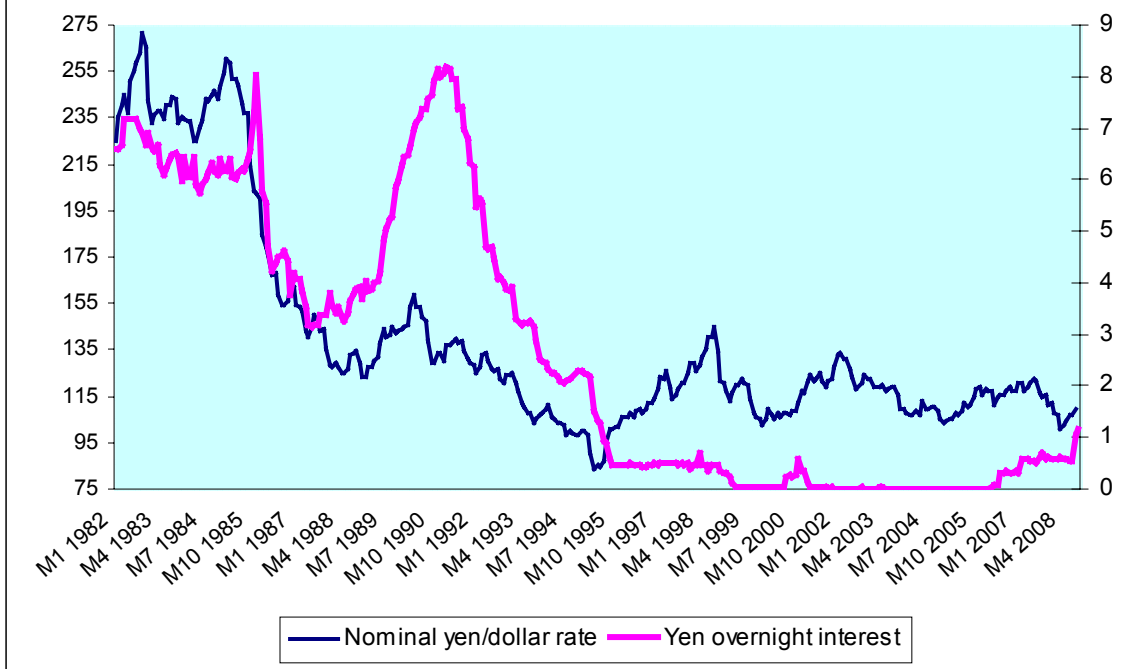


Figure 5: Yen/dollar real CPI exchange rates

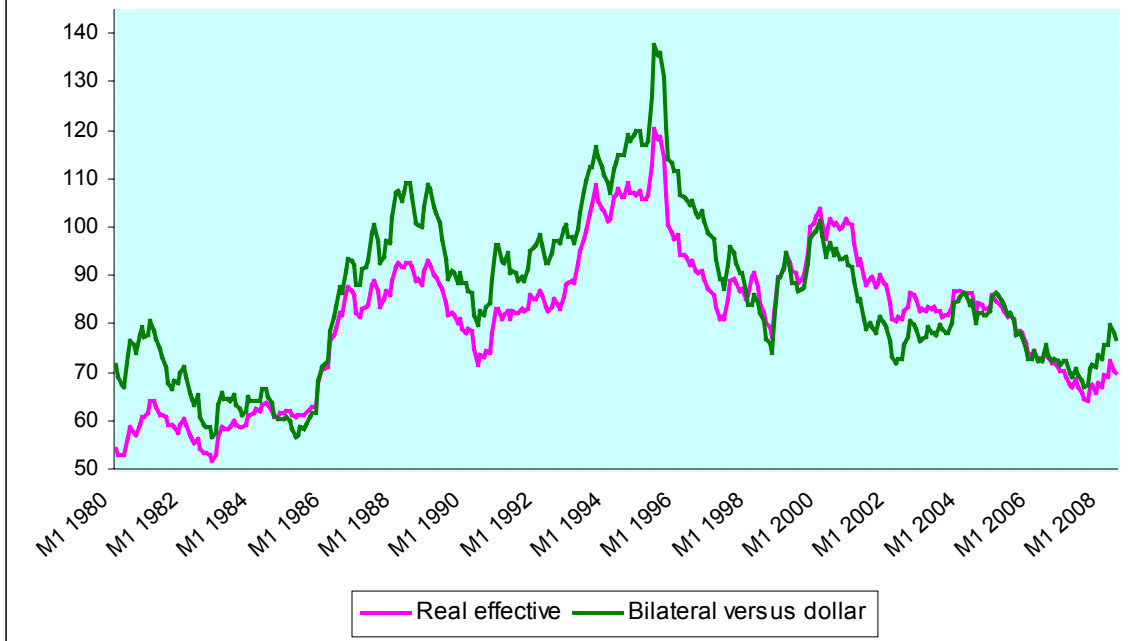


Figure 6: Japan and US Core CPI Inflation

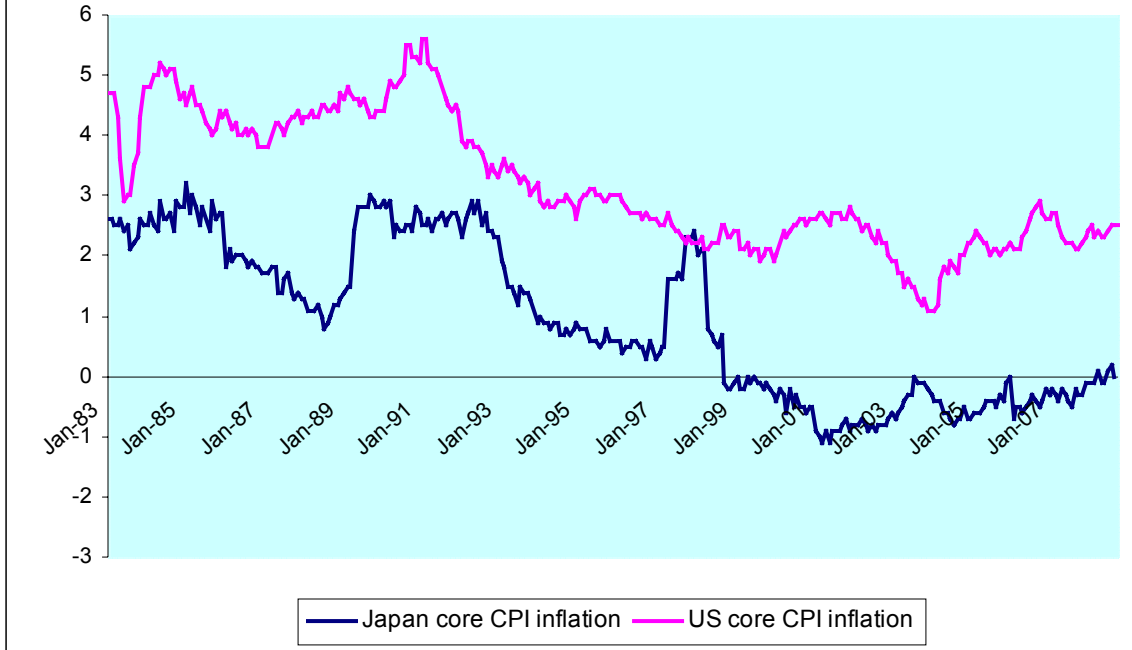


