Inflation, Foreign Exchange, and Parsimonious Equity Valuation

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Abstract

Inflation poses problems for parsimonious equity valuation using bottom line accounting numbers. At issue are the distortions in earnings and book values that follow from the use of historical cost unadjusted for general price level changes. These distortions include the understatement of operating assets and the mismatching of allocated costs that reflect past price levels with revenues that reflect current price levels. In this paper, we consider accounting policies that allow one to recover parsimonious valuation in an inflationary environment. Our model generalizes the cash flow dynamics of Feltham and Ohlson (1996) to encompass stochastic inflation. We show that parsimonious valuation can be achieved through either a restatement of book value and increase in depreciation similar to the policy recommended by SFAS 33, or a decrease in depreciation sufficient to capture both effects. We also suggest an approach for approximate parsimonious valuation without preparing full-scale general price level adjusted financial statements. Extending the analysis to the setting of a multinational firm with a unit operating in a country experiencing inflation, we show how to achieve parsimonious valuation in domestic currency through foreign currency translation using either historical or current exchange rates as prescribed under SFAS 8 and SFAS 52, respectively. Results speak to the value relevance of components of comprehensive income.

1. Introduction

Distortions in book values of operating assets and operating income caused by inflation tend to compromise their role in achieving a parsimonious accounting representation of equity value; that is, expressing value as a function of current book value and comprehensive income alone.[1] In the absence of adjustments to historical cost based financial statements for general price level changes, book values of operating assets are understated and allocated costs of those assets reflecting past price levels are mismatched with revenues reflecting the current price level. As a consequence, not all information relevant for predicting future cash flows may be contained in current book values and operating income determined in this manner. The first purpose of this paper is to consider inflation accounting policies that restore the properties of book values and operating income necessary to achieve parsimonious valuation.

From a practical standpoint, inflation has not reached the point in the United States (U.S.) where there has been much demand for adjusting financial statements for general price level changes.[2] However, that is not the case for many foreign countries in which U.S. multinational firms have subsidiaries. For example, Latin American countries that are experiencing hyperinflation such as Argentina, Brazil, Chile, Columbia, and Mexico have all adopted accounting standards that require the preparation of price level adjusted statements. Accordingly, given an inverse relationship between relative inflation differentials and changes in exchange rates implied by parity conditions, the

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[1] There are two dimensions encompassed by "parsimony" as applied in this paper. Parsimony means that only the most recent book value and comprehensive income are needed to value the firm's equity, and that components of comprehensive income such as restatements for inflation or translation gains and losses can be aggregated with operating income with no loss of information.

[2] During the late 1970's, when U.S. inflation rates were at double digits, firms were obliged to provide supplemental price level adjusted financial statements. Presently, under Statement of Financial Accounting Standards No. 33, price level adjusted financial statements are recommended, but not required.

second purpose of this paper is to explore accounting policies for dealing with both inflation and foreign currency translation that lead to parsimonious valuation in domestic currency. Our analysis captures a crucial aspect of foreign exchange accounting that contrasts the distinctive accounting effects of using current exchange rates versus historical exchange rates to translate historical cost based accounting statements.

Our model is a generalization of Feltham and Ohlson (1996). In particular, we augment the cash flow dynamics of their model to encompass a stochastic inflation rate generating process that possesses the persistence and mean reversion properties of empirically observed inflation rates. A distinctive feature of this process is that the expected inflation rate, conditional on the currently observed rate, is time varying. In turn, this property implies that, unlike Feltham and Ohlson (1996), nominal cash flows dynamics have time varying coefficients. Notwithstanding this added complexity, one can still recover parsimonious valuation through appropriate inflation accounting policies by employing (conditional) expected inflation rates. The novelty from a purely modeling perspective is in achieving parsimonious valuation in this more general case.

