Board of Governors of the Federal Reserve System

International Finance Discussion Papers

Number 678

September 2000

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Abstract: This paper offers a framework for judging when the discrepancy embodied in current-account forecasts is large. The first step in implementing this framework involves developing an econometric model explaining the components of the aggregate discrepancy, estimating the associated parameters, and generating the aggregate discrepancy's conditional expectation. The second step is to compare this model-based forecast with the discrepancy embodied in countries' current-account forecasts. If the gap in discrepancies is below a critical value, then the discrepancy embodied in the countries' current-account forecasts is not large. Otherwise, the discrepancy is large and calls for a careful re-examination of the associated current-account forecasts.

Keywords: FIML, forecast uncertainty, global discrepancies, IMF

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1 Introduction

For projections of global external imbalances to be useful, they must be internally consistent: external surpluses and deficits across countries must add up to zero. That this adding-up condition does not hold in the data need not, by itself, undermine the usefulness of these projections: reporting mistakes, sampling errors, and recording asymmetries across countries are a fact of life and, when combined, they give rise to a statistical discrepancy. But when this discrepancy reaches the level of the current-account surplus of Japan in 1990 ($100 billion) and is projected to reach near $300 billion by 2001 (figure 1), one cannot avoid questioning the usefulness of such projections.

Sustained discrepancies of this magnitude are worrisome because they undermine the credibility of global current-accounts forecasts. Specifically, if the discrepancy stems from recording practices of a few countries, then their forecasts for growth could be systematically mismeasured with obvious implications for the global consistency of individual country forecasts of the current account. Such consistency is central to studying, for example, which countries will absorb any reduction of the U.S. external deficit.

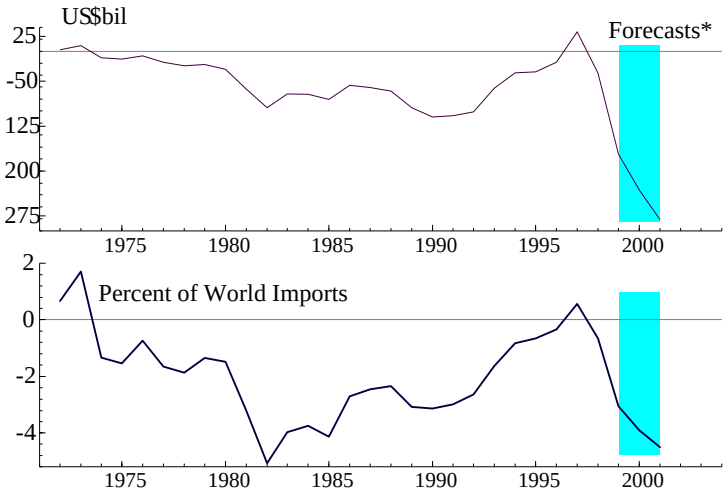


Figure 1: World Current-Account Discrepancy. * IMF's WEO May 2000

One tempting response to this statistical discrepancy is to develop a rule to allocate it across countries. Years of work by the IMF suggest, however, that reliance on such rules might distort further the countries' current-

account forecasts.[1] Indeed, the evolution of this discrepancy has no obvious statistical pattern and, thus, an allocation rule suitable for one year need not work in other years. Moreover, movements in the statistical discrepancy often reflect large and mutually offsetting movements in its components. This property can create the impression of improved accuracy when just the opposite is true (figure 2). Thus using a rule to allocate the aggregate discrepancy over 1993-97 would re-allocate relatively small amounts whereas allocating the components would reallocate large amounts. The results of the two reallocations could be, in principle, quite different.

Facing sustained and large discrepancies in the global current account with no reliable allocation rule leaves practitioners with two courses of action: Either ignore the discrepancy, and the internal consistency of global forecasts, or re-examine the associated current-account forecasts if the implied discrepancy is, in some sense, large. In other words, if we denote C_i as the current-account forecast for the ith country, then $D^c = \Sigma_{\forall i} C_i$ is the current-account discrepancy associated with those forecasts, and the question is whether D^c is large enough to merit a revision of the underlying $C_i s$.

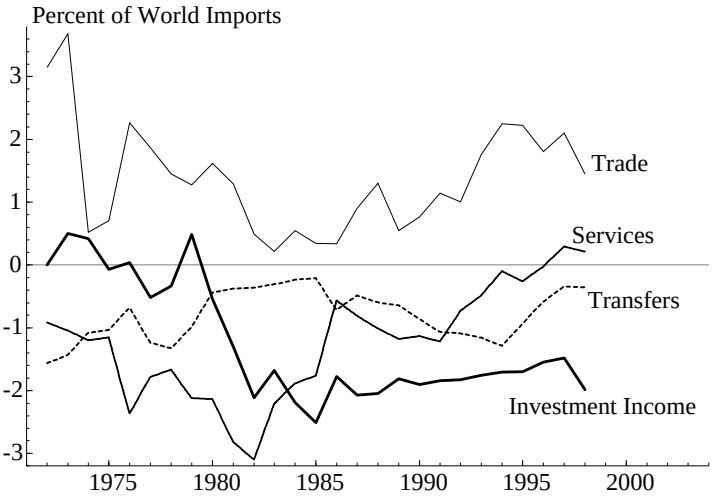


Figure 2: World Current-Account Discrepancy by Categories

Determining whether D^c is large involves specifying a reference value and this paper offers a practical approach to determining it. Specifically, as a

[1]The chief study on the global current-account discrepancy is the 1987 Report on the *World Current Account Discrepancy* (IMF 1987) which focuses on the 1983 discrepancy; its findings have been confirmed in IMF (1996, 1999a, 1999b). The appendix outlines the accounting principles and documents both data sources and time-series properties.

reference value we choose the expected value of the discrepancy. This choice allows us to define a discrepancy as large if it is significantly different from its conditional expectation. Implementing this choice involves first developing an econometric model explaining the components of the aggregate discrepancy, estimating the associated parameters, and using it to generate the distribution of the aggregate discrepancy; Sections 2-4 document the associated modeling aspects: level of disaggregation, functional form, explanatory variables, and estimation method.

To evaluate the usefulness of the model, Section 5 asks whether it can detect large discrepancies when large discrepancies are known to occur: not being able to detect a known significant change would question the model's usefulness. As a test case we use the switch in Europe's trade methodology in 1993, which is acknowledged to be responsible for large discrepancies (IMF 1997, page 9). We then generate ex-ante forecasts of the discrepancy through 2001 and compare them against those reported in the IMF's *World Economic Outlook* for May 2000. The model identifies the discrepancy in that report as large and calls for a re-thinking of the country-based forecasts.

2 Model Design

2.1 Aggregation

The model explains the global current-account discrepancy, D, as the sum of the discrepancies in four global accounts:

$$D = D_g(q) + D_i(q) + D_s(q) + D_u(q), \tag{1}$$

where q is a vector of explanatory variables, D_g is the global discrepancy in the trade account, D_i is the global discrepancy in the investment-income account, D_s is the global discrepancy in the service account, and D_u is the global discrepancy in the unrequited-transfers account.

The alternative to explaining the accounts' discrepancies is to develop a single-equation model for the overall discrepancy, as in Sheets (1998). A single equation is appealing because of its simplicity but it suffers from aggregation pitfalls. Specifically, the global discrepancy might be zero not because of accurate recordings but because discrepancies in various accounts are mutually offsetting (figure 2 above). Coefficient estimates of a single-equation would then reflect the happenstance of inaccurate recordings whereas coefficient estimates for separate equations would avoid them.

2.2 Analytical Framework

We differentiate between *actual* and *recorded* transactions. Let *actual* global credits in a given account be X_a and actual global debits be M_a, where $a = g, i, s, u$. Whereas $X_a \equiv M_a$, the corresponding *recorded* measures need not be identical:

$$\begin{aligned} X'_a &= X_a \cdot (1 + e_{xa}) \\ M'_a &= M_a \cdot (1 + e_{ma}),\ a = g, i, s, u, \end{aligned}$$

where the $'$ indicates a recorded magnitude, e_{xa} is the error in credits, and e_{ma} is the error in debits. The global discrepancy in that account is

$$\begin{aligned} \digamma'_a &= X'_a - M'_a \\ &= X_a - M_a + X_a \cdot e_{xa} - M_a \cdot e_{ma} \\ &= X_a \cdot (e_{xa} - e_{ma}),\ a = g, i, s, u. \end{aligned}$$

To translate this accounting identity into a statistical model, we postulate that $e_{xa} = e_{xa}(q, u_a)$ and $e_{ma} = e_{ma}(q, v_a)$ where u and v are random variables. Thus

$$\digamma'_a = X_a \cdot [e_{xa}(q, u_a) - e_{ma}(q, v_a)],\ a = g, i, s, u.$$

We now assume that

$$X_a = \theta_a \cdot z_a(q, w_a) \cdot M'_w,\ a = g, i, s, u,$$

where M'_w is recorded world imports and w_a is a random variable. With this assumption, we model the importance of a statistical discrepancy as

$$\frac{\digamma'_a}{M'_w} \equiv D_a = [\theta_a \cdot z_a(q, w_a)] \cdot [e_{xa}(q, u_a) - e_{ma}(q, v_a)],\ a = g, i, s, u.$$

which is non-linear in the variables included in q.

