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USING EXTERNAL SUSTAINABILITY TO FORECAST THE DOLLAR

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ABSTRACT

The sizable run-up in U.S. external debt over the 1980s has prompted many to ask whether continued current account deficits of the magnitude witnessed can be sustained. In several recent papers, different authors have concluded that a given path of the dollar is unsustainable. The conclusion drawn in these earlier papers does not allow for the substantial uncertainty that surrounds this issue, however. There is uncertainty about the estimated model of the U.S. current account that is used to generate the net demand for foreign assets for a given path of the dollar, about the preferences of foreign investors for U.S. assets, and about the mechanics of exchange rate determination that yields a particular path for the dollar.

In this paper, we develop a way to explicitly address these sources of uncertainty. We find that for any given assumption about foreign preferences or the willingness of foreigners to supply net capital, there is a range of sustainable exchange rates. Moreover, that range of sustainable exchange rates varies considerably with changes in the assumption about foreign preferences. Using our framework, we can recast the earlier studies in terms of the likelihood that particular levels of the dollar would be consistent with sustainability.

USING EXTERNAL SUSTAINABILITY TO FORECAST THE DOLLAR

Ellen E. Meade

Charles P. Thomas[1]

1. Introduction

The sizable run-up in U.S. external debt over the 1980s has prompted many to ask whether continued current account deficits of the magnitude witnessed can be sustained. The long-run sustainability of the current account has been the subject of papers by Hooper [1989], Krugman [1985, 1988], and Marris [1985, 1987]. In these studies, the authors have used partial equilibrium models of the U.S. current account, in which the dollar is predetermined, to draw inferences about the path that the dollar must follow to guarantee external sustainability. When model extrapolations of the current account, given a path for the dollar, imply an ever increasing U.S. net demand for foreign capital, these authors have concluded that the given path of the dollar is unsustainable. This is because, in their view, it is unlikely that the net supply of foreign capital available to finance such deficits would be forthcoming.

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1. The authors are staff economists in the International Finance Division. This paper represents the views of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or other members of its staff. This paper was prepared for "Empirical Evaluation of Alternative Policy Regimes" held at the Brookings Institution, March 8-9, 1990 and is to be published in the conference volume edited by Ralph C. Bryant, Peter Hooper, Catherine L. Mann, and Ralph W. Tryon. We would like to thank Brian Cody, Craig Hakkio, David H. Howard, Eric Leeper, participants of the Brookings conference and of a workshop at the Federal Reserve, especially Mike Gavin and Dale Henderson, for comments on an earlier version of this paper; thanks also to Peter Hooper for comments on a later draft. Virginia Carper provided expert research assistance.

The conclusion drawn in these earlier papers about sustainability is sharp, and does not allow for the substantial uncertainty that surrounds this issue. In particular, there is uncertainty about the estimated model of the U.S. current account that is used to generate the net demand for foreign assets for a given path of the dollar. In addition, there is considerable uncertainty about the preferences of foreign investors for U.S. assets. Finally, there is uncertainty about the mechanics of exchange rate determination, which yields uncertainty about the particular path for the dollar.

In this paper, we develop a way to link the long-run net demand for and supply of foreign capital to the path of the dollar in a way that explicitly addresses these sources of uncertainty. We find that for any given assumption about foreign preferences or the willingness of foreigners to supply net capital, there is a range of sustainable exchange rates. Moreover, that range of sustainable exchange rates varies considerably with changes in the assumption about foreign preferences. Using our framework, we can recast the earlier studies in terms of the likelihood that particular levels of the dollar would be consistent with sustainability.

The paper is organized as follows: in the next section, we present a partial equilibrium model of the current account and discuss the cumulative net demand for foreign assets that is generated using that model. We also present estimates of a cumulative net demand schedule. This is in the spirit of the earlier work on sustainability; however, unlike earlier work, we attempt to quantify some of the uncertainty associated with the cumulative net demand schedule. Section 3 addresses the cumulative net supply of foreign funds available to the United

States. Rather than estimate a cumulative net supply schedule, we impose a set of priors over the supply of funds. In the fourth section of the paper, we present a method for combining the demand schedule generated by the current account model with the priors on the supply of foreign funds to produce a forecast for sustainable exchange rates. We then discuss the initial distribution for the dollar and the posterior "sustainable" distribution that results from the interaction of demand and supply. Section 6 concludes the paper.

2. The Current Account and the Cumulative Net Demand Curve

As in the earlier papers on sustainability, the net demand for foreign capital is evaluated using a partial equilibrium model of the U.S. current account. Before discussing the results of simulations with that model, we first review the dynamics of net foreign asset accumulation in a stylized model.

Stylized Model

A minimum requirement for sustainability is that, for a fixed exchange rate, the current account balance adjust to ensure that the long run ratio of net foreign assets to nominal GNP is bounded. The net foreign asset (NFA) position impinges on the current account through two effects in our model -- one direct and one indirect. The "direct" effect is simply the service income component of the current account balance. As the NFA position deteriorates, service payments increase, the current account worsens, and the NFA position deteriorates further. This effect is destabilizing.

The second, or "indirect", effect is stabilizing. When the NFA position declines and service payments on the position increase, the level of income declines, for a given level of production. With imports determined by income, such a decline in income will reduce imports. Similarly, when exports are specified to depend on foreign income, a decline in the home NFA position will increase foreign income and home exports. This effect is incorporated in the simulation model by exogenizing GDP and endogenizing GNP for both the U.S. and foreign countries.[2]

The essential structure of our partial equilibrium model is as follows. We assume real production (GDP) in the United States and foreign countries, g and g*, grows at a common exogenous rate γ and prices, p and p*, grow at a common rate π. Nominal income (GNP) in the United States and foreign countries, Y and Y^*, is the value of domestic production plus net factor income:[3]

(1a) $$Y = g \cdot p + D \cdot r$$

(1b) $$Y^* = g^* \cdot p^* - D \cdot r \cdot E$$

where D = NFA position of the United States denominated in dollars ($D < 0$ is a debtor position)

r = rate of interest

E = nominal exchange rate, foreign currency per dollar.

Real incomes, y and y*, are given as:

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2. There are other indirect effects that are not captured in our model, namely the effect of changes in wealth on consumption and income, and the effect of changes in net exports on income.

3. The assumption that real productive capacity is identical to GDP is a strong one, and implies that changes in the current account must be accomodated by changes in absorption. A more complicated model would allow deviations of output from capacity both in the United States and in foreign countries.

(2a) $y = Y/p$

(2b) $y^* = Y^*/p^*$

Real exports from the United States, x, depend on real foreign income and the real exchange rate R, while real imports, m, depend on real domestic income and the real exchange rate:

(3a) $x = a[R] \cdot y^*$

(3b) $m = b[R] \cdot y$

where $R = (p/p^*) \cdot E$
$a[\,] \geq 0, \quad b[\,] \geq 0, \quad a'[\,] < 0, \quad b'[\,] > 0.$[4]

The change in the NFA position for the United States, or the current account balance, is given by the trade balance plus net factor income:[5]

4. Note that the stylized trade equations are specified in share form which imposes a unitary income elasticity. Long run analysis, such as that in the following note, requires unitary income elasticities in the long run. Otherwise, trade shares explode or fall to zero.

5. This stylized model is bounded in the sense that the stabilizing influence of the "indirect" effect is sufficient to offset the destabilizing influence of the "direct" effect, keeping the NFA/GNP ratio from exploding for an arbitrary level of the real exchange rate. Thomas (1991) demonstrates that:

$$\lim_{t\to\infty} [D/Y] = Z / ((\rho-\delta r)\cdot g_0 + Z\cdot r) \qquad (*)$$

provided that $(\rho-\delta r) > 0$ (**)

where $\rho = \pi + \gamma$
$\delta = (1 - a\cdot E - b/E)$
$Z = (a\cdot g_0^* - b\cdot g_0/E)$

and g_0 , g_0^* are the initial levels of production in the United States and foreign countries. Since δ is less than unity, condition (**) says that so long as the nominal interest rate is not too much larger than the

(Footnote continues on next page)

(4) $\dot{D} = CA = x \cdot p - m \cdot p^{*}/E + D \cdot r$

Empirical Model

The empirical model of the current account is a modified version of the Helkie-Hooper model that has been employed in several recent studies (see Helkie-Hooper [1988], Cline [1989], Hooper-Mann [1989]). The most significant modification of the Helkie-Hooper model is the incorporation of the indirect income effect discussed above. Without this indirect effect, the Helkie-Hooper model is inherently unstable, because there is no internal mechanism to limit debt or wealth accumulation. For example, in the case of an overvalued dollar, there is nothing to stop the NFA position from deteriorating to the point where net factor payments exceed GDP. In the modified Helkie-Hooper model, GDP is predetermined for the United States and foreign industrial countries. GNP is computed endogenously given GDP and U.S. net factor payments. For the United States, the computation of GNP is straightforward. The computation of GNP for foreign countries is analagous, although it requires an assumption about the distribution of factor payments across creditor countries.[6]

To the Helkie-Hooper equations for merchandise trade and non-factor services, we append a number of identities to calculate net investment income, the current account, net capital flows, and the NFA

(Footnote continued from previous page)
nominal growth rate of the economies, the ratio of NFA/GNP will stabilize even for a fixed real exchange rate.