Results of our analysis of inflation accounting *per se* yield interesting insights. Specifically, we show that parsimony in valuation can be achieved by following procedures similar though not precisely the same as those recommended by Statement of Accounting Standards No. 33 (SFAS 33).[3] These procedures include restating beginning balances of operating assets, a component of comprehensive income, and increasing the

[3] There is a large empirical literature on inflation accounting. Studies have tried to ascertain whether inflation adjusted accounting data are incrementally value relevant after controlling for historical cost based accounting data that is not adjusted for inflation. U.S. evidence is generally negative. Beaver, Christie and Griffin (1980), Beaver and Landsman (1983) find no incremental information content, while Bernard and Ruland (1987) detect positive results only for some industries. However, studies using Latin American data have consistently found incremental information content. See for example, Rivera (1987), Davis-Friday (2001), Gordon (2001), Swanson, Rees and Juarez-Valdes (2001).

depreciation rate on those assets. Alternatively, the same result can be achieved without restatement of operating assets by reducing the depreciation rate. A departure from SFAS 33 necessary to achieve parsimony lies in the use of expected rather than realized inflation rates to implement the asset restatement and/or depreciation rate adjustment. Using realized inflation rates leads to the presence of a transitory component in comprehensive income and a loss of parsimony due to the addition of a term in order to undo an over weighting of that component in the valuation equation.

Noting that even conditional expected inflation is time varying and preparation of full-scale general price level adjusted financial statements each period may be quite costly, we consider accounting for inflation through a one-time adjustment of depreciation policy based on the long run average inflation rate. Deviations of conditional expected inflation rates from the long run average imply an incomplete adjustment, resulting in errors when parsimonious valuation is employed. In this regard, we show that the absolute valuation error is an increasing function of the persistence of inflation rate innovations and the mean absolute deviations of realized rates from the long run average. Both of these sources of valuation error are positively associated with inflation rate volatility. This observation suggests that, somewhat contrary to received wisdom, it is the volatility rather than the level of inflation rates that is likely to prompt the adoption of accounting standards that require annual restatements.

Extending our analysis to address the effects of inflation on accounting for foreign exchange,[4] we consider a setting in which expected changes in foreign exchange rates are

[4] Liu (2003) also examines equity valuation implications of foreign currency translation. He characterizes foreign accounting policy as a convex combination of mark-to-market and permanent income accounting and depicts how translation gains and losses map into value. His focus is on how foreign accounting policy

driven by relative expected inflation consistent with Interest Rate Parity. We show that, similar to SFAS 8's translate-restate approach, using historical rates to translate foreign currency denominated transactions into domestic currency implicitly adjusts for inflation differentials, with resulting translated accounting numbers subject to domestic inflation. Further adjustment for domestic inflation allows us to recover parsimonious valuation. Alternatively, under current rate translation (SFAS 52), parsimonious valuation from the domestic perspective requires that foreign accounting numbers be appropriately adjusted by changes in exchange rates. Under a stronger restriction on exchange rates specified by Purchasing Power Parity, the adjustment for foreign accounting numbers is equivalent to inflation adjustments using *realized* rates. The reason that realized rates are required, but not expected rates, is that shocks to exchange rates and inflation rates are negatively correlated under purchasing power parity.

The remainder of this paper is organized as follows. Section 2 sets up the starting point for our analysis by revisiting Feltham and Ohlson's (1996) model on depreciation policies and parsimonious accounting representations of equity value. Section 3 introduces inflation and considers accounting policies that adjust for inflation in a manner that fully or approximately recovers parsimonious valuation. Special cases are considered to depict the effects of uncertainty in inflation rates and time dependency of expected inflation on accounting policies. Section 4 adds foreign currency translation to the picture where exchange rates and inflation obey interest rate parity. Attention is given to the alternatives of historical exchange rates to translate foreign transactions or current exchange rates to translate accounting book values and income and depreciation

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affects the weights placed on translation gains and losses rather than on the achievement of parsimonious valuation as in this study.

policies that, again, achieve parsimonious valuation. Section 5 concludes the paper with a discussion of implications.

2. Basic Structure

To analyze accounting for inflation and its role in equity valuation, we begin with the setting modeled in Feltham and Ohlson (1996), wherein an all equity firm consists of a single class of infinitely lived, depreciatable operating assets.[5] Cash flow processes are exogenous and determine firm value. Revenues are recognized when cash is received. Cash investments are capitalized and depreciated using a declining balance method. Operating earnings is defined as the difference between cash revenues and depreciation expenses. Given that cash flows determine firm value, accrual accounting numbers provide the basis for an alternative *representation* of the firm value. Feltham and Ohlson (1996) show that such an accrual accounting based representation could be equally or more *parsimonious* than a cash flow based representation in the sense of containing fewer terms or permitting greater aggregation.