The appendix documents how we apply this framework to deriving estimating equations for each account's discrepancy. But to illustrate the key features of our approach, assume the simplest formulation:

$$\begin{aligned} e_{xat} - e_{mat} &= (e_{xa} - e_{ma})(\gamma_{a0} + \gamma_{a1} \cdot q_{1t} + u_{at}), u_{at} \tilde{} N(0, \sigma^2_{at}) \\ z_a(q, w_a) &= \pi_{a0} \cdot q_{1t} \text{ for } a = g, i, s, u. \end{aligned}$$

Then

$$\begin{aligned} D_a &= (e_{xa} - e_{ma}) \cdot [(\theta_a \cdot \pi_{a0}) \cdot \left(\gamma_{a0} \cdot q_{1t} + \gamma_{a1} \cdot q_{1t}^2 + q_{1t} \cdot u_t\right)] \\ &= (e_{xa} - e_{ma}) \cdot [\ell_{a0} \cdot q_{1t} + \ell_{a1} \cdot q_{1t}^2 + \ell_{a1} \cdot q_{1t} \cdot u_t],\ a = g, i, s, u. \end{aligned}$$

The term $(e_{xa} - e_{ma})$ embodies the factors that give rise to a statistical discrepancy in the first place: reporting mistakes and sampling errors. In the absence of these factors, the actual and the recorded transactions would be equal to each other and there would be no statistical discrepancy. The term in square brackets embodies the factors that account for movements in the (scaled discrepancy). For example, if q_{1t} is a variable capturing behavioral incentives to misreport by one of the transactors, then changes in those incentives will induce non-linear changes in the account's statistical discrepancy.

2.3 Statistical Framework

Our modeling recognizes the roles of simultaneity and dynamics. Simultaneity considerations arise because international transactions are recorded using the principle of double entry. This principle requires recording two accounts simultaneously and, thus, discrepancies in one account could reflect mismeasurements from another.[2] Dynamic considerations might arise because faulty recording practices are institutionalized and fixing them takes time. One formulation capturing these two features is

$$A_o \cdot \Lambda_t = A_1 \cdot \Lambda_{t-1} + B \cdot Q_t + U_t \quad (2)$$

$$D_t = 1' \cdot \Lambda_t, \quad (3)$$

where A_0 is a 4×4 matrix of coefficients recognizing the role of simultaneity; Λ_t is the 4×1 vector of discrepancies to be modeled ($\Lambda' = (D_g\ D_i\ D_s\ D_u)$); A_1 is a 4×4 matrix of coefficients capturing the importance of dynamic considerations; B is a $4 \times n$ matrix of coefficients; Q_t is the vector of explanatory

[2]For example, a donor country may record the value of a transfer as both a credit (e.g. merchandise exports for aid) and as a debit (unrequited transfer). The recipient country might debit the trade account (e.g. merchandise imports) and credit the capital account (e.g. capital inflow) instead of crediting unrequited transfers.

variables consisting of the entries in q_t as well as non-linear terms (more below); U_t is the vector of disturbances distributed as $IN(0, \Omega_{Ut})$; and $1'$ is a vector of ones.

The reduced form implied by equation (2) is

$$\begin{aligned} \Lambda_t &= \Pi_d \cdot \Lambda_{t-1} + \Pi_q \cdot Q_t + V_t \quad (4) \\ D_t &= 1' \cdot \Lambda_t, \quad (5) \end{aligned}$$

where $\Pi_d = A_o^{-1} \cdot A_1$, $\Pi_q = A_o^{-1} \cdot B$, and $V_t = A_o^{-1} \cdot U_t \tilde{} \; N(0, \Omega_{Vt})$. Section 4 uses the Full Information Maximum Likelihood method (FIML) for parameter estimation and Section 5 uses dynamic simulations to estimate the expected global discrepancy at time t as

$$\widehat{E}(D_t) = 1' \cdot \widehat{\Lambda}_t = 1' \cdot E(\widehat{\Pi}_d \cdot \widehat{\Lambda}_{t-1} + \widehat{\Pi}_q \cdot Q_t + V_t), \quad (6)$$

where "$\widehat{\ }$" denotes an estimated magnitude. Note that $\widehat{E}(D_t)$ is conditioning on the model's own generated values for the lagged endogenous variables and not on historical values. The estimate of the variance of the discrepancy at time t is

$$\widehat{var}(D_t) = 1' \cdot var(\widehat{\Pi}_d \cdot \widehat{\Lambda}_{t-1} + \widehat{\Pi}_q \cdot Q_t + V_t). \quad (7)$$

Note that $\widehat{var}(D_t)$ varies with changes in the explanatory variables. Furthermore, reliance on FIML allows for the correlations across the residuals of the model to affect $\widehat{var}(D_t)$.

One can use these equations to test whether the discrepancy embodied in countries' current-account forecasts, D_t^c, is large. Specifically, the null and alternative hypotheses are

$$\begin{aligned} H_o &: E(D_t) = D_t^c \\ H_1 &: E(D_t) \neq D_t^c, \end{aligned}$$

and the test statistic is

$$\tau = \frac{D_t^c - \widehat{E}(D_t)}{\sqrt{\widehat{var}(D_t)}}.$$

If $V_t \tilde{} N(0, \Omega_V)$, then finding that $|\tau| > 2$ means that D_t^c is statistically different from its expected value at the five percent significance level. We interpret such a finding a suggesting that D_t^c is large.

3 Model Assembly

3.1 Selection of Explanatory Variables

Looking to economic theory for what variables to include in q is not fruitful here because there is no economic theory of current-account discrepancies as such. Thus to select the explanatory variables, we identify the factors responsible for each account's discrepancy and then translate those forces into a list of macroeconomic variables.[3]

This approach yields too many variables to consider and thus, to discriminate among them, we invoke additional criteria. First, the data must be available on a timely basis. Arguing that a variable should be included in a model because its coefficient is highly significant loses its force if the associated data are available with a long delay. Second, given the annual frequency of observations, the number of explanatory variables should be as small as possible. Third, generating a forecast of q should not be more difficult than generating forecasts of the discrepancies directly. Finally, the estimation results cannot violate the maintained assumptions for the residuals. These assumptions are central to the definitions of a large discrepancy.

Discrepancies in Trade The factors responsible for a discrepancy in the global trade account are transportation delays, asymmetric valuations, and quality differentials in recording practices. Transportation delays in shipping merchandise imply that recorded increases in export credits are not accompanied by simultaneous recorded increases in import debits. To translate the role of these shipment delays into an explanatory variable, we assume that fluctuations in world trade are driven by fluctuations in economic activity. Thus faster world growth raises recorded exports ahead of recorded imports and raises net credits in the global trade balance.

Asymmetric valuations arise whenever different prices are used to value the same transaction. For example, recipients of OPEC oil subsidies could record oil imports (debits) at the subsidized price whereas OPEC could record the corresponding oil exports (credits) at the market price. In that case,

[3]Idiosyncratic recording practices can also induce discrepancies. For example, Bermuda, Cayman Islands, and Hong Kong combine direct-investment income with other income measures. Similarly, Middle Eastern oil exporters do not report cross-border investment income of private non-banks (IMF 1987, pages 57-58). By their nature, idiosyncratic factors lack an obvious representation in terms of a macroeconomic variable.

debits would increase less than credits inducing a discrepancy in the global trade account. Another example involves the use of different exchange rates to value the same transaction by at least one of the reporting countries. To model these valuation asymmetries we use the price of oil, as a proxy for commodity prices, and the U.S. federal funds rate, as a proxy for exchange rates. The alternative of including in q the numerous exchange rates would exhaust the degrees of freedom.

Differentials in recording quality across countries help explaining movements in the discrepancies. Specifically, if countries with high-quality data increase their share of world trade, then one would expect a reduction in the trade discrepancy. To model this possibility, we assume that the United States is the high-quality data country and postulate that if the US share of world imports increases, then there would be a reduction of the trade discrepancy, all else given. A more concrete example of the role of quality involves the change in methodologies for collecting intra-EU trade data by the European Union in 1993: A switch from custom records to value-added tax records (IMF 1997, page 9). The IMF estimates that this switch induced an excess of credits over debits of $40 billion per year (IMF 1999a, page 4). We model this effect with a dummy variable.[4]

Discrepancies in Investment Income Discrepancies in this account reflect misrecordings in portfolio-investment income and direct-investment income. These discrepancies stem from incentives to understate capital outflows, the growth of offshore financial centers, and recording idiosyncrasies.[5]

The incentive to underreport capital outflows arises from tax avoidance on the corresponding income. This tax-evasion incentive leads to an underreporting of investment income because accounting practices use cumulated capital outflows to estimate the corresponding stock of claims on foreigners

[4]To investigate this possibility further, we use the IMF's Direction of Trade that reports bilateral trade data. We then compute intra-EU credits and debits and find a sharp increase in net credits starting in 1993. As a fraction of EU imports from their members, the discrepancy increases from about one percent prior to 1993 to 7.3 percent in 1993. This gap reaches a maximum of 9.3 percent in 1996.