Figure 7: Dollar nominal short-term interest and nominal exchange rate

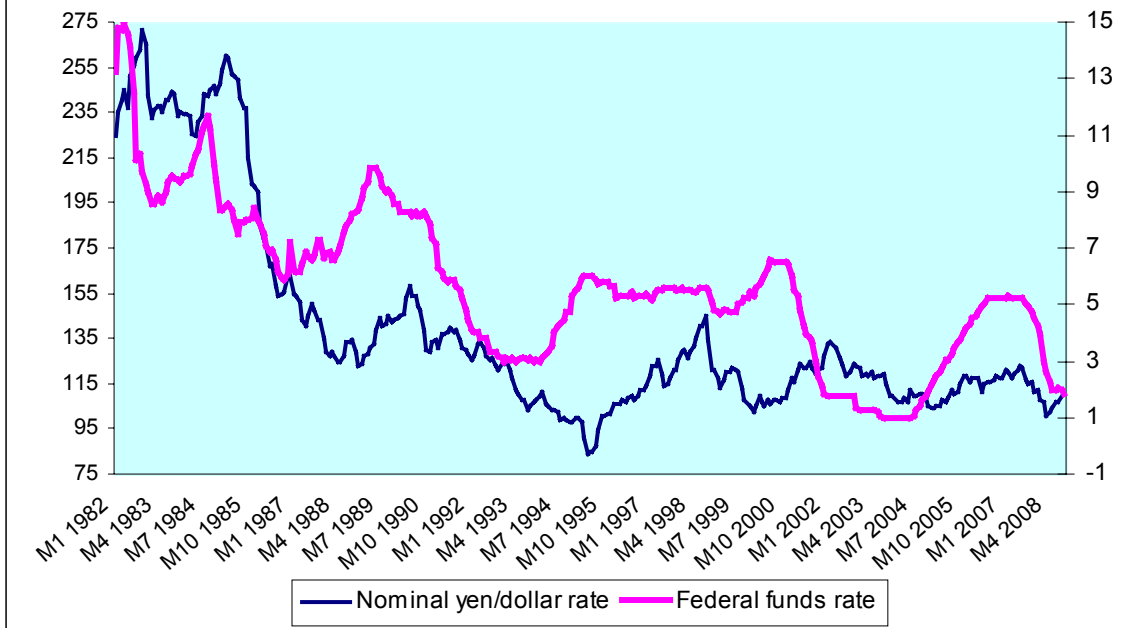


Figure 8: Japan and US Real GDP Growth Rates (percent per year)