Specifically, suppose at each date $t \in \{0,1,2, \ldots\}$, the firm's economic activities can be characterized by cash receipts cr_t and cash investments ci_t. Cash flows are denominated in real dollars. Next period's cash receipts depend on current period cash receipts, cash investment, while next period's cash investment depends on current period cash investment. Analytically, the (real) cash flow dynamics take the following form:

[5] We omit financial assets because the accounting for them is usually straightforward. The general mark-to-market treatment of financial assets suggests that book values fully capture the purchasing power gains and losses in the case of inflation accounting, as well as translation gains and losses in the case of foreign exchange accounting. The assumption that assets have infinite lives can be potentially relaxed. Feltham and Ohlson (1996) consider finite lived assets and derive qualitatively similar results.

$$\tilde{cr}_{t+1} = \gamma cr_t + \kappa ci_t + \tilde{\varepsilon}_{1,t+1}$$
$$\tilde{ci}_{t+1} = \omega ci_t + \tilde{\varepsilon}_{2,t+1} \qquad \text{(CFR)}$$

where $\tilde{\varepsilon}_{k,t+1}, k = 1,2,$ are independent, identically distributed (i.i.d.) random innovations with zero mean; i.e. $E_t[\varepsilon_{k,t+1}] = 0$ with $E_t[.]$ representing the conditional expectation given the information set at date *t*.

The parameters of (CFR) can be interpreted as follows. κ >0 represents the influence of date t cash investments on date $t+1$ cash receipts; $\gamma \in [0,1)$ represents the persistence in cash receipts, implying that 1-γ is the decay rate of the future cash receipts; and $\omega \in [0, R)$ represents the expected growth of cash investments where R is one plus the risk free rate. Term structure is flat and risk free rates are non-stochastic.[6] Firm value is determined by the present value of future cash flows discounted at the risk free rate:

$$V_t = \sum_{\tau=1}^{\infty} R^{-\tau} E_t[\tilde{c}_{t+\tau}] \qquad \text{(PVR)}$$

where $c_t = cr_t - ci_t$ is date t net cash flows.

Combining (CFR) and (PVR), Feltham and Ohlson (1996) establish that firm value can be expressed as a function of expected cash flows or current cash flows:[7]

OBSERVATION 1. *Given (CFR) and (PVR), then*

$$V_t = \Phi E_t[\tilde{cr}_{t+1}] + \beta E_t[\tilde{ci}_{t+1}] = \Phi[\gamma cr_t + \kappa ci_t] + \beta[\omega ci_t] \qquad (1)$$

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[6] Feltham and Ohlson (1999) and Ang and Liu (2001) generalize the setting to allow for non-trivial term structure and stochastic real interest rates.

[7] All proofs are gathered in the appendix.

$$\text{where:} \quad \Phi = [R-\gamma]^{-1}, \quad \beta = [\Phi\kappa - 1]\frac{1}{R-\omega}.$$

The first part of the above valuation equation, $\Phi[\gamma cr_t + \kappa ci_t]$, represents the value of assets in place, and the second part, $\beta[\omega ci_t]$, represents the value of future investment opportunities. Since $\Phi\kappa = 1$ implies and is implied by $\beta = 0$, we interpret the condition $\Phi\kappa = 1$ as the absence of positive net present value investments in the future.

Using oa_t to denote net operating asset at time t and ox_{t+1} to denote operating income from t to t+1, we assume operating assets, operating income and net cash flows follow a clean surplus relation:

$$oa_{t+1} = oa_{t+1} + ox_{t+1} - c_{t+1} \qquad \text{(OAR)}$$

Depreciation expense is measured using a declining balance method, i.e., $dep_{t+1} = (1-\delta)oa_t$, where the parameter δ is a choice variable and characterizes accounting policy. Since revenues are recognized upon receipt of cash, operating earnings ox_t in period t is equal to

$$ox_t = cr_t - dep_t = cr_t - (1-\delta)oa_{t-1}. \qquad \text{(OXR)}$$

For convenience, we also define abnormal operating earnings as $ox_t^a = ox_t - (R-1)oa_{t-1}$. (OAR) and (OXR) combined describe a historical cost based accrual accounting system.