[5]Portfolio income includes interest payments/receipts among banks, interest and dividends on securities, commercial paper, mortgages, and supplier credits. Direct-investment income includes earnings of foreign subsidiaries, earnings of unincorporated business in foreign countries, and interest of foreign-incorporated affiliates and branches. The bulk of the discrepancies in Investment Income stem from discrepancies in portfolio-investment income.

which is then used to compute investment income. Thus understating capital outflows translates into understating the associated income. To model this factor, we assume that increases in the U.S. federal funds rate accentuate the incentive to understate capital outflows which results in an underestimate of the stock of claims on foreigners and the resulting investment income.

The growth of offshore financial centers is contributing to the discrepancy in investment income by undermining the ability of statistical agencies to track financial transactions. Specifically, such centers are largely unrelated to domestic activities of the host country and typically do not have to report to the host's statistical agencies.[6] Also, the associated transactions involve securitization with numerous participants not all of whom report to any national compilers.[7] Expecting financial innovation to grow over time, we use a trend to capture the effect of this process on the discrepancy.

Recording idiosyncrasies come in two flavors: misclassifications and asymmetries. Misclassifications arise from the ambiguity of the term *lasting interest,* which is the criterion for classifying foreign-direct investment. This ambiguity has led some countries to record reinvested earnings as a capital inflow from the parent company (IMF 1987, page 36) and not as investment income.[8] Asymmetries arise from cross-country differences in recording practices for a given transaction. For example, a donor country may record the value of the transfer as both a credit (e.g. merchandise exports for aid) and as a debit (unrequited transfer). The recipient country might debit the trade account (e.g. merchandise imports) but, and here is the asymmetry, credit the capital account (e.g. capital inflow) instead of crediting unrequited transfers. The measured inflow overstates the associated stock of liabilities and the corresponding investment income. Given that both misclassifications and asymmetries reflect institutional practices, we model the persistence of errors they induce by including the lag of the discrepancy of the investment-income account.

[6]The new offshore financial centers are located in Hong Kong, Singapore, Bahrain, Bahamas, Cayman Islands, and Panama; Bahrain's operations are recorded in that country's statistics. These centers offer unregulated operations and tax advantages not offered by traditional centers (New York, London, Zurich).

[7]Securitization takes place when direct loans by banks are replaced by underwriting commitments which do not appear on banks' balance sheets.

[8]The IMF's approach to measuring reinvested earnings requires direct questioning to multinational enterprises, which is difficult given the resources available. Given these difficulties, the IMF recommends dropping this account from the global sum of current accounts and investment-income accounts (IMF 1987, page 43).

Discrepancies in Services The discrepancy in services reflects misrecordings in travel expenses, shipping, and other transportation services. This discrepancy is declining but that trend conceals the growing importance of errors in shipping (table 1).[9]

Table 1: Discrepancies in Services Account ($bill)

	1991	1992	1993	1994	1995	1996	1997	1998
Services	-44.1	-28.1	-18.3	-4.0	-13.1	-1.3	16.6	12.0
Shipping	-50.6	-53.0	-55.8	-55.7	-66.3	-63.6	-64.8	-60.9

Source: IMF's BOP Statistics; see data appendix

Given that most countries have good records of their payments to foreign shippers, the discrepancy arises from underreporting of revenue by ship operators. Indeed, ship operators of the world's largest fleet claim Greece, Hong Kong, and Eastern Europe as residence but these economies do not report such earnings to the IMF (IMF 1996, page 146).[10]

To model this discrepancy we assume (1) that shippers seek to avoid income taxes and thus underreport their shipping revenues and (2) that their propensity to underreport is directly related to the price of oil. We use this price because oil is an important commodity in maritime transportation and because the price of oil is correlated with the prices of other raw materials.[11]

Counteracting the effects of underreporting credits is the adoption of alternative modes of transportation. Specifically, declines in the physical weight of products allow their transportation using the growing air fleet. The associated tight security procedures virtually guarantee that all the items transported are accounted for leaving little room for misreporting. To the extent that the decline in physical weight of products will continue, we use a time trend to capture how substitution away from maritime shipping reduces the scope for underreporting export services.

[9] Shipment debits include the cost of freight, insurance, and those distribution services paid by the importer; shipment credits include gross revenue on freight earned by vessels operated by residents of the reporting country regardless of the flag registry of the vessel.

[10] Moreover, the Greek balance of payments excludes the operations of the Greek fleet because the owners of that fleet do not reside in Greece and, as far as the IMF is aware, they are not residents in other countries either (IMF 1987, page 90).

[11] We also considered the IMF's Commodity Price Index but we did not find it to exert a significant influence on the behavior of discrepancies.

Discrepancies in Unrequited Transfers Discrepancies in transfers arise from two sources: the recording asymmetries of workers' remittances and the exclusion of the intermediation by international-donor organizations from balance of payments accounts. Asymmetries in recording remittances arise when (1) the host country treats temporary workers as residents, recording their remittances as unrequited transfers; and (2) the country of origin also treats these workers as residents, recording their remittances not as unrequited transfers but as service exports (IMF 1987, page 104).

Intermediation by international-donor agencies are excluded from countries' balance of payments because these agencies are not considered residents of any country; some of these agencies report to the IMF. As long as this intermediation operates without delays, the transaction by itself does not generate a statistical discrepancy. Over a given horizon, however, these institutions receive contributions for assistance in excess of what their disbursements. The shortfall in disbursements is not recorded because these international institutions do not conform to the principle of residency (IMF 1987, page 103) giving rise to the account's discrepancy.[12]

A convenient way of modeling this feature is to recognize that if the share of intermediation by international institutions declines, then so will the discrepancy they induce. The share of intermediation declines when donor countries provide their assistance directly to recipient countries and avoid the side effects of the intermediary role of international institutions (delays and residency). To this end we assume that OPEC members, who have been important donors in the past, are more likely to be donor countries the higher is the price of oil. An increase in that price would, if we are correct, translate into greater assistance from OPEC, a reduction in the intermediation from international institutions, and a decline in the excess of debits over credits in transfers.

Summary Table 2 lists the factors we have identified to explain movements in the various discrepancies. This list is what we denoted as q :

$$q' \quad = \quad (\tfrac{dY}{Y} \quad P_o \quad R \quad M_{us} \quad dum \quad trend) \ .$$

[12]From an accounting standpoint, the transfer from a donor country to an international institution is recorded in the donor's accounts as a credit in the capital account and a debit in unrequited transfers. The transaction from the international institution to the recipient country is recorded in the recipient's accounts as a debit in capital account and a credit in the unrequited transfer account.

To recognize the role of nonlinearities, we expand this list to include the squares of the price of oil and the interest rate as well as the interactions between these two variables and the trend. The resulting list of explanatory variables is denoted as Q :

$$Q' = (Intercept\ q'\ P_o^2\ R^2\ P_o \cdot trend\ R \cdot trend),$$

We want to emphasize that table 2 does not offer a list of zero restrictions on the coefficients of the reduced form. The simultaneous character of the model allows all exogenous variables to affect the discrepancies in all of the accounts and our statistical analysis allows for that possibility.

Table 2: Factors Explaining the Global Discrepancies

Variables: q	Factor Modeled	Account
World Growth: $\left(\frac{dY}{Y}\right)$	Recording Delays	Trade
Oil Prices: P_o	Valuation Asymmetries	Trade
	Tax Evasion	Services
	Disbursement Delays	Transfers
US Interest Rate: R	Tax Evasion	Inv. Income
	Valuation Asymmetries	Trade
US Share of World Imports: M_{us}	Quality Differentials in Data	Trade
Trend: $trend$	Financial Globalization	Inv. Income
	Transportation Technology	Services
Dummy Europe: dum	Methodological Changes	Trade

3.2 Parameter Estimation

Based on annual data from 1972 to 1998, table 3 shows the least-squares estimates for the unrestricted reduced form, equation(4). The results reveal numerous t-ratios below the 5% critical value, which is not surprising given

the relatively small number of degrees of freedom. Second, the maintained assumptions for the residuals are supported empirically.[13]

Table 3: Estimates of Unrestricted Reduced Form–OLS: 1972-98

	Trade D_{gt}	Services D_{st}	Investment D_{it}	Transfers D_{ut}
D_{gt-1}	0.15	-0.26	-0.19	0.04
D_{st-1}	0.02	-0.06	0.08	0.46*
D_{it-1}	-0.12	0.54	0.24	-0.12
D_{ut-1}	-0.29	-0.24	0.31	1.05*
$\frac{dY}{Y}$	0.37*	-0.03	0.26*	0.01
P_o	-0.24*	-0.11	0.15	0.03
R	-0.49	0.50	0.57	0.09
M_{us}	-0.19	0.17	-0.34*	-0.04
$trend$	-0.07	0.18	0.12	-0.04
dum	0.63	0.06	0.58	0.17
P_o^2	0.01*	0.00	-0.004	0.003
R^2	0.02*	-0.01	-0.012	-0.01
$P_o \cdot trend$	0.00	0.003	-0.003	0.00
$R \cdot trend$	0.01	-0.02	-0.02	-0.002
$Intercept$	6.67*	-5.70*	0.14	0.71
SER	0.297	0.354	0.337	0.181

* t-ratio above the 5% level. P_o=Oil price; R=Federal Funds Rate; $\frac{dY}{Y}$=World Growth; dum=Dummy for European Trade; M_{us}=US share in World Imports.