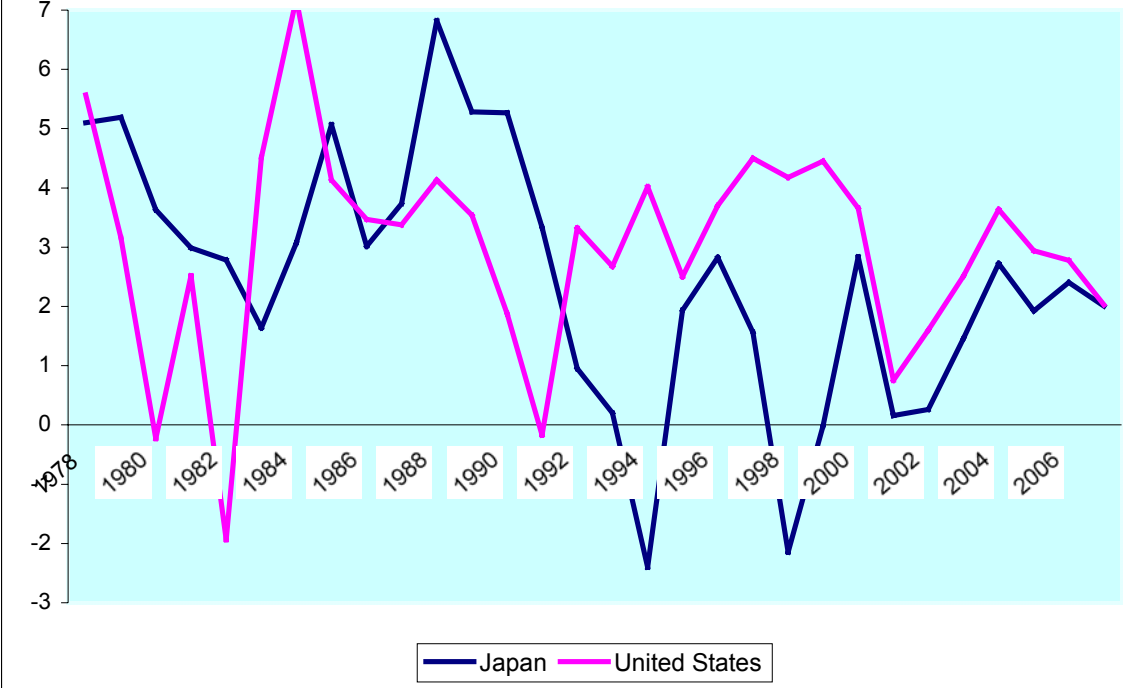


Figure 9a: Japan Tradables

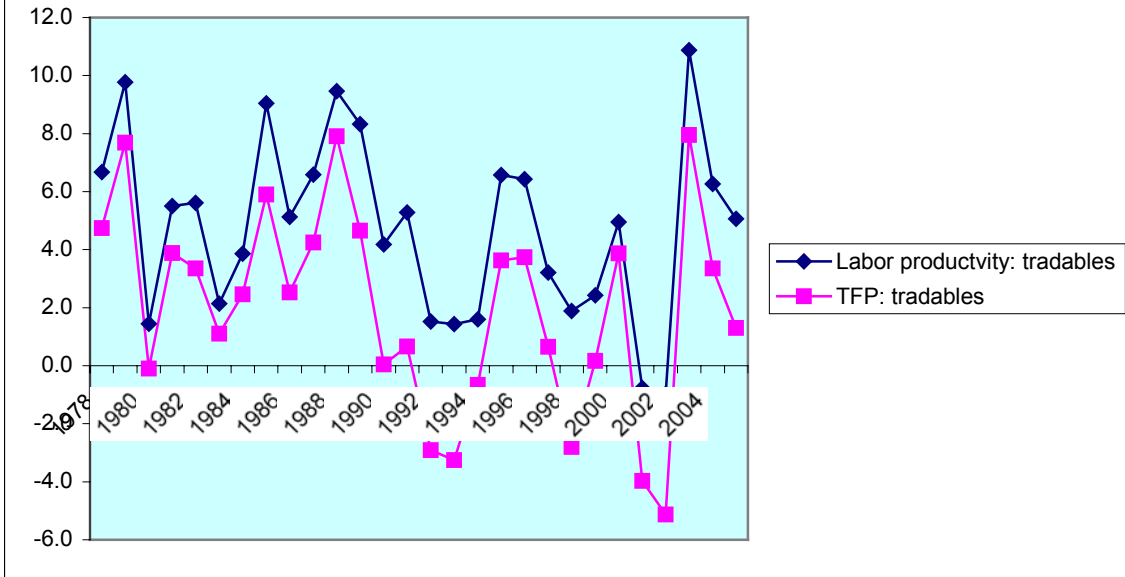


Figure 9b: Japan Nontradables