4. The computation of the "indirect" income effects is outlined in Appendix 1.

position for the United States.[7] For simplicity, we treat net investment income as the product of a single rate of return and the NFA position. Historically, the rate of return received on U.S. investment claims has exceeded the rate of return paid on U.S. liabilities.[8] Because of this difference in gross rates of return, the measured implicit net rate of return on the recent U.S. net foreign liability position has been quite low. In the simulations that follow, we assume that the low net rate of return continues to apply to the initial or historical NFA position (which we label "old" NFA). Any future additions to the initial net position that arise in simulations with the model are assumed to pay market rates of return (we term the NFA position cumulated over the simulation horizon "new" NFA.) This distinction between "old" NFA and "new" NFA positions allows us to impose the long-run property that the rate of return on the net position equal the rate of growth of nominal GNP.[9] Equation (5) describes net investment service income:

$$(5) \qquad NSYV = (RORNFA_{old} \cdot NFA_{old}) + (RORNFA_{new} \cdot NFA_{new})$$

7. Complete documentation of the modified Helkie-Hooper model used here is available from the authors upon request.

8. Several factors contribute to this rate of return differential. First, direct investment (DI) positions are recorded at "book" value. Since U.S. DI claims abroad are generally older than foreign DI claims in the United States, the use of "book" value tends to overstate the net liability position (by as much as $300 billion; see Stekler-Stevens [1989]). Second, U.S. and foreign based multinationals both have tax incentives to adjust the prices they charge affiliates so as to report profits outside of the United States. Finally, the return on portfolio claims includes some fee income that is not included in the imputed return on portfolio liabilities.

9. In the early years of the simulations, the average rate of return on the <u>total</u> NFA is less than the marginal rate of return, since the "new" net position is a small fraction of the total net position. By the end of the thirty-year simulation horizon we consider, however, the average and marginal returns are approximately equal.

where[10]

NSYV = net investment service income

$RORNFA_{old(new)}$ = rate of return on old (new) net foreign asset position

$NFA_{old(new)}$ = old (new) net foreign asset position cumulated over the historical (simulation) period.

To close the model we include an identity for the current account balance and add to the "new" NFA position the capital flows necessary to finance the current account:[11]

$$(6) \qquad CABAL = GBAL + NSYOV + NSYV + TRAN$$

$$(7) \qquad \Delta NFA_{new} = CABAL$$

where

CABAL = current account balance

GBAL = net exports of goods

NSYOV = net service income other than investment services

NSYV = net investment service income

TRAN = net unilateral transfers

ΔNFA_{new} = change in NFA_{new}.

Each behavioral equation in the model was estimated through the second quarter of 1989 (the last quarter of data available when this research was undertaken).[12] The simulations reported cover a post-sample

10. This formulation assumes that the NFA position and the factor payments associated with it are denominated in dollars.

11. In the simulations we assume that an imbalance in the current account represents a change in net foreign assets. That is, we abstract from such factors as capital gains and the statistical discrepancy in the balance of payments accounts which, historically, have caused the measured change in net foreign assets to differ from the current account.

12. Most of the equations in the model were estimated using a correction for first-order serial correlation, as in the original Helkie-Hooper work.

period that begins in the third quarter of 1989 and ends in the fourth quarter of 2020. Although the simulation horizon examined in this paper is much longer (30 years) than studies in previous work, we deemed such a lengthy horizon necessary in order to adequately address the long-run nature of sustainability. Before turning to the results of several simulation experiments, it is important to review the baseline assumptions used to extrapolate the predetermined variables:

- The weighted-average dollar (an index of the currencies of the G-10 countries aggregated using weights in multilateral trade from 1972-76) was held unchanged at its value in the second quarter of 1989.

- All prices in the model, both domestic and foreign (except for export and import prices, which are endogenous), were extrapolated at 3.5 percent per year (note that the real exchange rate and the price of oil relative to the price of other imports remain unchanged over the simulation horizon).

- The growth of real GDP in the United States and foreign industrial countries on average was extrapolated at 2.5 percent per year (roughly in line with recent estimates of potential GNP growth), and the real growth rate in developing countries was assumed to be 4 percent (overall foreign growth averages about 3 percent per year, outpacing activity in the United States by about 1/2 percentage point).

- U.S. short-term interest rates were assumed to ease gradually to 6 percent by the end of 1990. The rate of return on the "old" NFA position was assumed to remain at its 1989:Q2 average of 3.5 percent; the rate of return on the "new" NFA position was assumed to increase gradually from 3.5 percent to 6 percent by the end of 1990.

Baseline Simulation

Simulation of the model through 2020 given the baseline paths for the predetermined variables yields a predicted path for the current account -- we term this the net demand for foreign assets. We focus our analysis on the cumulative net demand for foreign assets (or the NFA position) relative to nominal GNP. The simulation suggests that if the weighted-average dollar were to have remained unchanged at its level in the second quarter of 1989 (about 100), the ratio of the NFA position to nominal GNP would decline from -12 percent to -90 percent in 2020 (shown by the solid line in chart 1).[13] The current account deficit as a share of nominal GNP grows from 2 percent in the second quarter of 1989 to 5.4 percent at the end of the simulation. The implication of this increase in the current account deficit is that domestic absorption is reduced.

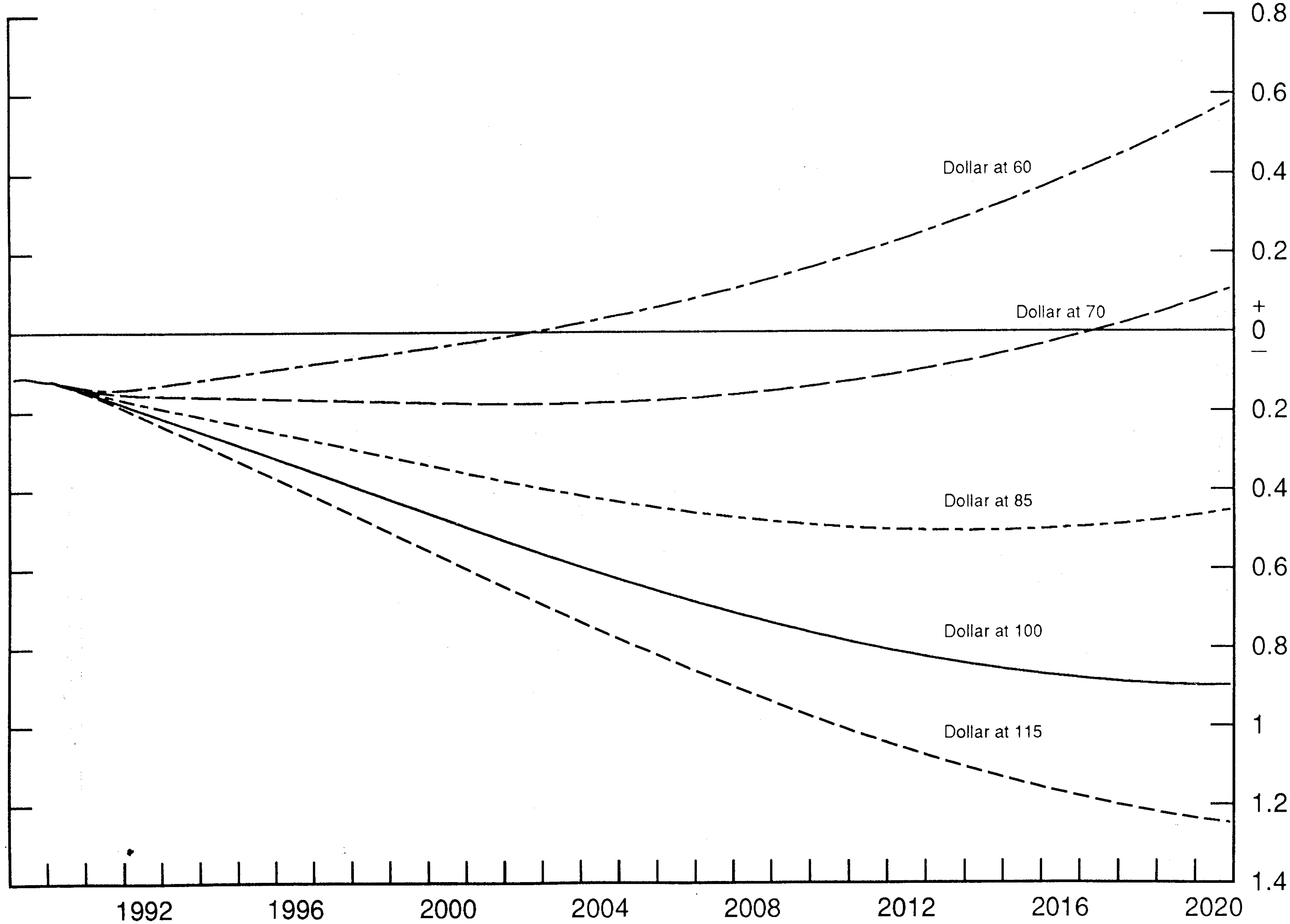
This simulation experiment is practically identical to the exercise performed in the earlier studies of current account sustainability. Both Hooper [1989] and Marris [1985, 1987] conditioned their analyses on particular values for the dollar; Krugman [1985, 1988] assumed that the dollar would follow the path dictated by the differential between U.S. and foreign interest rates. In these earlier studies, for the exchange rates considered, the current account, if simulated over a sufficiently long horizon, would have grown without bound. Due to the inclusion of the indirect income effects described above, our simulation would eventually converge to a stable ratio of the NFA position to nominal GNP. (In fact, a dollar of about 100 appears to yield a relatively stable NFA/GNP ratio, roughly -90 percent, by 2020.)