Hypothesis Testing

Null Hypothesis:	Test Statistic	Result (p-level)
Residuals are jointly normal	$\chi^2(8)$	11.845 (0.16)
Residuals are jointly ser. independent	F(16, 12)	1.54 (0.23)

[13]We test for joint normality using the Jarque-Bera test; the statistic is distributed as $\chi^2(n \cdot 2)$ where n is the number of equations. We test for joint serial independence with an F-test for the hypothesis that the coefficients for VAR(1) of the estimation residuals are jointly equal to zero. We applied an ARCH test to each equation separately and the results cannot reject (not shown) the hypothesis of homoskedasticity. See Hendry and Doornik (1996) for details.

Using a log-likelihood ratio test, we eliminate variables that are not jointly significant and re-estimate the parameters of the restricted reduced form using FIML. According to the estimates, the data support the maintained assumptions for the residuals (table 4) but persistence effects are small and limited to discrepancies in transfers.

Table 4: Estimates of Restricted Reduced Form–FIML: 1972-98[a]

	Trade D_{gt}		Services D_{st}		Investment D_{it}		Transfers D_{ut}	
D_{gt-1}	-		-		-		-	
D_{st-1}	-		-		-		0.35	(0.08)
D_{it-1}	-		0.25	(0.11)	-		-	
D_{ut-1}	-		-		-		0.84	(0.1)
$\frac{dY}{Y}$	0.40	(0.03)	-		0.23	(0.06)	-	
P_o	-0.20	(0.03)	-0.11	(0.02)	0.11	(0.04)	-	
R	-0.07	(0.03)	0.14	(0.06)	0.23	(0.03)	-	
M_{us}	-0.25	(0.04)	0.13	(0.06)	-0.30	(0.06)	-	
$trend$	-		0.09	(0.03)	-		-0.02	(0.01)
dum	0.86	(0.03)	-		0.58	(0.18)	-	
${P_o}^2$	0.005	(0.0006)	-		-0.003	(0.001)	0.0007	(0.0001)
R^2	-		-		-		-	
$P_o \cdot trend$	-		0.005	(0.001)	-		-	
$R \cdot trend$	0.004	(0.001)	-0.01	(0.004)	-0.01	(0.002)	-	
$Intercept$	5.56	(0.62)	-3.4	(1.15)	1.11	(0.70)	0.34	(0.25)
SER	0.281		0.339		0.329		0.173	

[a] Entries in parentheses are heteroskedasticity corrected standard errors. P_o=Oil price; R=Federal Funds Rate; $\frac{dY}{Y}$=World Growth; dum=Dummy for European Trade; M_{us}=US share in World Imports.

Hypothesis Testing

Null Hypothesis:	Test Statistic	Result (p-level)
Residuals are jointly normal	$\chi^2(8)$	3.57 (0.89)
Residuals are jointly ser. independent	F(16, 37)	0.84 (0.64)
Overidentifying restrictions hold	$\chi^2(31)$	34.57 (0.30)

Also, the dummy for the switch in European data methods is positive, significant, and suggests that the switch of recording practices of Europe raised the trade discrepancy by about 0.9 percentage points of world imports. The coefficient for the trend is positive and significant for services: the underreporting of credits due to maritime shipping is ameliorated by the growing role played by the alternatives to maritime shipping.

Non-linearities (interactions and squared terms) have statistically significant coefficients which calls for model simulations to evaluate the effects of changes in the remaining variables; we use one-year shocks evaluated in 1998. Based on these simulations, a 10 percent increase in the price of oil lowers net credits in the global discrepancy by 0.03 percent of world imports (table 5). This small effect reflects offsetting responses from the various accounts. An increase of the federal funds rate by one percentage point lowers net credits in the discrepancies for investment income and services; the overall discrepancy declines by 0.24 percent of world imports or about $13 billion. Raising the world's growth rate by one percentage point increases net credits in the trade discrepancy: faster growth accelerates trade and accentuates the extent to which trade credits are recorded ahead of trade debits. The overall discrepancy experiences an increase in net credits of 0.64 percentage points of world imports or about $35 billion.

Table 5: Responses to Exogenous Shocks[a]

$\frac{Shock\rightarrow}{\downarrow \mathrm{Re}\, sponse}$	ΔP_o	ΔR	$\Delta \frac{dY}{Y}$	ΔM_{us}
ΔD_{gt}	-0.10	0.03	0.40	-0.25
ΔD_{it}	0.03	-0.12	0.23	-0.30
ΔD_{st}	0.02	-0.15	0.00	0.13
ΔD_{ut}	0.02	0.00	0.00	0.00
ΔD	-0.03	-0.24	0.64	-0.42

[a] Fraction of world imports in 1998 ($5543 billion, IFS, Sep. 1999).

An increase of the US share of world imports by one percentage point reduces net credits in the trade discrepancy by 0.25% of world imports ($14 billion) given that a greater fraction of world trade is being recorded by the country with the high-quality data. Higher US imports also affect the investment-income discrepancy given that financing an increase of US imports involves an increase in foreign capital outflows. The underreporting of these outflows accentuates the understating of claims of the rest of the world on the United States and the associated interest receipts. Finally, to

the extent that a fraction of the increase in U.S. imports is transported by the U.S. fleet, shipping credits that would not have been recorded are now being reported with an increase in net credits of the service discrepancy.

Figure 3 compares historical values against model predictions.[14] Judging by the mean absolute errors (MAE), either as a percentage of world imports and in US dollars, the predictions of the model are close to historical values and the residuals are not one-sided. The exception is the transfer equation which shows systematic deviations during the 1990s.

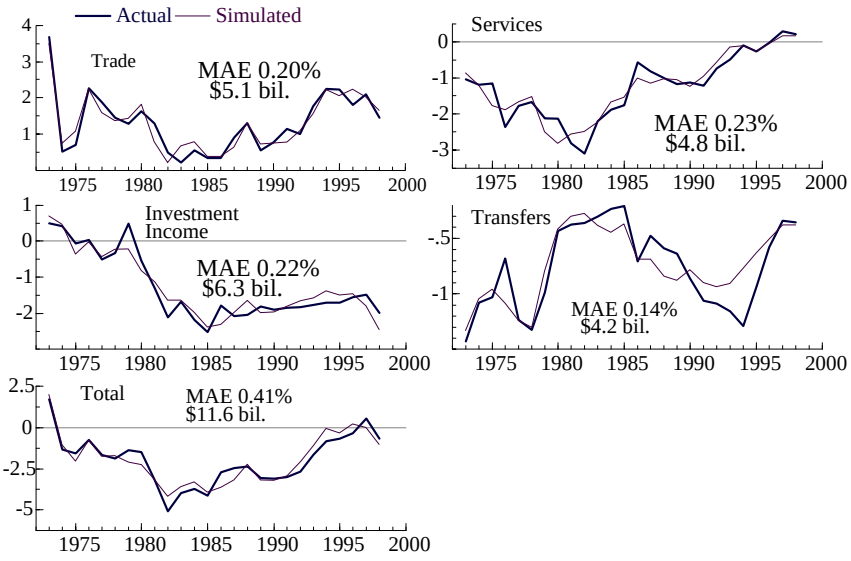


Figure 3: Actual and Simulated Values-Constrained Reduced Form

4 Model Applications

For the model developed here to be useful, it should detect large discrepancies when large discrepancies are known to occur. According to the IMF (IMF 1997, page 9), the change in European methodology for collecting trade data induced a major increase in the trade discrepancy and the question is whether

[14]The predicted value is $\widehat{\Lambda}_t = \widehat{\Pi}_d \cdot \widehat{\Lambda}_{t-1} + \widehat{\Pi}_q \cdot Q_t$ and thus we use the model's own predictions for the lagged endogenous variables instead of the historical values.

the model detects it as such. Thus, the null and alternative hypotheses are

$$\begin{aligned} H_o &: E(D_t) = D_t^c \\ H_1 &: E(D_t) \neq D_t^c, \end{aligned}$$

where D_t^c is the observed value for the discrepancy at date t, t=1993-98. A rejection of the null hypothesis means that the model identifies as large the change in European methods to collect data.