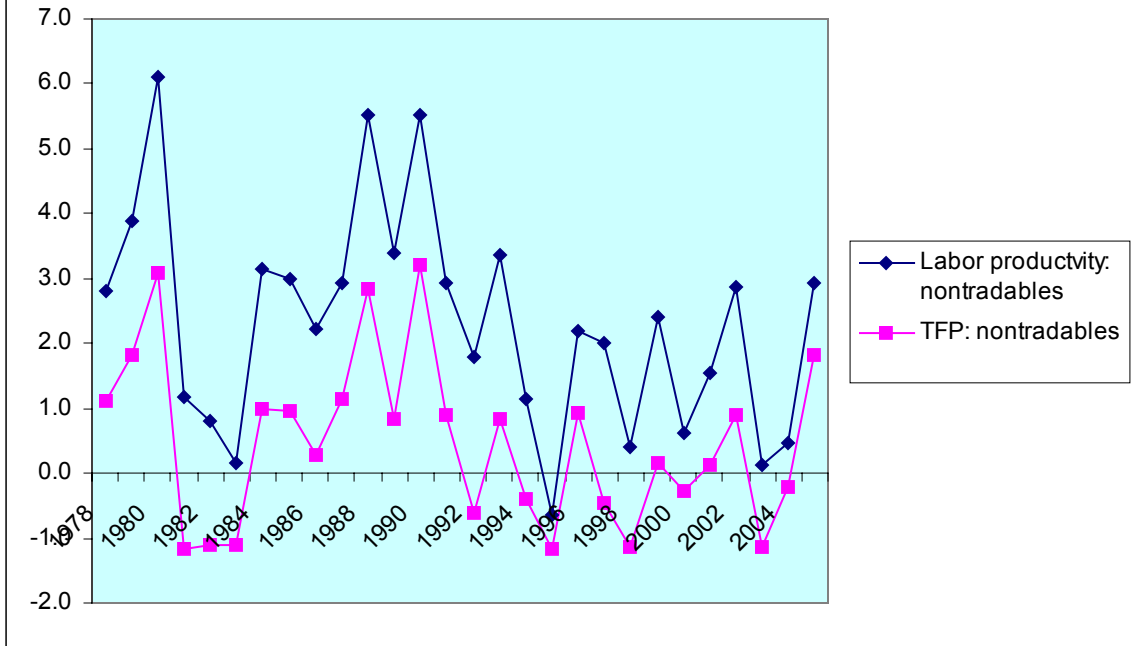


Figure 9c: United States Tradables

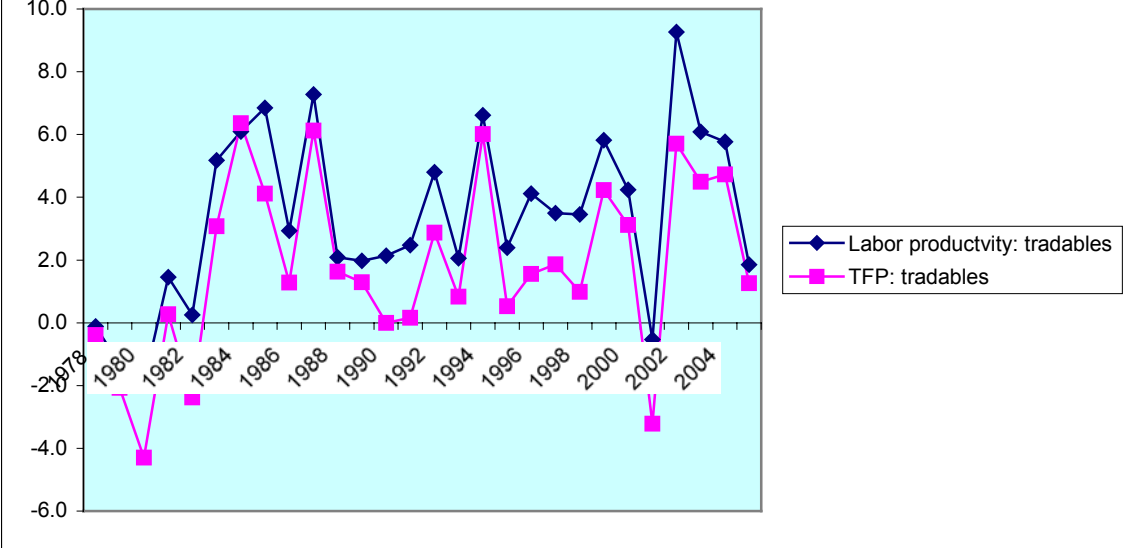


Figure 9d: United States Nontradables