Model simulations conditioned on alternative paths of the dollar result in different net demands for foreign assets. (This is demonstrated in chart 1 for a weighted-average dollar unchanged at 115, 85, 70, and 60). These alternative simulations can be viewed as generating a demand schedule for cumulative net foreign assets in 2020, shown graphically as the downward-sloping line labelled baseline in chart 2. Each point on the cumulative net demand schedule represents the level

13. We discuss simulation results only for the year 2020, an arbitrarily chosen date in the distant future.

Chart 1

Ratio of NFA to GNP



of the dollar upon which each simulation is conditioned, and the ratio of the NFA position to nominal GNP that results in 2020.[14]

Uncertainty

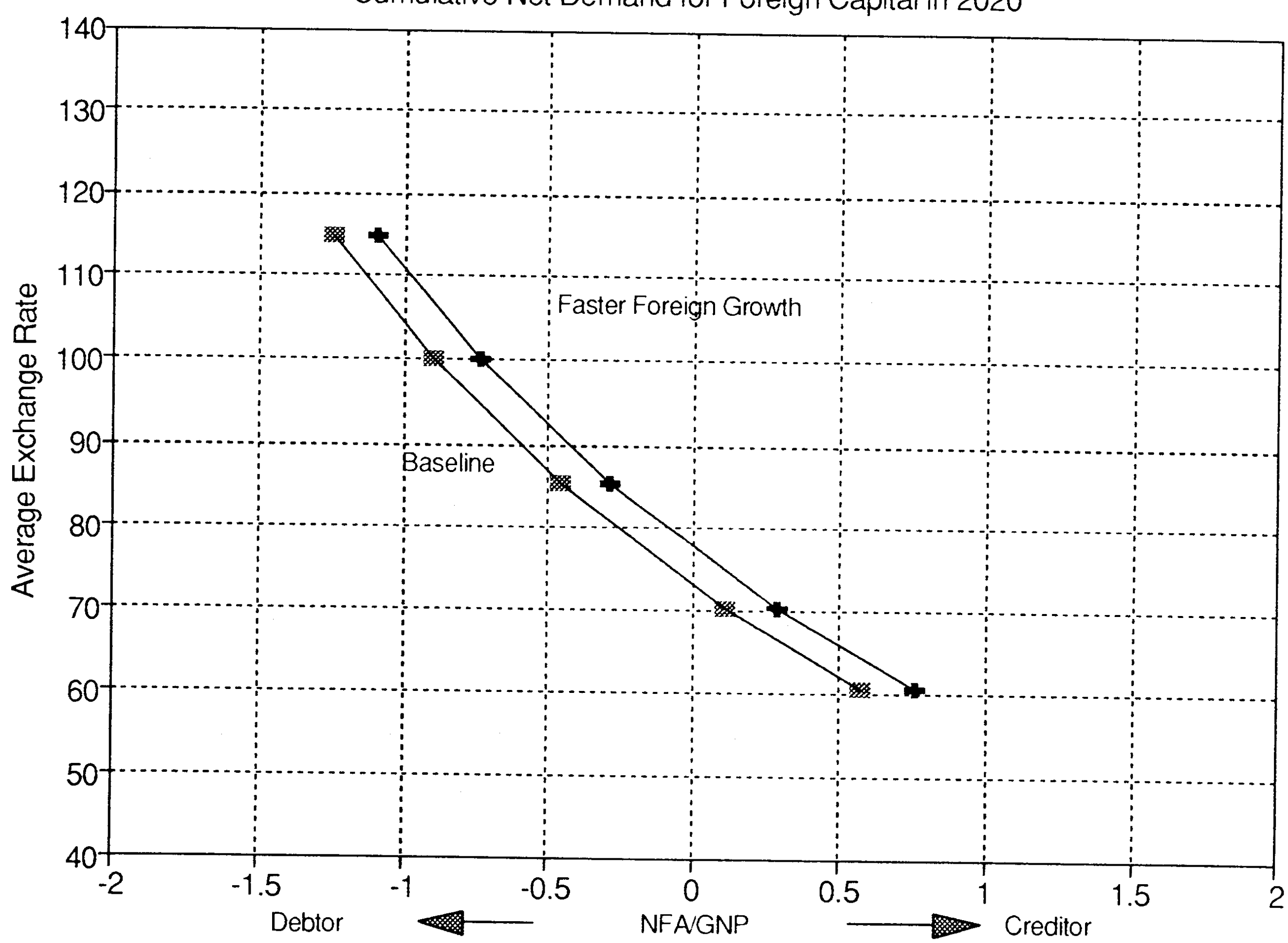
Considerable uncertainty surrounds the estimated cumulative net demand curve, however. One source of uncertainty arises from the assumptions for the predetermined variables in the system. To illustrate this, we have considered a "faster foreign growth" alternative, in which, for example, the opening of markets in Eastern Europe leads to annual average growth in foreign industrial countries of 3.3 percent (almost one percentage point higher than in the baseline). This faster growth is allowed to persist through 1993 before returning to the 2.5 percent pace assumed in the baseline. This temporary increase in the rate of foreign growth results in a significant shift out in the cumulative net demand schedule as shown in chart 2.

Another source of uncertainty about the cumulative net demand curve arises from the uncertainty associated with the parameters and residuals in the model equations. To quantify this uncertainty, we performed 1000 stochastic simulations in which the residuals and estimated parameters of the model were chosen from their sample distributions (the stochastic simulation technique is described in Appendix 3). This exercise was performed for each of five different paths of the dollar used to generate charts 1 and 2 (an unchanged dollar at 60, 70, 85, 100, and 115).

14. If the simulation horizon is extended beyond 2020, the cumulative net demand schedule rotates counter-clockwise. For very high (low) values of the dollar, the NFA/GNP ratio worsens (improves) as the simulation horizon lengthens.

Chart 2

Cumulative Net Demand for Foreign Capital in 2020



When "model" uncertainty is included, a given level of the dollar yields a probability distribution over the NFA/GNP ratio rather than a single value for that ratio. Chart 3 illustrates this distribution by plotting the one-sixth quantile, the median, and the five-sixths quantile of the NFA/GNP ratio for various levels of the dollar. For a given level of the dollar, two-thirds of the simulated values for the ratio of the NFA position to nominal GNP fall within the band formed by the one-sixth and five-sixths quantiles.