Being able to identify statistically large discrepancies is a necessary but not a sufficient condition to judge the model's usefulness. Specifically, this switch is credited with an *increase* in net credits of the trade discrepancy. Thus model predictions that exclude the switch from the data used for parameter estimation should understate net credits in the trade discrepancy. Also, the recorded increase in the trade discrepancy tended to offset the discrepancy in investment income (see figure 2 above) and induced a seemingly small recorded global discrepancy. Thus model predictions that exclude the switch should show a worsening of the global discrepancy. Finally, we need evidence of stability in the model's parameters to avoid confusing the effects of parameter instability with the effects of changes in data-collection methods.

To implement the test, we start by estimating the model's parameters with data through 1992, which excludes post-switch observations. Comparing the estimation results to those based on the full-sample reveals that both sets of parameter estimates are virtually identical (table 6). With one exception, neither sign nor statistical significance of the estimates change as a result of using the shorter sample.[15] Also, the maintained assumptions for the residuals are supported empirically. Moreover, relative to the parameters of the unrestricted reduced form estimated with data through 1992, the log-likelihood ratio test does not reject the same set of zero restrictions. Overall, this evidence rules out parameter instability as a factor in a finding of large discrepancies.[16]

[15] The exception is the coefficient for interaction of trend and oil prices in the service equation: significant with the full sample and insignificant otherwise.

[16] We examined the sensitivity of the estimated parameters (unconstrained and restricted reduced forms) to using the Libor rate on six-month instruments instead of the US Federal funds rate. We find that the point estimates are quite robust but the zero restricitions for the shorter sample are rejected for the model based on the Libor rate. Thus one cannot determine whether ex-post tests from the Libor-based model are due to parameter instability.

Given the coefficient estimates, we use dynamic simulations to generate predictions for 1993-98 with 1992 as the initial condition:

$$\begin{aligned} \widehat{\Lambda}_t &= \widehat{\Pi}_{sd} \cdot \widehat{\Lambda}_{t-1} + \widehat{\Pi}_{sq} \cdot Q_t \\ \widehat{E}(D_t) &= 1' \widehat{\Lambda}_t \text{ for } t = 1993 - 98, \end{aligned}$$

where the subscript $_s$ denotes that the estimates use the short sample (1972-1992). If

$$\left| D_t^c - \widehat{E}(D_t) \right| > \widehat{\delta}_t = 2 \cdot \sqrt{\widehat{var}(\widehat{D_t})},$$

then the observed discrepancy differs significantly from its expected value and we interpret this result as a large discrepancy.

Table 6: Parameter Estimates with FIML: 1972-98 and 1972-92

	Trade D_{gt}		Services D_{st}		Investment D_{it}		Transfers D_{ut}	
	72-98	72-92	72-98	72-92	72-98	72-92	72-98	72-92
D_{gt-1}	-	-	-	-	-	-	-	-
D_{st-1}	-	-	-	-	-	-	0.35	0.35
D_{it-1}	-	-	0.25*	0.33*	-	-	-	-
D_{ut-1}	-	-	-	-	-	-	0.84*	0.84*
$R \cdot trend$	0.004*	0.004*	-0.01*	-0.01*	-0.01*	-0.01*	-	-
$trend$	-	-	0.09*	0.17*	-	-	-0.02*	-0.02*
P_o	-0.20*	-0.25*	-0.11*	-0.07*	0.11*	0.20*	-	-
${P_o}^2$	0.005*	0.01*	-	-	-0.003*	-0.005*	0.0007*	0.0007*
R	-0.07*	-0.10*	0.14*	0.16*	0.23*	0.25*	-	-
$\frac{dY}{Y}$	0.40*	0.36*	-	-	0.23*	0.30*	-	-
$P_o \cdot trend$	-	-	0.005*	0.001	-	-	-	-
M_{us}	-0.25*	-0.21*	0.13*	0.16*	-0.30*	-0.32*	-	-
$Intercept$	5.56*	5.83*	-3.4*	-4.44*	1.11	0.45	0.34	0.36
SER	0.281	0.294	0.339	0.356	0.329	0.331	0.173	0.183

* Statistical significance at the 5% level

Hypothesis Testing with observations ending in 1992

Null Hypothesis:	Test Statistic	Result (p-level)
Vector of residuals is normal	$\chi^2(8)$	8.19 (0.41)
Vector of residuals is ser. independent	F(16, 22)	1.77 (0.11)
Overidentifying restrictions hold	$\chi^2(29)$	41.14 (0.07)

Figure 4 reports the results which reveal statistically significant underpredictions in the trade discrepancy and overprediction for the overall discrepancy, just as one expects. Overall, the results show that the model's confidence intervals are narrow enough to detect the European switch in data recording procedures as a major development. By itself, this finding does not constitute an endorsement of the approach. However, not being able to identify a known significant change would question its usefulness.

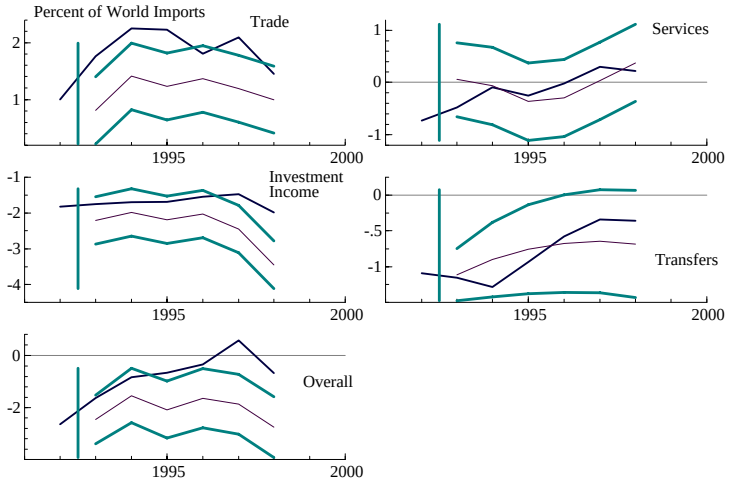


Figure 4: 95% Confidence Bands for Forecast Discrepancies–1993-98

We now test whether the IMF's latest figures for the overall discrepancy over 1999-2001 are large. To this end we use the IMF's extrapolations for the exogenous variables (table 7).[17]

Table 7: Assumptions for Exogenous Variables

	$P_o(\frac{\$}{b})$	$R(\%)$	$\frac{dY}{Y}(\%)$
1999	17.1	5.2	3.3
2000	23.1	5.8	4.2
2001	18.7	6.3	3.9

Source: IMF (2000)

[17] We apply the growth rates for oil prices reported on IMF (2000, page 277) to a 1998 oil price of \$12.3 per barrel. For the interest rate, we combine the projections for the real world interest rate (IMF, 2000, page 277) with the projections for inflation in the US GDP deflator (IMF, 2000, page 215). For the world growth rate, we use the projections reported on IMF(2000, page 277).

The results suggest that the IMF's current-account predictions embody a global discrepancy, D_t^c, that is significantly below our model's expectation of that discrepancy, $\widehat{E}(D_t)$ (figure 5). This finding calls, according to our approach, for a re-thinking of the current-account forecasts for the individual countries.

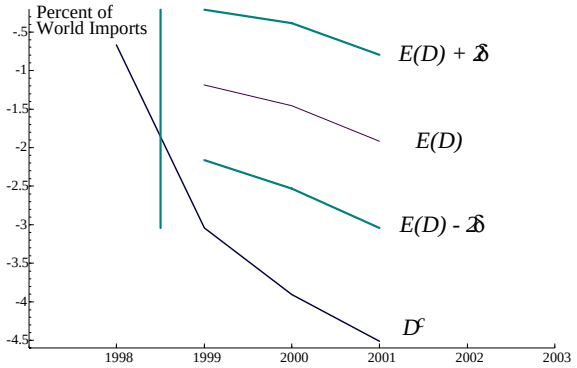


Figure5: 95% Confidence Band for Forecasts of Global Discrepancy

5 Conclusions

This paper offers a framework for judging when the discrepancy embodied in current-account forecasts is large. To this end, the first step involves developing an econometric model explaining the components of the aggregate discrepancy, estimating the associated parameters, and generating the aggregate discrepancy's conditional expectation. The second step is to compare this model-based forecast with the discrepancy embodied in countries' current-account forecasts. If the gap in discrepancies is below a critical value, then the discrepancy embodied in the countries' current-account forecasts is not large. Otherwise, the discrepancy is large and calls for a careful re-examination of the associated current-account forecasts.