Combining the accounting system, (OAR) and (OXR), with valuation equation (1), we replicate Feltham and Ohlson's (1996) result below:

PROPOSITION 1. *Given (CFR), (PVR), (OAR), (OXR) with depreciation policy parameter* δ *, then*

$$V_t = oa_t + \alpha_1 ox_t^a + \alpha_2 oa_{t-1} + \alpha_3 ci_t \ , \tag{2}$$

where:

$$\alpha_1 = \Phi \gamma$$
$$\alpha_2 = \Phi R(\gamma - \delta)$$
$$\alpha_3 = \frac{R}{(R-\omega)}(\Phi \kappa - 1)$$

It follows from the above observation that in the absence of positive net present value investments ($\Phi \kappa = 1$), if we choose *unbiased* depreciation, $\delta = \gamma$, then we arrive at a parsimonious equity valuation equation,

$$V_t = oa_t + \alpha_1 ox_t^a \ ,$$

where value equals net operating assets plus a multiple of current abnormal operating earnings. The above expression is "parsimonious" because current earnings and book values suffice for valuation, i.e., value can be expressed as a convex combination of book value and capitalized earnings adjusted for free cash flows, i.e.

$$V_t = oa_t + \alpha_1 ox_t^a = k\left(\phi ox_t - c_t\right) + \left(1-k\right)oa_t \quad , \tag{3}$$

where $k = \left(R-1\right)\alpha_1$ and $\phi = \dfrac{R}{R-1}$.

The above result underscores the point that accrual accounting, when properly done, can be useful in valuation because firm value can be expressed as a parsimonious function of bottom line accounting numbers. Note, in particular, that unbiased depreciation (determined by the choice of δ) directly corresponds to the persistence factor of cash revenues (γ) is consistent with the *matching concept* in income measurement.

3. Accounting For Inflation

We assume that inflation rates, denoted ρ_t, t=1, 2, …, are generated by the following detrended AR (1) process:

$$\left(\tilde{\rho}_{t+1} - \rho_0\right) = \lambda\left(\rho_t - \rho_0\right) + \tilde{\mu}_{t+1}, \qquad \text{(IFP)}$$

where $\lambda \in [0,1]$, $\tilde{\mu}_{t+\tau}$ ($\tau = 1,2,3...$) are i.i.d. with zero mean and variance σ^2.[8] The above process captures two features of inflation rates observed empirically; persistence in innovations and mean reversion. This point can be seen more clearly if we express (IFP) in the following form:

$$\tilde{\rho}_{t+1} = (1-\lambda)\rho_0 + \lambda\rho_t + \tilde{\mu}_{t+1}$$

It is readily seen that the inflation process is a convex combination of a mean reversion process and a random walk process. When $\lambda = 0$, $\tilde{\rho}_{t+1} = \rho_0 + \tilde{\mu}_{t+1}$, the process exhibits extreme mean reversion, i.e., all shocks to inflation rates are transitory; when $\lambda = 1$, the process is a random walk, $\tilde{\rho}_{t+1} = \rho_t + \tilde{\mu}_{t+1}$, i.e., all shocks to inflation rates are permanent. Except for the extreme case of $\lambda = 0$, the expected inflation rate at time *t* conditional on the observed rate is time varying. In the long run, the inflation rates converge to a constant long-run average ρ_0, i.e., $\lim_{\tau\to\infty} \mathrm{E}_t\left(\tilde{\rho}_{t+\tau}\right) = \rho_0$. It is also useful to note that $\mathrm{var}\left(\tilde{\rho}_{t+\tau}\right) = \left(1+\lambda+\lambda^2+...+\lambda^{\tau-1}\right)\sigma^2$, implying that the volatility of the inflation rates increases with λ and σ^2.