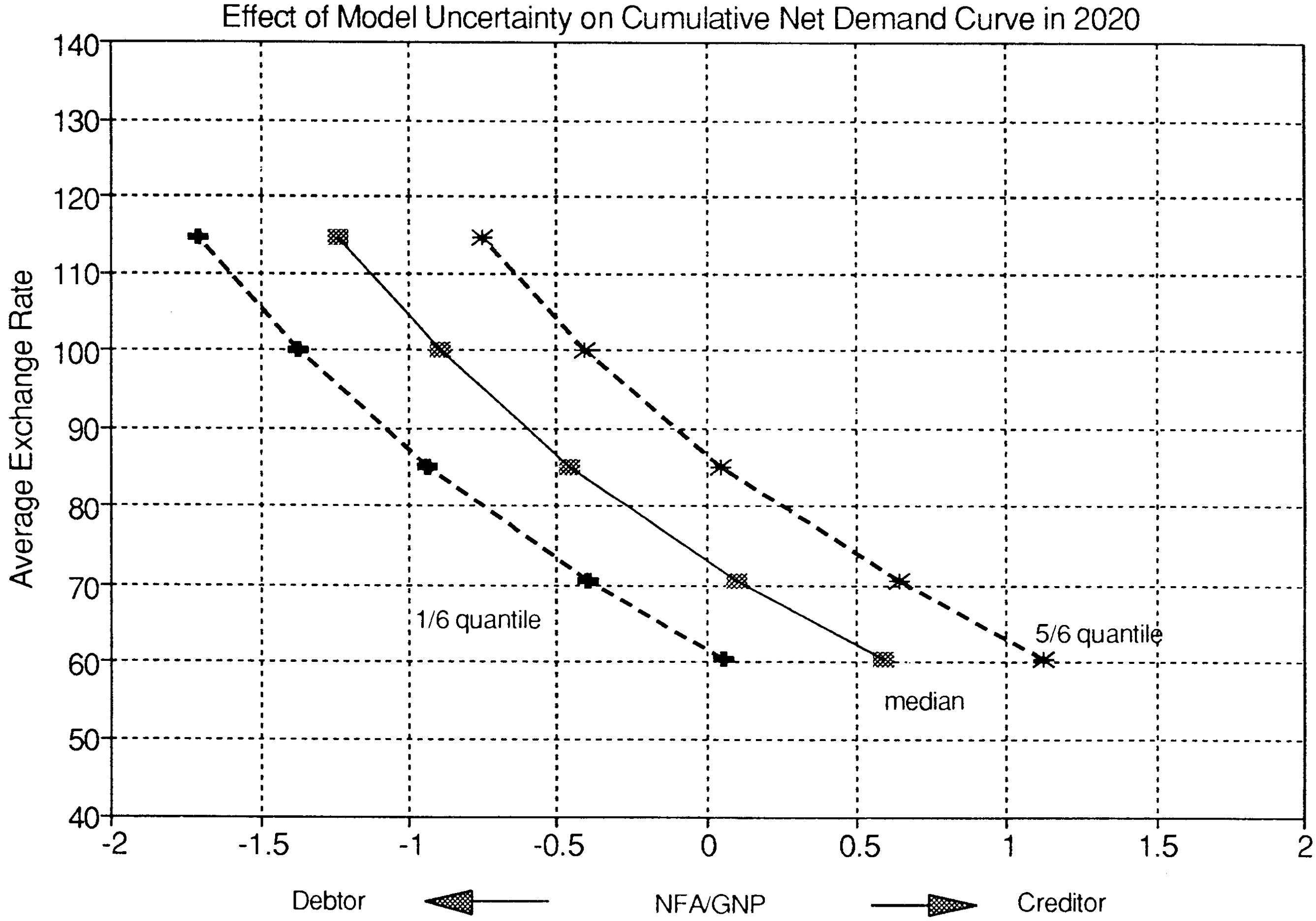
The uncertainty associated with the cumulative net demand schedule has obvious implications for the analysis of sustainability. Since there is a range of NFA/GNP ratios consistent with any value of the dollar, it is impossible to draw sharp conclusions about sustainability for any particular level of the dollar. Or, put another way, any given level of the NFA/GNP ratios is consistent with a wide range of paths for the dollar.

3. Cumulative Net Supply Curve

In the earlier studies on sustainability, no explicit assumptions about asset preferences were made. Judgments about the sustainability of the demand for foreign capital generated by a partial equilibrium model of the current account were based on an implicit notion of foreign preferences for holding U.S. assets. In this section, foreign preferences for U.S. assets and the uncertainty surrounding those preferences are considered explicitly. We do this by postulating a

Chart 3

Effect of Model Uncertainty on Cumulative Net Demand Curve in 2020



specific set of priors over the supply of funds available from foreigners.[15]

We postulate priors over the supply of funds rather than estimate asset demand equations for two reasons. First, equations of foreign asset demands have generally failed to measure parameters very precisely or to pass standard specification tests. In fact, the literature on portfolio balance models offers little hard empirical evidence on the preferences of foreigners for U.S. assets (Levich [1985] provides a summary of empirical work; also see Dooley and Isard [1983], Isard [1987]). Second, even if we had a well-specified system to describe foreign portfolio choices, it would undoubtedly depend on variables not modelled here. Uncertainty about these unmodelled variables would lead to a distribution for holdings which would result in a set of priors analagous to those we postulate.

Our priors over the supply of foreign capital are expressed in terms of a distribution over the NFA/GNP ratio. Scaling the NFA position by nominal GNP is certainly simple to compute and may be the measure most appropriate for capturing default risk, but is not the only conceivable measure of external imbalance. Alternatively, scaling the NFA position by foreign wealth may better measure the degree of concentration in foreign portfolios and thus may be a better measure of external imbalance. Another alternative is to consider the share of dollar-denominated assets in foreign portfolios (that is, the total outstanding

13. For expositional reasons, the discussion of the net supply of funds is in terms of foreign preferences. Portfolio preferences of domestic residents are equally important and it is the net supply of funds, including both domestic and foreign investors, that determines whether a particular NFA position is sustainable.

stock of dollar-denominated liabilities worldwide, not just claims on U.S. residents) in order to measure currency risk.[16] While there are a number of different measures that might be considered, most of these measures are extremely difficult to compute. For that reason, our analysis centers on the ratio of the NFA position to nominal GNP.[17, 18]

The priors are described by a probability distribution over the potential cumulative net supply of capital (the ratio of the NFA position to nominal GNP) consistent with foreign preferences. We consider three alternative prior distributions, shown in chart 4. Each prior is normally distributed with a mean of zero; the priors differ in the degree of concentration about the mean. The "tight", "medium", and "loose" prior distributions have a standard deviation of 0.25, 0.5, and 1.0, respectively.[19]

16. See Dealtry and Van't dack [1990] for a discussion of the difficulties in computing the share of dollar denominated assets in the portfolios of non-U.S. residents.

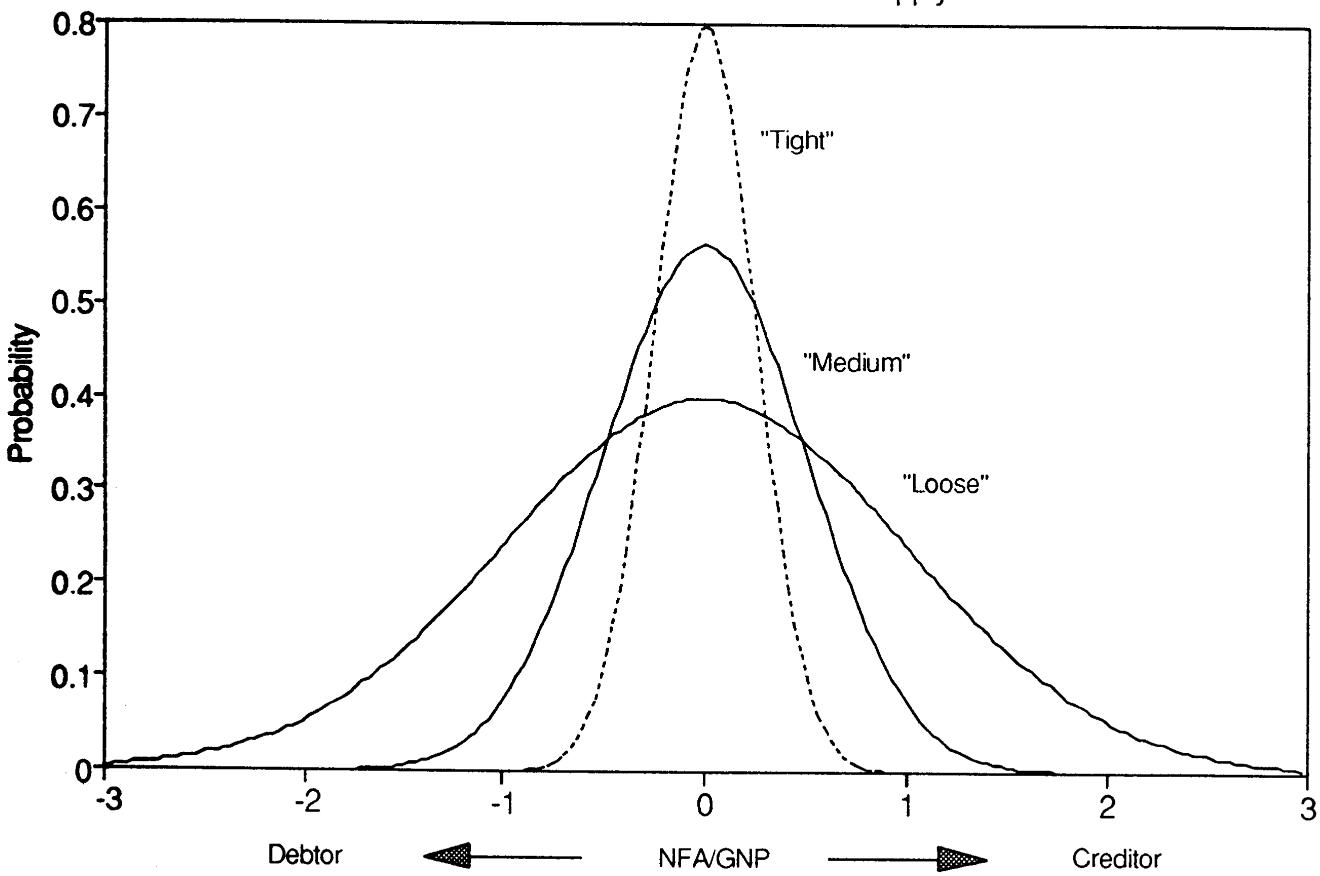
17. Even this relatively straightforward measure is subject to severe error, owing to the difficulty in computing the NFA position. See Scholl [1990] and the references therein for a discussion of the issues in valuing the U.S. NFA position.