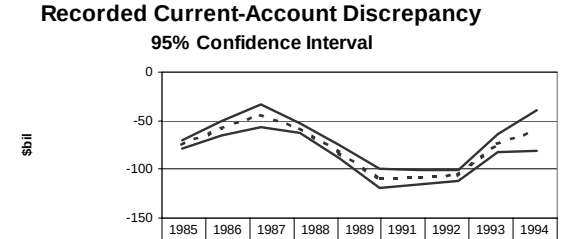
Econometric modeling of these discrepancies is not the obvious first step in addressing global discrepancies. The first obvious step is to design fixed rules to allocate the discrepancies across countries. Though appealing, reliance on rules is at odds with the often large and mutually offsetting movements in the discrepancies of the components of the current-account and thus might distort further countries' current-account forecasts. Econometric

modeling of discrepancies, unusual as it is, offers a well-defined framework for determining when discrepancies in the global current account are unusual.

6 Data Appendix

Recording Principles Recording international transactions involves two principles: double entry and residency. The principle of double entry requires that every increase in asset must be offset by a decrease in another asset or by an increase in a liability. Thus every transaction is recorded as both a debit (increase in assets) *and* as a credit (decrease in asset or increase in liabilities). The principle of residency restricts the recording to transactions between *residents* of one country and residents of the rest of the world. That is, residency of the transactor, and not citizenship, is the determinant factor for recording the transaction.

Data Sources The published discrepancy for a given year is subject to large revisions in subsequent data releases. For example, the value for the 1994 discrepancy ranges from -$75 billion in the 1995 data release to less than -$50 billion in the 1998 data release. Thus each observation in figure 1 comes from the most recent release containing data for that year. To get a sense of the range of uncertainty, we treat a year's observations from various releases as independent draws and construct the 95% confidence band (figure 6). We find that reductions in the mean discrepancy are accompanied by an increase in the range of uncertainty.



	1985	1986	1987	1988	1989	1991	1992	1993	1994
mean	-74.5	-57.38	-44.45	-57.94	-81.99	-108.3	-106.1	-73.16	-60.35
upper bound	-69.94	-50.14	-32.62	-53.23	-75.61	-101	-100.6	-63.51	-39.08
lower bound	-79.06	-64.62	-56.28	-62.65	-88.36	-115.5	-111.5	-82.81	-81.62
# of observations	4	5	6	7	7	7	6	5	4

Figure 6: 95% Confidence Interval for the Mean Discrepancy

One reason for the large revisions is the difficulty of gathering a comprehensive information set for a given date. For discrepancies in investment income, the IMF assumes that debit measures are reliable, collects data on cross-border assets and liabilities (from the BIS), applies rates of returns, and then estimates income credits. For shipping, the IMF estimates revenues by allocating operators' world tonnage by country, estimating a price per ton, and allocating credits to the non-reporting countries.

The source for all years is:

1972 data from 1979 BOP Vol. 30
1973 data from 1980 BOP Vol. 31
1974 data from 1981 BOP Vol. 32
1975 data from 1982 BOP Vol. 33
1976 data from 1983 BOP Vol. 34
1977 data from 1984 BOP Vol. 35
1978 data from 1985 BOP Vol. 36
1979 data from 1986 BOP Vol. 37
1980 data from 1987 BOP Vol. 38
1981 data from 1988 BOP Vol. 39
1982 data from 1989 BOP Vol. 40
1983 data from 1990 BOP Vol. 41
1984 data from 1991 BOP Vol. 42
1985 data from 1992 BOP Vol. 43
1986 data from 1993 BOP Vol. 44
1987 data from 1994 BOP Vol. 45
1988 data from 1995 BOP Vol. 46
1989 data from 1996 BOP Vol. 47
1990 data from 1997 BOP Vol. 48
1991 data from 1998 BOP Vol. 49
1992-1998 data from 1999 BOP Vol. 50
Spot World US$ per barrel for oil: IMF 00176AAZ
Federal Funds Rate: IMF 11160B
World Imports: IMF 00171D
US Imports: IMF 11171D
GDP Growth: IMF 1997 Yearbook 'GDP at Constant Prices' p. 144-45

Time-series Properties The regressions presented earlier assume that the variables have the same degree of stationary. To test whether that property holds, we use an Augmented Dickey-Fuller (ADF) test with a constant and three lags.

Augmented Dickey-Fuller Tests–1972-98

Exogenous Variables	ADF	Discrepancy	ADF
Price of Oil	-1.91	Trade	-1.09
Fed. Funds Rate	-1.10	Income	-1.88
US share of World Imports	-2.05	Service	-0.63
World Growth	-2.88	Transfers	-2.02

5% value is -2.997; 1% value is -3.75

The evidence suggests that one cannot reject the hypothesis that all of the variables used here are integrated of order one.

7 Model Appendix

Model for Discrepancies in Trade We use a two-country world and differentiate *actual* from *recorded* measures. For country one, the actual trade account is

$$T_{1t} = P_{x1t} \cdot X_{1t} - P_{m1t} \cdot M_{1t},$$

where X is real exports, M is real imports, P_x is the export price index, and P_m is the import price index. The recorded trade account is

$$T'_{1t} = P'_{x1t} \cdot X'_{1t} - P'_{m1t} \cdot M'_{1t},$$

where the $'$ indicates a recorded magnitude.

Without loss of generality, we now assume that measurement errors stem from inaccurate recordings of trade volumes only:

$$\begin{aligned} T'_{1t} &= P_{x1t} \cdot X_{1t} \cdot (1 + e_{x1t}) - P_{m1t} \cdot M_{1t} \cdot (1 + e_{m1t}) \\ &= T_{1t} + P_{x1t} \cdot X_{1t} \cdot e_{x1t} - P_{m1t} \cdot M_{1t} \cdot e_{m1t}, \end{aligned}$$

where the e's denote percent errors.[18] Re-arranging gives

$$T'_{1t} - T_{1t} = P_{x1t} \cdot X_{1t} \cdot e_{x1t} - P_{m1t} \cdot M_{1t} \cdot e_{m1t}.$$

[18] If one allows for errors in prices and quantities, then one gets $T'_{1t} = T_{1t} + P_{x1t} \cdot X_{1t} \cdot (e_{x1t} + e_{px1t} + e_{x1t} \cdot e_{px1t}) - P_{m1t} \cdot M_{1t} \cdot (e_{m1t} + e_{pm1t} + e_{m1t} \cdot e_{pm1t})$.

Thus, in the absence of errors, the actual and the recorded balance of trade are equal. By analogy, the trade discrepancy for the second country is

$$T'_{2t} - T_{2t} = P_{x2t} \cdot X_{2t} \cdot e_{x2t} - P_{m2t} \cdot M_{2t} \cdot e_{m2t}.$$

Recognizing that actual world exports and world imports are equal to each other–that is, $T_{1t} + T_{2t} = 0$, we get the global discrepancy in goods trade:

$$\begin{aligned} T'_{wt} &= (T'_{1t} - T_{1t}) + (T'_{2t} - T_{2t}) = T'_{1t} + T'_{2t} \\ &= P_{x1t} \cdot X_{1t} \cdot e_{x1t} - P_{m1t} \cdot M_{1t} \cdot e_{m1t} + P_{x2t} \cdot X_{2t} \cdot e_{x2t} - P_{m2t} \cdot M_{2t} \cdot e_{m2t}. \end{aligned}$$

To translate this accounting identity into a statistical formulation, we make the following assumptions:

1. Recording practices understate trade flows in real terms: $E(e_{xit}) < 0$, $E(e_{mit}) < 0$. Understating exports is consistent with the idea that, lacking a tariff-revenue incentive, government supervision of the outflow of goods is not likely to be tight. For imports, the presence of tariffs create an incentive to misreport or to introduce foreign products through smuggling.

2. Recording practices understate imports to a greater extent than they understate exports– that is, $E(e_{xit} - e_{mit}) > 0$. This assumption is consistent with transportation delays: an increase in export credits is accompanied by the corresponding increase in import debts only with a delay. To the extent that a fraction of world exports in one year are recorded in the subsequent year, then one can expect a positive trade discrepancy, which is what figure 2 shows.

3. Measurement errors in exports are the same across countries: $e_{x1t} = e_{x2t} = e_{xt}$.

4. Measurement errors in imports differ across countries: $e_{m1t} = e_{m2t} + \theta, \theta > 0$ which says that the measurement errors of imports for country 1 are smaller than those of country 2 given the assumption that $E(e_{mit}) < 0$.