(IFP) implies that the following process generates the general price level at time *t*, denoted p_t:

$$\tilde{p}_{t+1} = \tilde{\rho}_{t+1} p_t = E(\tilde{\rho}_{t+1}) p_t + \tilde{\mu}_{t+1} p_t = E(\tilde{\rho}_{t+1}) p_t + \tilde{\varsigma}_{t+1},$$

where $\tilde{\varsigma}_{t+1} = \tilde{\mu}_{t+1} p_t$. Combining the above expression with the cash flow dynamics from (CFR) yields cash flow dynamics denominated in nominal currency:

$$\begin{aligned} \tilde{cr}^n_{t+1} &= \gamma_{t+1} cr^n_t + \kappa_{t+1} ci^n_t + \tilde{\upsilon}_{1,t+1} \\ \tilde{ci}^n_{t+1} &= \omega_{t+1} ci^n_t + \tilde{\upsilon}_{2,t+1} \end{aligned} \qquad \text{(CFN)}$$

where

$$\gamma_{t+1} = E_t(\tilde{\rho}_{t+1})\gamma,\ \kappa_{t+1} = E_t(\tilde{\rho}_{t+1})\kappa,\ \omega_{t+1} = E_t(\tilde{\rho}_{t+1})\omega,$$

$$\tilde{\upsilon}_{1t+1} = \tilde{\varsigma}_{t+1}\left(\gamma cr_t + \kappa ci_t + \tilde{\varepsilon}_{1,t+1}\right) + E(\tilde{\rho}_{t+1}) p_t \tilde{\varepsilon}_{1,t+1}, \text{ and}$$

$$\tilde{\upsilon}_{2,t+1} = \tilde{\varsigma}_{t+1}\left(\omega ci_t + \tilde{\varepsilon}_{2,t+1}\right) + E(\tilde{\rho}_{t+1}) p_t \tilde{\varepsilon}_{2,t+1}.$$

Nominal cash flows equal real cash flows multiplied by the general price level, $c^n_t = p_t c_t$, and the nominal interest rate equals real interest rate multiplied by the expected rate of inflation, $R^n_{t,t+\tau} = R^\tau E_t(\tilde{\rho}_{t,t+\tau}) = R^\tau E_t(\prod_{s=1}^{\tau} \tilde{\rho}_{t+s})$. Working in a neoclassical setting, we assume no correlation between the error terms in (CFR) and (IFP), that is, inflation has no real effects. Hence the residual terms in (CFN), $\tilde{\upsilon}_{1t+1}$ and $\tilde{\upsilon}_{2t+1}$, all have zero conditional expectations.

The value of equity in nominal terms is

$$V^n_t = \sum_{\tau=1}^{\infty} \frac{E_t[\tilde{c}^n_{t+\tau}]}{R^n_{t,t+\tau}}. \qquad \text{(PVN)}$$

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[8] We found $\lambda = 0.8$ when we fitted IFP using US data from 1960 to 2000.

Analogous to Observation 1, we have

OBSERVATION 2. *Given (IRP), (CFN), and (PVN), then*

$$V_t^n = \Phi_t[\gamma_t cr_t^n + \kappa_t ci_t^n] + \beta_t[\omega_t ci_t^n] \tag{4}$$

where:

$$\Phi_t = [R_{t-1,t} - \gamma_t]^{-1},$$
$$\beta_t = [\Phi_t \kappa_t - 1]\frac{1}{R_{t-1,t} - \omega_t},$$
$$R_{t-1,t} = RE_{t-1}\left(\tilde{\rho}_t\right)$$

This observation differs from Observation 1 in that cash flows and interest rates are in nominal terms. Note although individual valuation coefficients, Φ_t, γ_t, κ_t, β_t and ω_t are time varying, reflecting the conditional expected inflation rate for period from *t-1* to *t*, their combined effect is that the valuation loadings on current cash flows are constants, i.e.,

$$V_t^n = \Phi_t[\gamma_t cr_t^n + \kappa_t ci_t^n] + \beta_t[\omega_t ci_t^n] = \Phi[\gamma cr_t^n + \kappa ci_t^n] + \beta[\omega ci_t^n].$$

The reason is that conditional expected inflation rates are canceled out in the products of individual coefficients. As discussed in the introduction, on introduction of an inflation process with time varying expectations, the forecasting coefficients in the nominal cash flow dynamics (CFN) become time varying. In this case, a closed form valuation solution is achievable because the stochastic process for inflation rates determines the stochastic processes for both the forecasting coefficients of (CFN) and the nominal interest rates.