18. It is worth noting that the United States is not the largest world debtor, even among industrialized nations. In 1988, the NFA/GNP ratio was about -10 percent for the United States. This compares with a NFA/GDP ratio in 1988 of -38 percent for Canada (the largest debtor among industrial countries). The external debt position in a number of developing countries exceeded that of the United States in 1988 (for example, the NFA/GDP ratio was -103 percent for Ecuador, -71 percent for Argentina, -59 percent for Chile, and so on).

19. While we think these priors are reasonable, they are certainly not exhaustive. An advantage of the method used here is that it is easily adapted to alternative priors, including those not centered at zero.

Chart 4

Prior Distribution on Cumulative Net Supply Curve



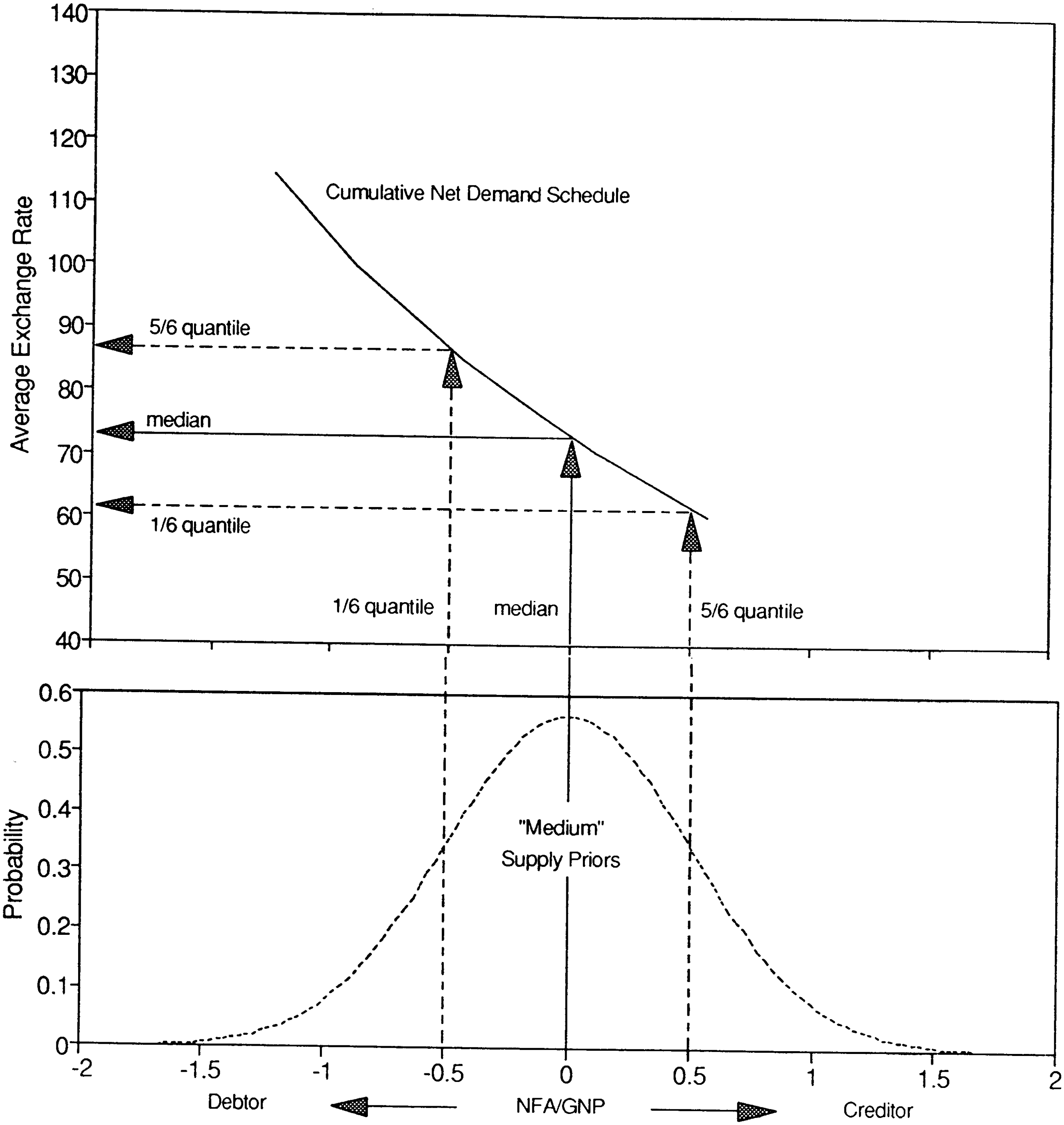
4. The Interaction of Demand and Supply

Similar to the earlier studies on sustainability, we believe it unlikely that a very high cumulative net demand for foreign capital, such as that associated with a debtor position in excess of 100 percent for example, would be forthcoming from foreign suppliers. Because every point on the cumulative net supply schedule is not equally likely, we can use the priors on the supply of foreign capital to shed light on the distribution of "sustainable" exchange rates. Specifically, each point on the cumulative net demand curve represents the outcome of a simulation with the current account model, given an initial path for the dollar. Each simulated demand outcome is measured against the prior distribution over supply and assigned a probability. The posterior "sustainable" distribution of exchange rates results from weighting each initial exchange rate path by its probability.

The method for obtaining the posterior distribution of the dollar is outlined in chart 5. The "medium" prior over supply is illustrated by the arrows that project from the x-axis up to the demand schedule. The solid arrow projects from the mean of the supply prior, while the dashed arrows project from the 1/6 and 5/6 quantiles, encompassing two-thirds of the distribution. The value for the dollar associated with each point on the demand curve (shown on the y-axis) is then weighted by its probability of occurrence, as determined by the prior distribution over supply. This method yields a posterior "sustainable" distribution of exchange rates, as opposed to a single value for the dollar that was the focus of earlier studies.

While we abstract from the effects of "model" uncertainty in the discussion that follows, it is nevertheless important to keep in mind

Chart 5
Interaction of Demand and Supply



that the "sustainable" distribution would be significantly wider were we to explicitly consider the effects of "model" uncertainty on the cumulative net demand scheule.

5. Sustainable Paths for the Dollar

So far, we have described the derivation of the cumulative net demand schedule (given a path for the dollar), the use of a prior distribution for the cumulative net supply schedule, and the interaction of demand and supply. What remains is the discussion of the initial distribution for the dollar upon which the demand schedule is conditioned. We then turn to a discussion of the posterior "sustainable" distribution for exchange rates.