5. Trade depends on income–$M_{it} = \beta Y_{it}$–and thus measurement errors have a cyclical component:

$$e_{xt} - e_{m2t} = (e_x - e_{m2}) \left(\gamma_0 + \gamma_1 \left(\frac{dY}{Y} \right)_t + u_t \right), u_t \tilde{} N(0, \sigma^2),$$

where $(e_x - e_{m2}) > 0$ and $\left(\frac{dY}{Y}\right)$ is the world's growth rate. To determine the sign of γ_1, we set prices equal to one and find that

$$sign(\gamma_1) = sign(\frac{dT'_{wt}}{dY}) = sign(2\beta(e_x - e_m)) > 0.$$

Substituting assumptions (3)-(4) into the equation for T'_w yields

$$T'_{wt} = (P_{x1t} \cdot X_{1t} + P_{x2t} \cdot X_{2t})e_{xt} - (P_{m1t} \cdot M_{1t} + P_{m2t} \cdot M_{2t})\, e_{m2t} - (P_{m1t} \cdot M_{1t})\theta.$$

Dividing both sides by $MV_{wt} = P_{m1t} \cdot M_{1t} + P_{m2t} \cdot M_{2t}$ yields

$$\frac{T'_{wt}}{MV_{wt}} = \left(\frac{(P_{x1t} \cdot X_{1t} + P_{x2t} \cdot X_{2t})}{(P_{m1t} \cdot M_{1t} + P_{m2t} \cdot M_{2t})}\right) e_{xt} - e_{m2t} - \left(\frac{P_{m1t} \cdot M_{1t}}{MV_{wt}}\right)\theta.$$

Recognizing that the first term is equal to one given that actual exports equal actual imports yields

$$\frac{T'_w}{MV_{wt}} = (e_{xt} - e_{m2t}) - \theta\left(\frac{P_{m1t} \cdot M_{1t}}{MV_{wt}}\right). \tag{8}$$

Substituting assumption (5) into equation (8) gives

$$\frac{T'_{wt}}{MV_{wt}} = (e_x - e_{m2})\gamma_0 - \theta\left(\frac{P_{m1t} \cdot M_{1t}}{MV_{wt}}\right) + (e_x - e_{m2})\gamma_1\left(\frac{dY}{Y}\right)_t + u_t.$$

If one were to assume that the country with the high-quality data is the United States, then the term $\left(\frac{P_{m1t} \cdot M_{1t}}{MV_{wt}}\right)$ would be measured as the ratio of US merchandise imports relative to world imports, M_{us}. Abstracting from persistence and simultaneity, we get a list of variables that appear, at least a priori, relevant to explaining the trade discrepancy:

$$\frac{T'_{wt}}{MV_{wt}} = \delta_0 + \delta_1 M_{us} + \delta_2\left(\frac{dY}{Y}\right)_t + u_t. \tag{9}$$

We anticipate that $\delta_1 = -\theta < 0$ meaning that the increase in the share of world imports of the country with high-quality data lowers the discrepancy in the global trade account. We expect that $\delta_2 = (e_x - e_{m2})\gamma_1 > 0$ meaning that an increase in the world's growth rate worsens the trade discrepancy.

Model for Discrepancies in Investment Income Let X_t be the actual stock of world assets and R_t be the rate of return. Thus actual income credits, $R_t X_t$, are

$$R_t X_t = R_t \cdot \sum_{i=0}^{\infty} \Delta X_{t-i},$$

where $X_t = \sum \Delta X_{t-i}$ reflects statistical agencies' practice of using cumulated capital outflows to measure claims on foreigners. Assuming that the recording errors stem understating of capital outflows, the recorded income credits, $R_t X'_t$ are equal to

$$\begin{aligned} R_t X'_t &= R_t \cdot \sum_{i=0}^{\infty} \Delta X_{t-i}(1 + ex_{t-i}) \\ &= R_t \cdot \sum_{i=0}^{\infty} \Delta X_{t-i} + R_t \cdot \sum_{i=0}^{\infty} \Delta X_{t-i} \cdot ex_{t-i} \\ &= R_t \cdot X_t + R_t \cdot \sum_{i=0}^{\infty} \Delta X_{t-i} \cdot ex_{t-i}, \end{aligned}$$

where the $'$ indicates a recorded magnitude and $ex_{t-i} < 0$ is the under-reporting of capital outflows.

The gap between reported and actual credits, $R_t X'_t - R_t X_t \equiv I'_{wt}$ is

$$\begin{aligned} I'_{wt} &= R_t \cdot \sum_{i=0}^{\infty} \Delta X_{t-i} \cdot ex_{t-i} \\ &= R_t \cdot \Delta X_t \cdot ex_t + R_t \sum_{i=1}^{\infty} \Delta X_{t-i} \cdot ex_{t-i} \\ &= R_t \cdot \Delta X_t \cdot ex_t + \left(\frac{R_t}{R_{t-1}}\right) R_{t-1} \sum_{i=1}^{\infty} \Delta X_{t-i} \cdot ex_{t-i} \\ &= R_t \cdot \Delta X_t \cdot ex_t + \left(\frac{R_t}{R_{t-1}}\right) I'_{w,t-1}. \end{aligned} \tag{10}$$

In the absence of measurement errors ($ex_{t-i} = 0$ for all i), the discrepancy in investment income vanishes.

To translate this accounting result into a formulation explaining movements of this discrepancy we make the following assumptions:

1. The incentive to underreport capital flows is directly related to the return on those flows.

2. The effect of increasing integration of financial markets and financial innovation on the ability of governments to record the associated transactions can be captured by a trend.

3. Capital outflows are proportional to world trade:$\Delta X_t = \ell \cdot MV_{wt}, \ell > 0$.

4. The processes for the logarithms of world imports and asset returns are $\ln MV_{wt} = \mu_m + \ln MV_{wt-1} + u_{mt}$ and $\ln P_t = \mu_p + \ln P_{t-1} + u_{pt}$.

We express the first two assumptions as

$$ex_t = ex_0 \left(\theta_0 + \theta_1 \cdot R_t + \theta_2 \cdot t + u_t\right), u_t \tilde{} N(0, \sigma_u^2),$$

where we expect $\theta_1 < 0$ meaning that an increase in the return of the asset creates an incentive to underreport capital outflows–that is, to make ex_t more negative. Similarly, we expect $\theta_2 < 0$ meaning that increasing financial integration facilitates underreporting of capital flows and therefore worsens ex_t. Substituting the expression for ex_t into eq. (10) we get

$$I'_{wt} = \Delta X_t \cdot ex_0 \left(\theta_0 \cdot R_t + \theta_1 \cdot R_t^2 + \theta_2 \cdot t \cdot R_t + u_t\right) + \frac{R_t}{R_{t-1}} I'_{w,t-1}. \qquad (11)$$

Using assumption (3) we get

$$I'_{wt} = \ell \cdot MV_{wt} \cdot ex_0 \left(\theta_0 R_t + \theta_1 R_t^2 + \theta_2 t R_t + u_t\right) + \frac{R_t}{R_{t-1}} I'_{w,t-1}, \qquad (12)$$

which can be re-expressed as

$$\frac{I'_{wt}}{MV_{wt}} = ex_0 \left(\theta_0 R_t + \theta_1 R_t^2 + \theta_2 t R_t + u_t\right) \ell + \frac{\frac{R_t}{R_{t-1}} I'_{w,t-1}}{MV_{wt}}. \qquad (13)$$

The last term of this equation lacks an intuitive interpretation but it can be rewritten as

$$\frac{\frac{R_t}{R_{t-1}} I_{w,t-1}}{MV_{wt}} \equiv \left(\frac{MV_{w,t-1}}{MV_{wt}} \frac{R_t}{R_{t-1}}\right) \left(\frac{I'_{w,t-1}}{MV_{w,t-1}}\right).$$

If one invokes assumption (4), then[19]

$$\frac{MV_{w,t-1}}{MV_{wt}}\frac{R_t}{R_{t-1}} = \pi_0 + v_t, v_t \tilde{} N(0, \sigma_v^2).$$

Given this result, we find that

$$\begin{aligned}
\frac{\left(\frac{R_t}{R_{t-1}}\right) I_{w,t-1}}{MV_{wt}} &\equiv \left(\frac{MV_{w,t-1}}{MV_{wt}}\frac{R_t}{R_{t-1}}\right)\left(\frac{I'_{w,t-1}}{MV_{w,t-1}}\right) \\
&= (\pi_0 + v_t)\left(\frac{I'_{w,t-1}}{MV_{w,t-1}}\right) \\
&= \pi_0\left(\frac{I'_{w,t-1}}{MV_{w,t-1}}\right) + v_t\left(\frac{I'_{w,t-1}}{MV_{w,t-1}}\right). \qquad (14)
\end{aligned}$$

Substitution of (14) into (13) yields a list of variables relevant to explaining movements in the investment-income discrepancy:

$$\frac{I'_{wt}}{MV_{wt}} = \delta_0 R_t + \delta_1 R_t^2 + \delta_2 (t \cdot R_t) + \delta_3 \frac{I'_{w,t-1}}{MV_{w,t-1}} + w_t, \qquad (15)$$

where $\delta_0 = ex_0 \cdot \theta_0 \cdot \ell$; $\delta_i = ex_0 \cdot \theta_i \cdot \ell < 0$ for $i = 1, 2$; $\delta_3 = \pi_0$, and $w_t = u_t \cdot \ell + v_t \cdot D_{i,t-1}$.