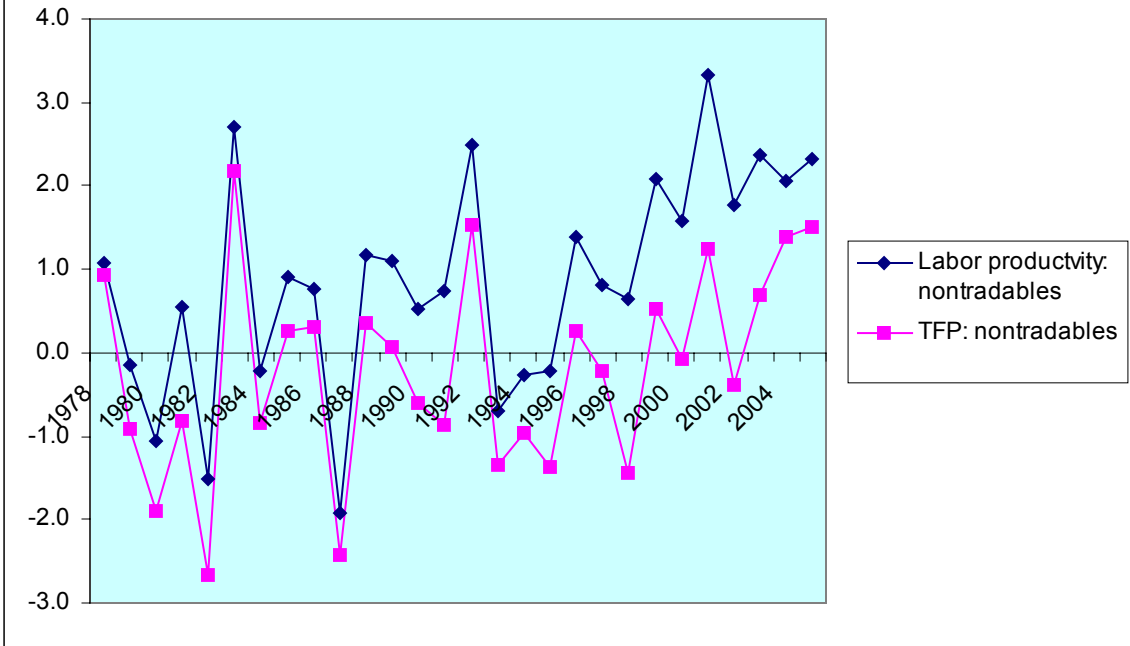


Figure 9e: Germany Tradables

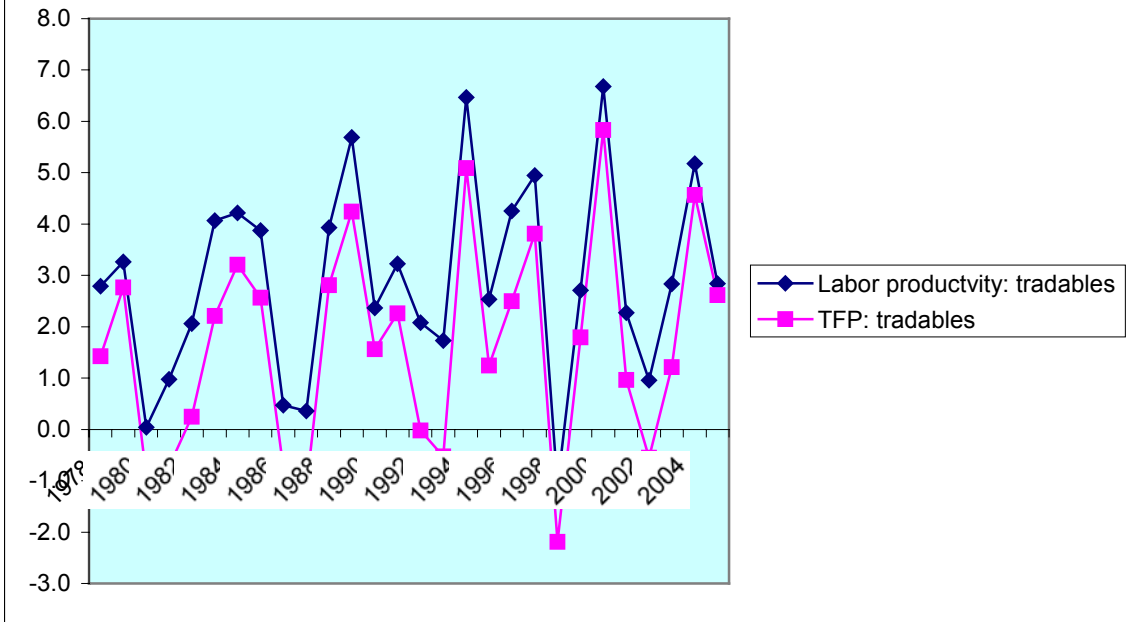


Figure 9f: Germany Nontradables