There are many plausible initial distributions for the dollar. The exchange rate paths used to derive the cumulative net demand schedule pictured in charts 2, 3, and 5 were unchanged at a particular level of the dollar. For the analysis of the sustainable paths, we want to condition on an initial distribution for the dollar that is empirically sensible. For this, we have looked to the literature on exchange rate behavior and have generated the initial distribution from a random walk process that mimics the historical volatility of the dollar.[20] Meese-Rogoff [1983] were the first to suggest that a random walk model of the dollar out-performed other models of exchange rate behavior;[21] since that time, many other studies have favored the random walk model in comparison with other models of exchange rate determination (see Boughton [1987],

20. The initial distribution consists of 1000 paths for the dollar that begin in the third quarter of 1989 and continue through 2020.

21. The Meese-Rogoff results covered out-sample simulation performance.

Diebold and Nason [1989], Edison [1985, 1989], Meese and Rose [1989], Schinasi and Swamy [1989]). Because of its wide acceptance in the literature, we chose to model the dollar initially as a random walk process.

Each of the random walk paths over T time periods was generated from T independent random draws from a normal distribution, with a mean of zero and a variance equal to that of the actual dollar between 1975:Q1 and 1989:Q2. To avoid any sampling bias in the initial distribution of 1000 paths, we drew 500 independent exchange rate paths and applied antithetics. This means that the final sample of 1000 paths included 500 independent random walk paths and the mirror image of each path.[22]

The initial distribution of random walk exchange rate paths for the simulation period beginning in the third quarter of 1989 and ending in 2020 is summarized in chart 6. Early on, the distribution of exchange rate values is concentrated around the initial value of 100; by 2020, the distribution has disbursed substantially around its original median, is symmetric, and is approximately lognormal.

These random walk paths for the dollar were used in simulations with the current account model to generate conditional forecasts of the NFA/GNP ratio, shown in chart 7 for the year 2020. Each dot on the downward-sloping line labelled "simulated demand" represents the outcome

22. The rth exchange rate path and its mirror image (denoted by a "+") were generated as follows:

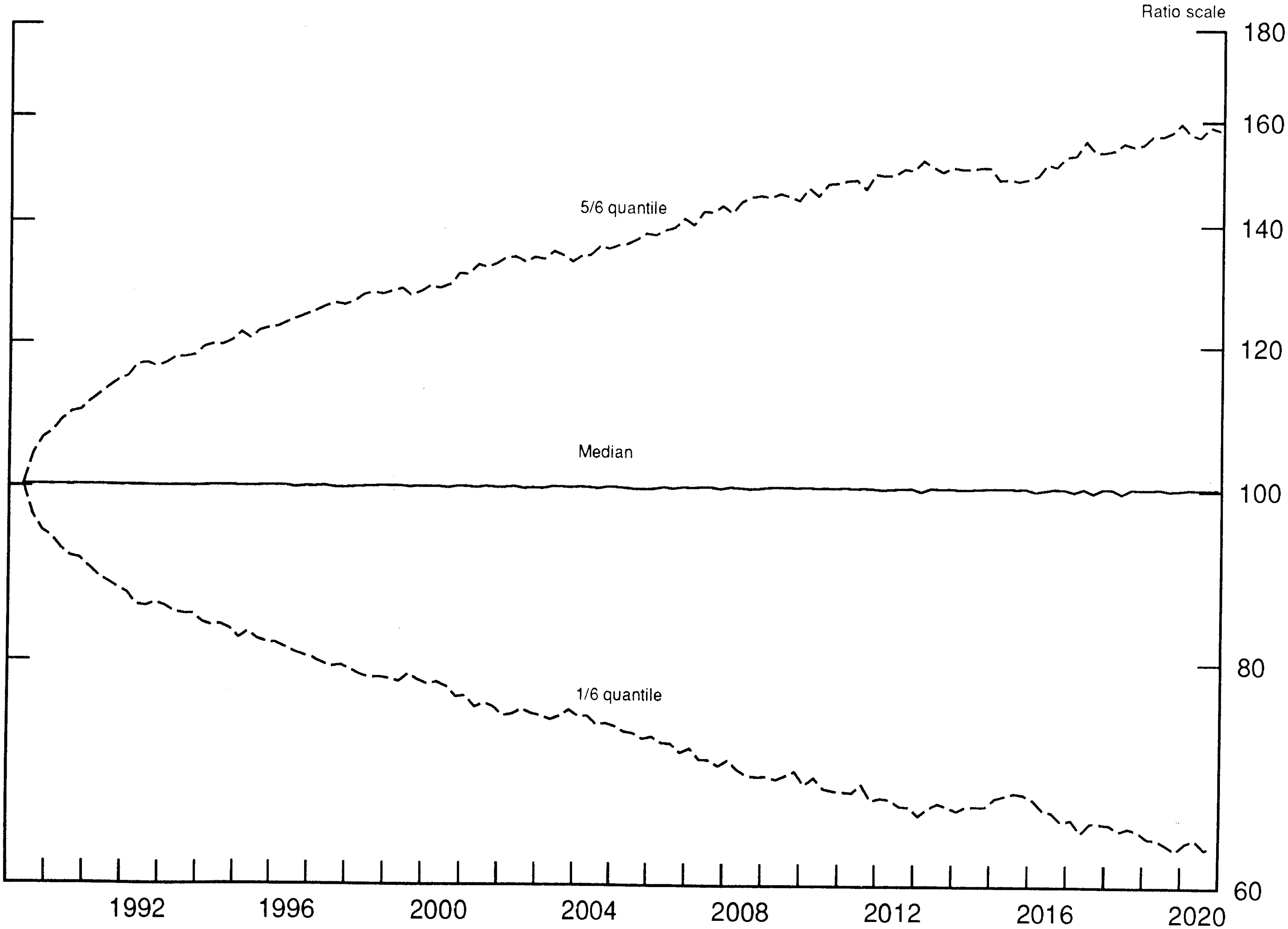
(*) $$\ln(E_{r,t}) = \ln(E_{r,t-1}) + \epsilon_{r,t}$$

and $$\ln(E^{+}_{r,t}) = \ln(E^{+}_{r,t-1}) - \epsilon_{r,t}$$

where $\epsilon_{r,t} \sim N(0,\sigma_E)$, $t = (1,\ldots,T)$, $r = (1,\ldots,500)$. For further details, see Marquez and Ericsson [1990].

Chart 6

Sample Distribution of Random Walk Dollar



of a single simulation. In isolation, these results suggest that the NFA/GNP ratio in 2020 could vary from a debtor position of almost 300 percent to a creditor position of almost 300 percent.

Imposition of the "medium" supply prior that is pictured in chart 7 on the simulated demand schedule results in a posterior distribution of the dollar, as described in section 4. This posterior distribution, shown in chart 8, indicates that it is likely that "sustainable" paths involve some depreciation of the dollar. More specifically, two-thirds of the posterior distribution (defined by the 1/6 and 5/6 quantiles) indicate that the dollar must either remain roughly unchanged at its level in mid-1989 (about 100) or depreciate in order to be consistent with external sustainability.

The range of sustainable values for the dollar depends on the concentration of the prior distribution on supply, as illustrated in chart 9. "Loose" priors on the supply of foreign capital widen the range of posterior exchange rates considerably and imply that appreciating paths are sustainable. On the other hand, "tight" priors narrow the range of sustainable dollar values. If foreign industrial countries are allowed to grow more rapidly than the United States, then the range of sustainable exchange rates involves somewhat less depreciation, regardless of the prior distribution on supply.

Two important points emerge from this exercise. First, unlike the earlier literature on sustainability, these results emphasize the range of sustainable paths for the dollar and the uncertainty involved in selecting any particular path. Second, paths for the dollar previously dismissed as unsustainable emerge from this exercise as potentially sustainable. Clearly, the choice of prior distribution over the supply