3.1 Valuation with *Expected* Inflation rates

We assume that clean surplus now holds in nominal terms, i.e.,

$$oa_{t+1} = oa_t + ox_{t+1} - c_{t+1}^n, \tag{OAN}$$

and (operating) earnings reflects price level changes through cash revenues measured in nominal terms less depreciation at an arbitrary rate, i.e.,

$$ox_t = cr_t^n - dep_t = cr_t^n - (1-\delta_t)oa_{t-1}. \tag{OXN}$$

The accounting reflected by (OAN) and (OXN) is still historical cost based. It is clear that in this accounting system, book value of operating assets is understated because it does not fully reflect current price levels (OAN), and revenues, which reflect current price levels, are mismatched with historical cost based expenses (OXN). We add a time subscript to the depreciation parameter, δ_t, to allow for time varying depreciation policies. We conjecture parsimonious valuation might require the accounting policy to be time varying because (CFN) features time varying coefficients. For convenience, we also define abnormal operating earnings as $ox_t^a = ox_t - \left(R_{t-1,t} - 1\right)oa_{t-1}$. A natural question to ask in this setting is whether unbiased depreciation in the absence of inflation would continue to allow parsimonious valuation to be achieved. The answer is implied by the following proposition:

PROPOSITION 2. *Given (IFP), (CFN), (PVN), (OAN), and (OXN) with depreciation policy parameter* δ_t, *then*

$$V_t^n = oa_t + \alpha_1^n ox_t^a + \alpha_2^n oa_{t-1} + \alpha_3^n ci_t^n, \tag{5}$$

$$\textit{where:}\quad \begin{aligned} \alpha_1^n &= \Phi_t \gamma_t = \Phi\gamma \\ \alpha_2^n &= \Phi_t R_{t-1,t}(\gamma_t - \delta_t) = \Phi R(\gamma_t - \delta_t) \\ \alpha_3^n &= \frac{R_{t-1,t}}{(R_{t-1,t} - \omega_t)}(\Phi_t \kappa_t - 1) = \frac{R}{(R-\omega)}(\Phi\kappa - 1) \end{aligned}$$

Comparing (5) to (2), we note that the coefficients on abnormal operating earnings and cash investments are the same under the two scenarios, i.e., $\alpha_1^n = \alpha_1$ and $\alpha_3^n = \alpha_3$. The former equality is by construction. The latter equality is intuitive because inflation should not affect the value of future investment opportunities given our assumption that inflation and real cash flows follow independent processes. The absence of positive net present value investments again implies $\alpha_3 = 0$. Accounting policy enters the valuation equation given by (5) through the depreciation parameter δ_t.

It is immediately apparent that, in order to achieve parsimonious valuation, the depreciation parameter δ_t should be time varying and set to be equal to γ_t. Unbiased depreciation in the absence of inflation, $\delta_t = \gamma$, would not result in the elimination of $\alpha_2^n oa_{t-1}$ from the valuation equation. Rather, $\delta < E_{t-1}(\rho_t)\gamma = \gamma_t$, implying that the depreciation rate, $(1-\gamma)$, is too aggressive. This result illustrates the classic inflation induced accounting problem of mismatching unadjusted historical cost-based depreciation with current revenues.

Accounting textbooks refer to the mismatch between revenues and expenses as an "earnings illusion" (e.g., Choi, Frost, and Meek, 2001), suggesting earnings are overstated without inflation adjustment. In contrast, our result suggests depreciation should be adjusted *downwards,* not *upwards*. The explanation is that we can recover parsimonious valuation by either *reducing* the depreciation rate such that $1-\delta_t = 1-\gamma E_{t-1}(\tilde{\rho}_t)$, or, consistent with textbook treatment, first restating the beginning book value of operating assets to give effect to expected inflation, $\left(E_{t-1}(\tilde{\rho}_t)-1\right)oa_{t-1}$, and then *increasing* depreciation expense to reflect that restatement, $(1-\gamma)E_{t-1}(\tilde{\rho}_t)oa_{t-1}$. While the former approach may seem counter-intuitive given that the earnings illusion alludes to depreciation expense being too low, it is because the depreciation parameter chosen must also correct for omitting the upward adjustment of beginning book value. Redefining operating income as *comprehensive income* inclusive of the restatement and increasing depreciation results in the following:

$$ox_t = cr_t^n - (1-\gamma)E_{t-1}(\tilde{\rho}_t)oa_{t-1} + \left(E_{t-1}(\tilde{\rho}_t)-1\right)oa_{t-1}$$