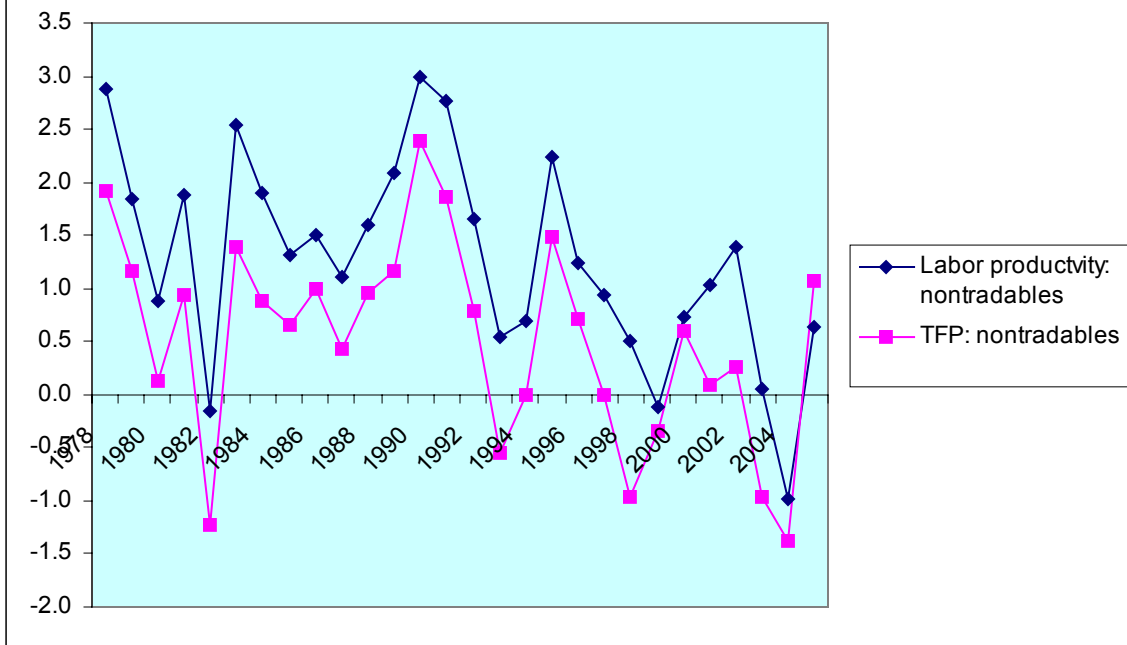


Figure 10a: Bilateral Japan/US Productivity Comparison and Real Exchange Rate: Percent Changes