Model for Discrepancies in Shipping Services We assume a two-country world and express the actual service balance for country one as

$$S_{1t} = P_{x1t} \cdot X_{1t} - P_{m1t} \cdot M_{1t}.$$

[19] Assumption 4 implies that

$$\ln\left(\frac{MV_{w,t-1}}{MV_{wt}}\frac{P_t}{P_{t-1}}\right) = (\mu_p - \mu_m) + u_{pt} - u_{mt}.$$

Thus $\frac{MV_{w,t-1}}{MV_{wt}}\frac{P_t}{P_{t-1}} =$
$= e^{(\mu_p - \mu_m)} \cdot e^{u_{pt} - u_{mt}} = \pi_0 e^{u_{pt} - u_{mt}}$
$= \pi_0[1 + (u_{pt} - u_{mt}) + \sum_j \frac{(u_{pt} - u_{mt})^j}{j!}]$
$= \pi_0 + \pi_0[(u_{pt} - u_{mt}) + \sum_j \frac{(u_{pt} - u_{mt})^j}{j!}]$
$= \pi_0 + v_t.$

Assuming that errors occur only in exports, we express the recorded service balance, S'_{1t} , as

$$\begin{aligned} S'_{1t} &= P_{x1t} \cdot X'_{1t} - P_{m1t} \cdot M_{1t} \\ &= P_{x1t} \cdot X_{1t} \cdot (1 + e_{x1t}) - P_{m1t} \cdot M_{1t} \\ &= P_{x1t} \cdot (X_{1t} + X_{1t} \cdot e_{x1t}) - P_{m1t} \cdot M_{1t} \\ &= S_{1t} + P_{x1t} \cdot X_{1t} \cdot e_{x1t}, \end{aligned}$$

where $e_{x1t} < 0$ means that there is underreporting of shipping services. The discrepancy between recorded and actual service balance for country one is

$$S'_{1t} - S_{1t} = P_{x1t} \cdot X_{1t} \cdot e_{x1t}.$$

By analogy, the corresponding discrepancy for country 2 is

$$S'_{2t} - S_{2t} = P_{x2t} \cdot X_{2t} \cdot e_{x2t},$$

where $e_{x2t} < 0$. Recognizing that actual credits and debits are equal to each other–that is, $S_{1t} + S_{2t} = 0$, we express the discrepancy for the world as

$$\begin{aligned} S'_{wt} &= S'_{1t} - S_{1t} + S'_{2t} - S_{2t} \\ &= S'_{1t} + S'_{2t} \\ &= P_{x1t} \cdot X_{1t} \cdot e_{x1t} + P_{x2t} \cdot X_{2t} \cdot e_{x2t}. \end{aligned} \tag{16}$$

Once again, in the absence of errors, the statistical discrepancy vanishes.

To translate this accounting identity into a formulation to explain movements in the service discrepancy, we make the following assumptions:

1. The underreporting of shipping revenues differs across countries: $e_{x1t} = e_{x2t} + \phi, \phi > 0$. In this case we assume that measurement errors of exports for country 1 are smaller than those of country 2.

2. Equation (16) shows that the value of underreporting of shipping revenues is directly related to the price of the items being transported. In other words, an increase in prices makes S'_{wt} more negative. To capture this price effect, we use the price of oil because oil is an important commodity in maritime transportation.

3. The value of underreporting of shipping revenues is inversely related to the use of alternative modes of transportation. Specifically, declines in the physical weight of products allow their transportation through alternative means such as airplanes. The associated tight security procedures virtually guarantee that all the items transported are accounted for which leaves little room for misreporting. In addition, the largest airplane fleet is not registered in Greece.

4. The value of export services is proportional to world imports:

$$P_{x1t} \cdot X_{1t} + P_{x2t} \cdot X_{2t} = \ell \cdot MV_{wt}.$$

We use assumptions (2) and (3) to express the service discrepancy as

$$e_{x2t} = e_{x0} \cdot (\theta_0 + \theta_1 \cdot t + \theta_2 \cdot P_{ot} + u_t), u_t \tilde{} N(0, \sigma^2).$$

We expect $\theta_1 > 0$ under the assumption that a substitution away from maritime shipping reduces the scope for underreporting export services. We expect that $\theta_2 < 0$ because higher oil prices raise the value of the oil being shipped, the value of the associated transportation services, and thus the misreported value.

Substituting these assumptions into equation (16) gives

$$\begin{aligned} S'_{wt} &= P_{x1t} \cdot X_{1t} \cdot (e_{x2t} + \theta) + P_{x2t} \cdot X_{2t} \cdot e_{x2t} \\ &= (P_{x1t} \cdot X_{1t} + P_{x2t} \cdot X_{2t}) \cdot e_{x2t} + P_{x1t} \cdot X_{1t} \cdot \phi \\ &= \ell \cdot MV_{wt} \cdot e_{x2t} + P_{x1t} \cdot X_{1t} \cdot \phi \\ &= \ell \cdot MV_{wt} \cdot (\theta_0 + \theta_1 \cdot t + \theta_2 \cdot P_{ot} + u_t) + P_{x1t} \cdot X_{1t} \cdot \phi, \end{aligned}$$

which can be re-expressed as

$$\begin{aligned} \frac{S'_{wt}}{MV_{wt}} &= (\theta_0 + \theta_1 \cdot t + \theta_2 \cdot P_{ot} + u_t)\,\ell + \left(\frac{P_{x1t} \cdot X_{1t}}{MV_{wt}}\right)\phi \\ &= \theta_0 \cdot \ell + \theta_1 \cdot \ell \cdot t + \theta_2 \cdot \ell \cdot P_{ot} + u_t \cdot \ell + \left(\frac{P_{x1t} \cdot X_{1t}}{MV_{wt}}\right)\phi \\ &= \delta_0 + \delta_1 \cdot t + \delta_2 \cdot P_{ot} + \left(\frac{P_{x1t} \cdot X_{1t}}{MV_{wt}}\right)\phi + v_t. \end{aligned}$$

If one were to assume that the United States is the country with the high-quality data, then the term $\left(\frac{P_{x1t} \cdot X_{1t}}{MV_{wt}}\right)$ would be measured as the ratio of

US exports of shipping services relative to world imports. Forecasting this variable is harder that forecasting the US share of world imports M_{us}. Thus the list of variables relevant for explaining discrepancy in services is:

$$\frac{S'_{wt}}{MV_{wt}} = \delta_0 + \delta_1 \cdot t + \delta_2 P_{ot} + M_{us}\phi + v_t, \tag{17}$$

where $\delta_1 = \theta_1 \cdot \ell > 0$ because $\theta_1 > 0$ and $\delta_2 = \theta_2 \cdot \ell < 0$ because $\theta_2 < 0$.

Model for Discrepancies in Transfers To model this discrepancy we focus on world aggregates expressed in nominal terms; we do not differentiate across countries or between quantities and prices. We denote actual credits as X_t and recorded credits as $X'_t = X_t(1 + ex_t)$. The gap in world credits is

$$X'_t - X_t = X_t(1 + ex_t) - X_t = X_t \cdot ex_t.$$

We denote actual debits as M_t and recorded debits as $M'_t = M_t(1 + em_t)$. Thus the gap in debits is

$$M'_t - M_t = M_t(1 + em_t) - M_t = M_t \cdot em_t,$$

and the discrepancy in transfers becomes

$$Z'_{wt} = X_t \cdot ex_t - M_t \cdot em_t = M_t \cdot (ex_t - em_t),$$

given that $X_t = M_t$.

For modeling purposes we make the following assumptions.

1. Transfer debits are proportional to world imports, $M_t = \ell \cdot MV_{wt}$.

2. A reduction in the share of intermediation by international institutions reduces the discrepancy. Specifically, we assume that an increase in OPEC's assistance (oil-subsidies and financial transfers) reduces the discrepancy in transfers because it bypasses intermediation from international institutions (delays and residency). We implement this hypothesis by postulating that

   $$(ex_t - em_t) = (ex_0 - em_0) \cdot (\theta_0 + \theta_1 \cdot P_{ot} + u_t), u_t \tilde{} N(0, \sigma^2).$$

   We expect that $\theta_1 > 0$: an increase in the price of oil raises OPEC's assistance, bypasses the need for intermediation from entities not conforming with the principle of residency, and thus reduces the discrepancy.

Using assumption (1) we get

$$\frac{Z'_{wt}}{MV_{wt}} = \ell(ex_t - em_t) = \theta_0 \cdot \ell + \theta_1 \cdot \ell \cdot P_{ot} + u_t \cdot \ell, \tag{18}$$

where we expect that $\delta_0 = \theta_0 \cdot \ell$ and $\delta_1 = \theta_1 \cdot \ell > 0$.

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