Chart 7
Simulation Results and Priors

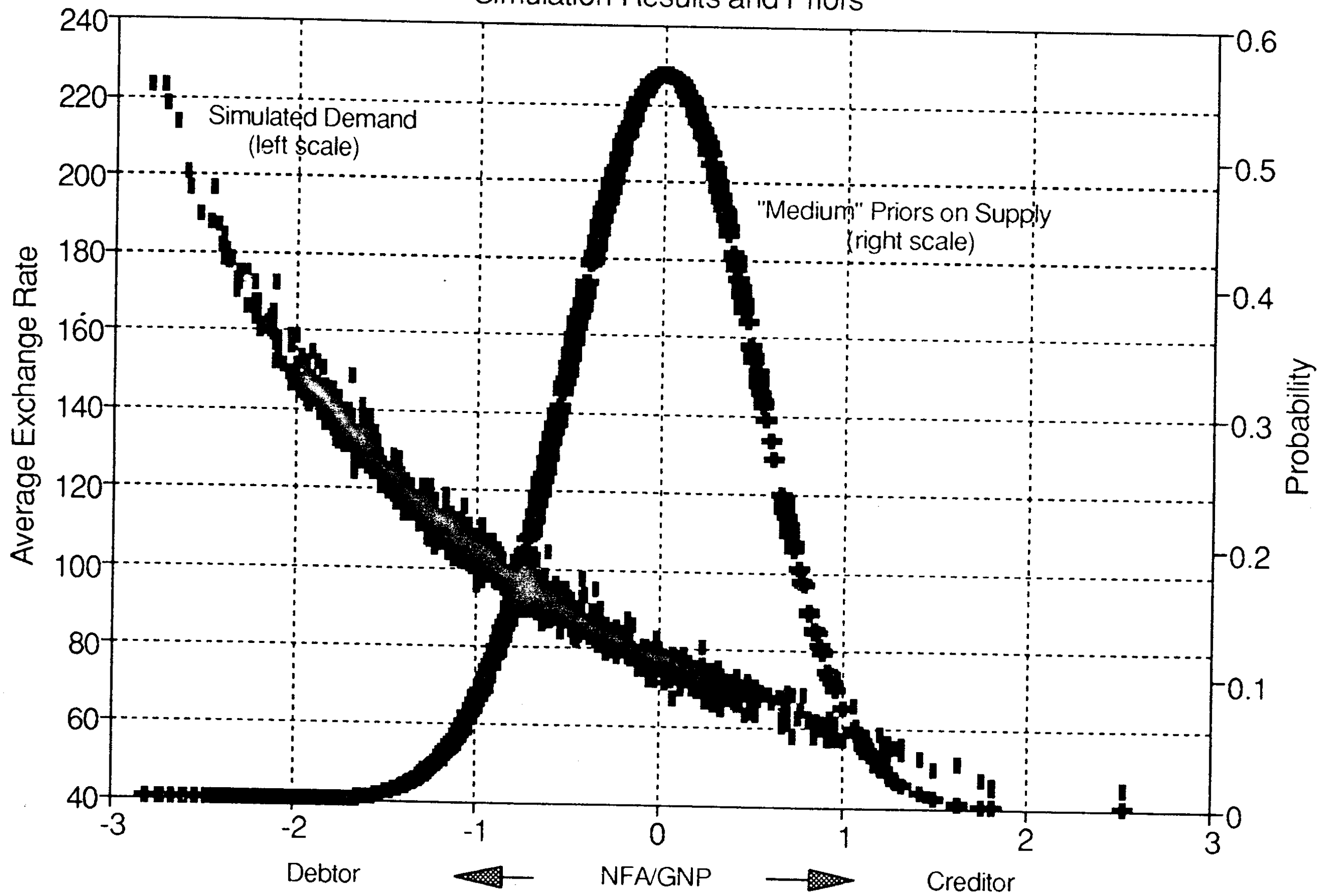


Chart 8

Posterior Distribution of the Dollar
"Medium" Supply Priors

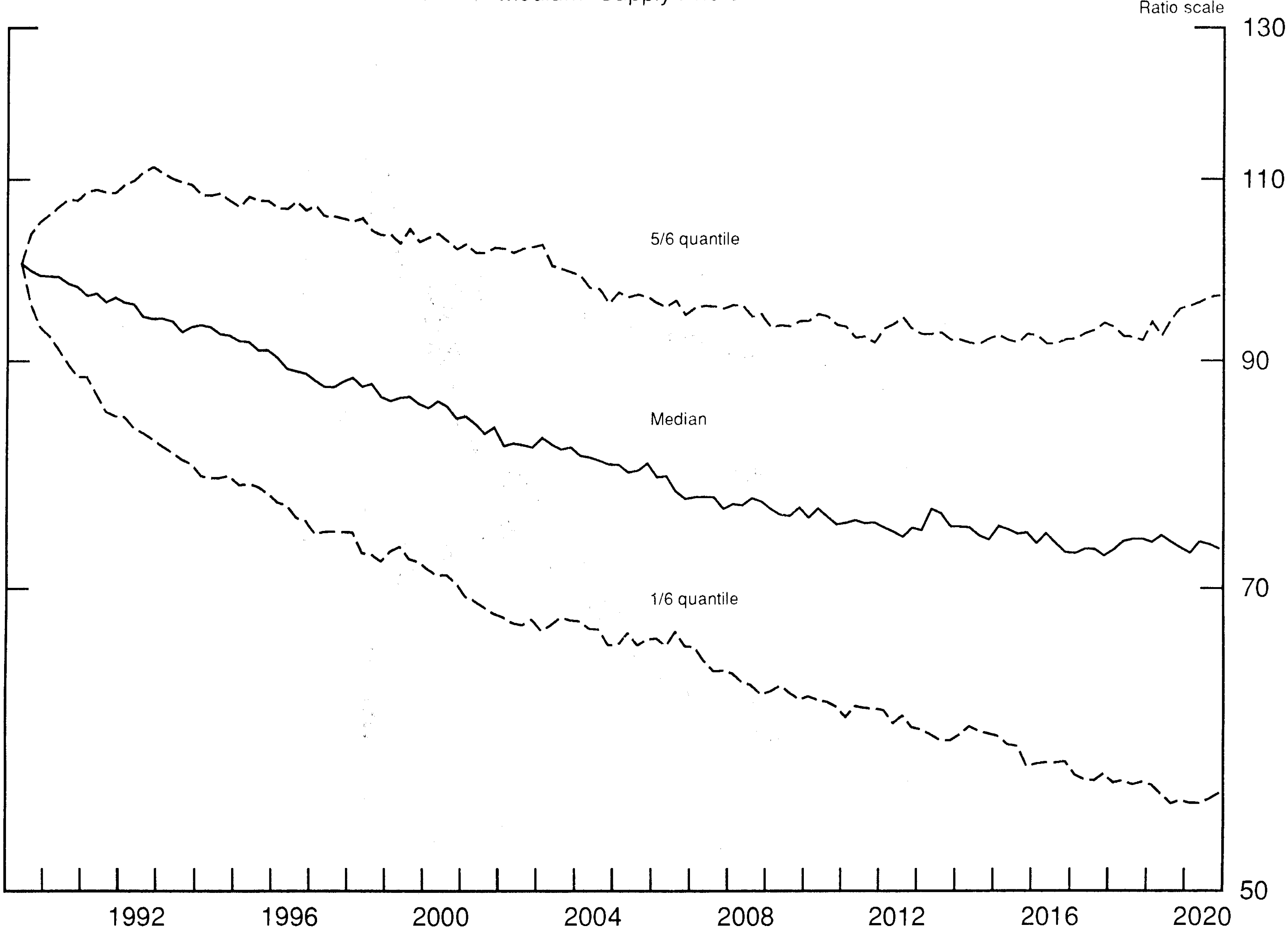
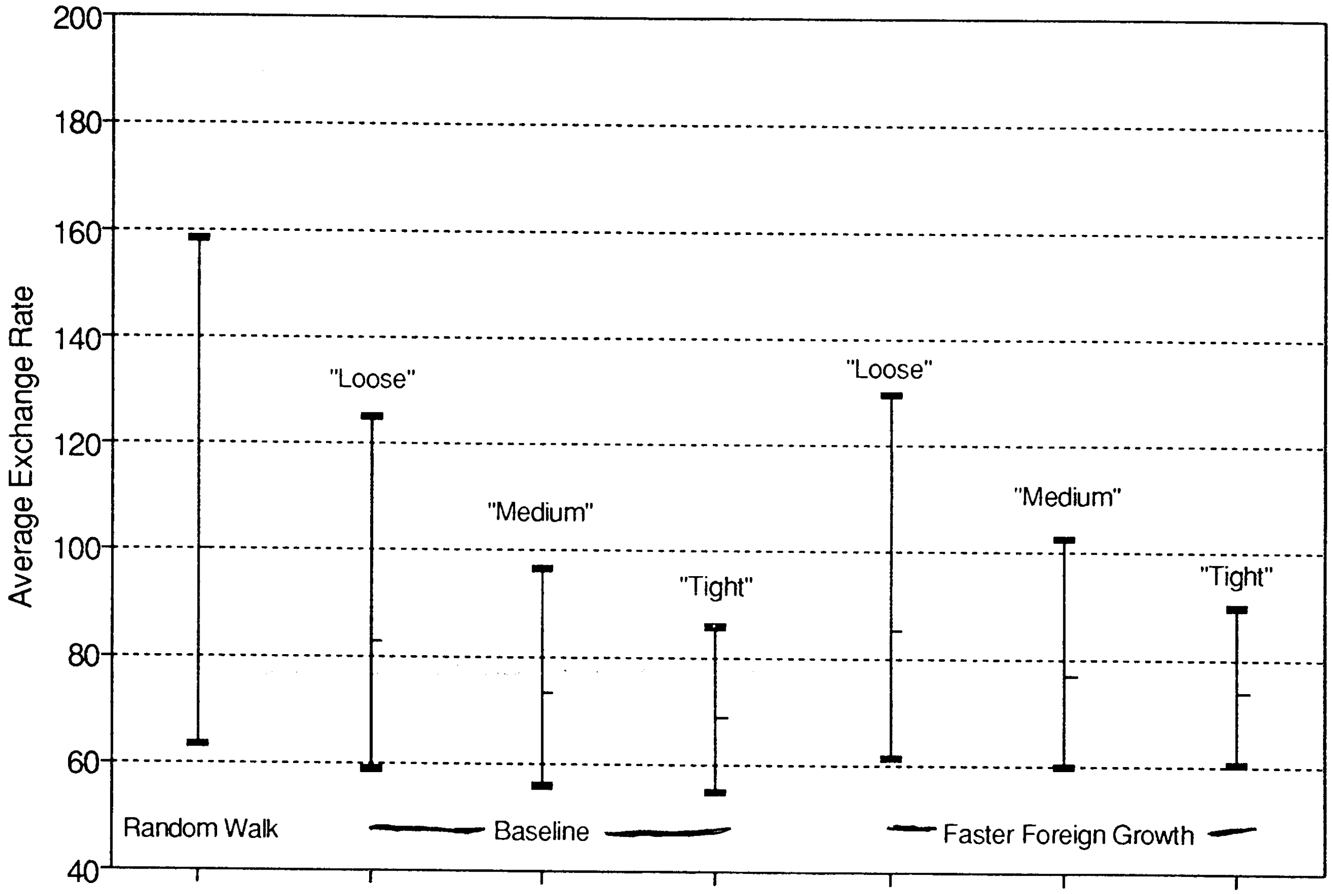