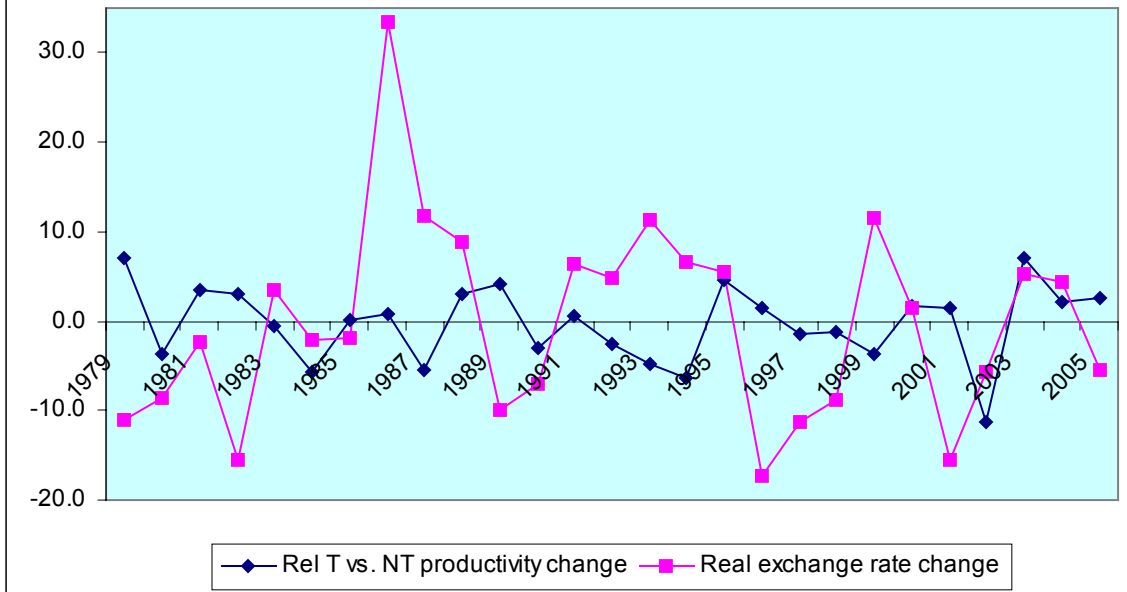


Figure 10b: Bilateral Germany/US Productivity Comparison and Real Exchange Rate: Percent Changes

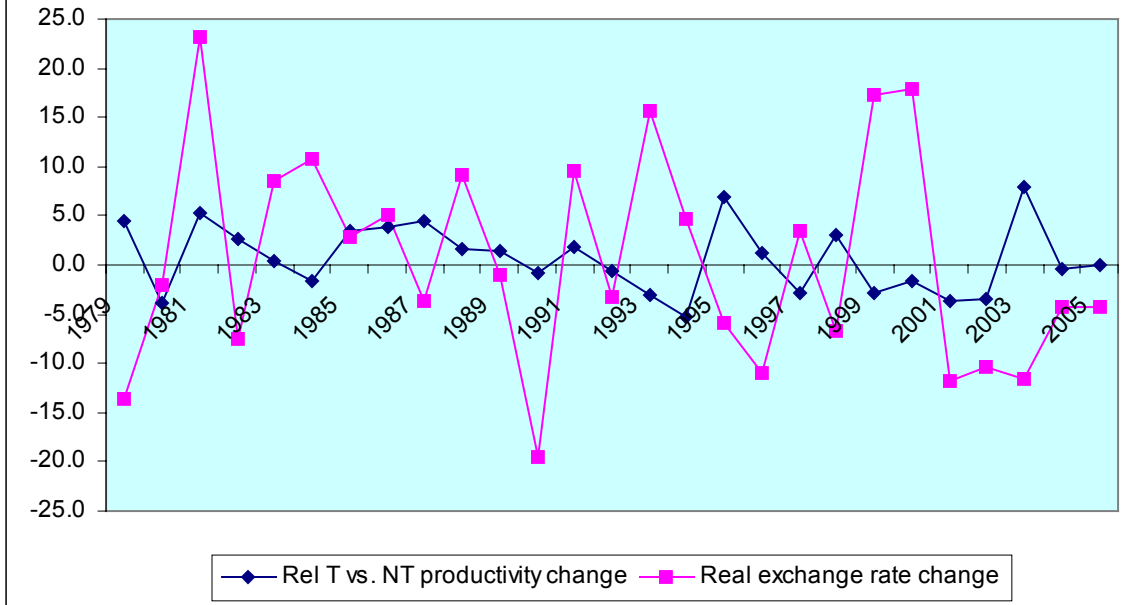


Figure 11a: Bilateral Japan/US Productivity Comparison and Real Exchange Rate: Levels

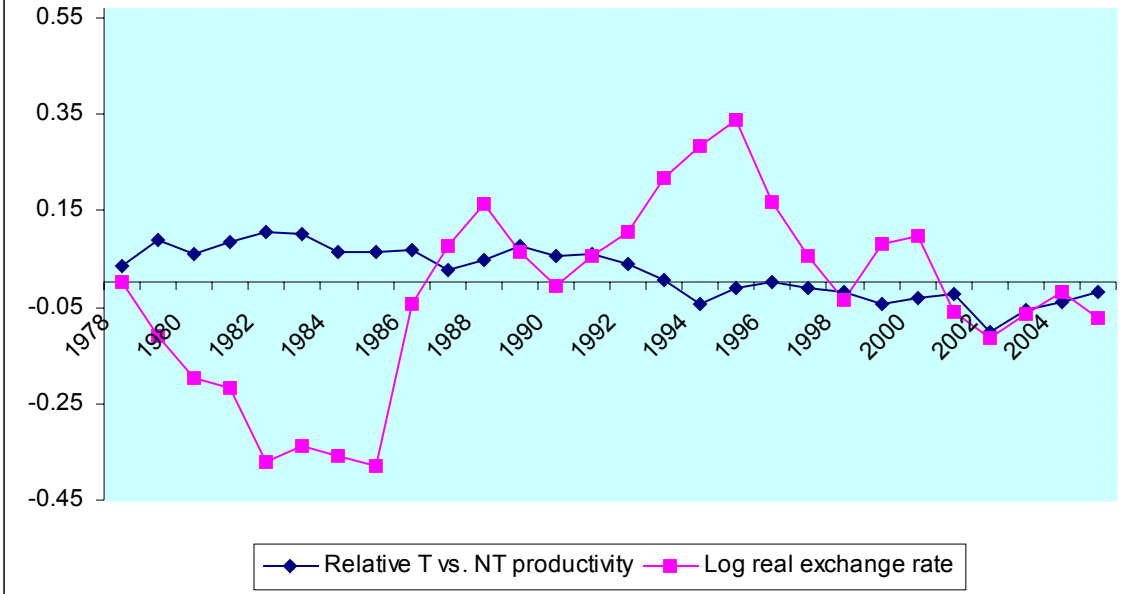


Figure 11b: Bilateral Japan/Germany Productivity Comparison and Real Exchange Rate: Levels