Chart 9
Distribution of Dollar in 2020



of foreign capital is important in the results presented here; in earlier studies, the supply of foreign capital was simply ignored.

6. Conclusion

External sustainability is a complicated issue. In this paper, we have integrated two important facets of sustainability -- the cumulative net demand for (as identified by the current account model) and the net supply of (as determined by factors that influence asset preferences) foreign capital -- to derive a distribution of "sustainable" exchange rates. We demonstrate that for any analysis, even one based on these two facets alone, it is appropriate to discuss external sustainability not in terms of a particular value for the dollar as in earlier studies, but in terms of a range of values. This emphasizes the importance of uncertainty about estimated model equations and foreign preferences for conclusions about "sustainable" exchange rates.

Appendix 1:

Incorporation of Indirect Income Effects into the Empirical Model

For the United States, going from GDP to GNP is an identity, with the deflator for net factor payments assumed to grow at the same rate as other prices. The equation used in the simulation model is:

$$GNP = GDP + NSYV/(PGNP/100)$$

where GNP = U.S. real GNP
GDP = U.S. real GDP
NSYV = value of U.S. net factor payments
PGNP = U.S. GNP implicit deflator

To incorporate U.S. net factor payments into foreign income, we translate U.S. nominal factor payments into units of real foreign income and augment foreign income by this amount. Specifically, we assume that all U.S. factor payments are denominated in dollars and are paid to the other G-10 countries. To compute the share of U.S. factor payments in G-10 GNP, we compute that ratio for 1988 and apply index changes for later years. The nominal, dollar-denominated, factor payments are converted into foreign currency using the G-10 exchange rate index, and then deflated by the the G-10 price. The adjustment factor for the indirect income effects is computed as follows:

$$FIA = \frac{NSYV}{\$FGNPV(88)} \cdot \frac{E}{E(88)} \cdot \frac{FPCPI(88)}{FPCPI} \cdot \frac{FGNP(88)}{FGNP}$$

where FIA = foreign income adjustment
FGNPV(88) = value of G-10 GNP in 1988
E = G-10 exchange rate index, foreign currency per dollar
FPCPI = G-10 index of consumer prices
FGNP = real G-10 GNP

In 1988 U.S. net factor payments were about 0.113% of foreign G-10 GNP. The foreign income adjustment is used in the simulations to augment the G-10 activity variables as they enter the U.S. export equations.

Including these income effects in the model makes a sizable difference in the NFA/GNP ratio by 2020. The table below compares the NFA/GNP ratio in 2020 for simulations with and without indirect income effects for various levels of the dollar.

Importance of Indirect Income Effects for Simulated NFA/GNP In 2020 for Various Levels of the Exchange Rate

	NFA/GNP (percent)	
Exchange Rate	With Indirect Income Effects	Without Indirect Income Effects
115	-125	-175
100	- 90	-131
85	- 45	- 72
70	11	4
60	58	72

Appendix 2:
Measures of Foreign Wealth

The willingness of foreigners to hold a given stock of net claims on the United States depends on foreign wealth and the return structure of the claims on the United States, including default risk. A common indicator of default risk is the portion of income that is required to meet interest obligations. In the extrapolations in the paper, the rate of return on U.S. claims is assumed to be constant at 6 percent; therefore, net service payments as a share of income are simply 0.06 times the ratio of the NFA position to GNP. Service payments as a share of GNP for the criteria used in the text are shown in column 2 of the table below.

To compute the share that the U.S. NFA position represents in foreign portfolios it is necessary to project a relevant measure of foreign wealth. Using OECD data for 1977 and 1978, we estimate that the financial wealth (excluding land) of the G-10 countries plus Switzerland but excluding the United States was on the order of $16.8 trillion at the end of 1988. This represents about 3-1/3 times U.S. GNP for that year. If we assume that the ratio of foreign wealth to foreign GNP remains roughly constant and that foreign GNP growth is equal to U.S. GNP growth, then we can project that this measure of foreign wealth will remain about 3-1/3 times U.S. GNP. Column 3 of the table restates the criteria used in the text in terms of the NFA position of the United States relative to foreign financial wealth, under the assumptions given above.

Sustainability Measures

U.S. NFA / U.S. GNP (1)	NSYV / U.S. GNP (2)	U.S. NFA / G-10 Wealth (3)
10%	0.6%	3%
50%	3.0%	15%
100%	6.0%	30%
200%	12.0%	60%

Appendix 3:
Stochastic Simulation Technique

In a deterministic simulation of the modified Helkie-Hooper model, the equation parameters equal their point estimates and the equation residuals equal their expected value.[23] "Model" uncertainty can be quantified through stochastic simulations. For each simulation, shocks are added to the estimated parameters and residuals of each behavioral equation in the model.[24] The shocked parameters are held unchanged over the simulation range. In contrast, different shocks to the residuals are drawn for each time period in the simulation. Thus, given N estimated parameters in the model and M behavioral equations, one stochastic simulation over T time periods involves drawing N shocks for the parameters from the distribution of those parameters, and M·T shocks for the equations from the distribution of the equation residuals.[25] (Note that R replications of a stochastic simulation involves drawing R·N parameter shocks and R·(M·T) residual shocks.)

The shocks to the equation parameters are drawn from a normal distribution with a mean of zero, and are scaled by the variance-covariance matrix of the parameter estimates in the individual equation. The residual shocks are drawn from a normal distribution, with a mean of zero and a variance equal to the variance of the historical equation errors between 1975:Q1 and 1989:Q2. The variance of the residuals is computed over the most recent 15-year period rather than over the estimation range of each equation for two reasons. First, it was deemed desirable to compute the residual variances over a common time period (and the estimation range of all equations is not identical). Second, the variance over the past 15 years may be a

23. Since most of the model equations were estimated with a correction for first-order serial correlation, the expected value of the residual for a given equation is: $\epsilon_t = \rho \cdot \epsilon_{t-1} + \eta_t$, where ρ is the estimate of persistence and η_t is a white-noise (mean zero) error.

24. Unlike the other estimates in the model, the coefficient for first-order serial correlation, ρ, remains equal to its point estimate throughout the stochastic simulations.

25. Although the description of the technique is rather brief here, Marquez-Ericsson [1990] contains additional details.

better approximation to the variance over the simulation horizon than the variance over the entire estimation range.[26]

26. Implicit in this method is the assumption that the parameters and residuals of the estimated model will remain stationary over the lengthy simulation horizon (1989:Q3 through 2020:Q4). Note that while the variance of the parameters is characterized by the entire estimation range of each equation, the variance of the residuals is not.

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