Equivalently, simplifying the right hand side of the above equation implies that one could capture the effects of inflation in one step by adjusting the depreciation parameter.

$$ox_t = cr_t^n - \left(1-\gamma E_{t-1}(\tilde{\rho}_t)\right)oa_{t-1}$$

One can view depreciation expense under the former approach as recovering matching by applying the unbiased rate in real terms $(1-\gamma)$ to an inflation-adjusted book value $E_{t-1}(\tilde{\rho}_t)oa_{t-1}$. The latter approach of reducing the depreciation rate from $(1-\gamma)$ to $\left(1-\gamma E_{t-1}(\tilde{\rho}_t)\right)$ in effect corrects for the absence of an explicit restatement of the beginning book value of operating assets and related adjustment of current period depreciation expense.

We point out that parsimony now encompasses the aggregation of inflation restatements and operating income with no loss of value relevant information, as well as the elimination of a lagged operating assets term through an appropriate choice of the accounting policy parameters.

3.2 Valuation with *Realized* Inflation Rates

In order to achieve parsimony from (5), we employed the expected inflation rate rather than the realized rate as called for under SFAS 33. This was natural given that only expected inflation is relevant for purposes of determining equity value. Moreover, as we see it, the matching concept is fundamentally concerned with future expectations. Were we to follow the dictates of SFAS 33 and use the realized rate in place of the expected rate, then lagged book value of operating assets would be restated as $(\rho_t - 1) oa_{t-1}$, and depreciation expense would become $(1-\gamma)\rho_t oa_t$. The valuation equation given zero net present value investments and increased depreciation based on ρ_t would then be

$$V_t^n = oa_t + \alpha_1^n ox_t^a + \alpha_2^n \mu_t oa_{t-1} \tag{6}$$

where
$$\alpha_1^n = \Phi\gamma$$
$$\alpha_2^n = -\Phi R\gamma = -R\alpha_1^n$$

As implied by the negative coefficient on lagged book value, the added term in (6) by comparison with (5) is necessary to correct for an over weighting of the component of comprehensive income created by the effect of unexpected inflation on the restatement net of depreciation when that component is aggregated with the rest of earnings. Over weighting occurs because of the transitory nature of adjustments for unexpected inflation as compared to the greater persistence of cash revenues combined with expected inflation. To see this, let us decompose comprehensive income as follows:

$$ox_t = ox_{1t} + ox_{2t},$$

$$ox_{1t} = cr_t^n - (1-\delta_t)oa_{t-1} + (\rho_0 - 1)oa_{t-1}, \text{ and}$$

$$ox_{2t} = \mu_t oa_{t-1}.$$

Taking the partial derivative of the value function with respect to ox_{1t} we get

$$\frac{\partial V_t^n}{\partial ox_{1t}} = \frac{\partial oa_t}{\partial ox_{1t}} + \alpha_1^n \frac{\partial ox_t^a}{\partial ox_{1t}} - R\alpha_1^n \frac{\partial ox_{2t}}{\partial ox_{1t}} = 1 + \alpha_1^n.$$

In like fashion, taking partial derivative of the value function with respect to ox_{2t} we get

$$\frac{\partial V_t^n}{\partial ox_{2t}} = \frac{\partial oa_t}{\partial ox_{2t}} + \alpha_1^n \frac{\partial ox_t^a}{\partial ox_{2t}} - R\alpha_1^n \frac{\partial ox_{2t}}{\partial ox_{2t}} = 1 + \alpha_1^n - R\alpha_1^n < 1 + \alpha_1^n.$$

Looking at the special case in which cash revenues are highly persistent, $\gamma \approx 1$, it's easy to show that the marginal valuation effect of the book value restatement due to unexpected inflation is approximately zero, i.e., $\frac{\partial V_t^n}{\partial ox_{2t}} \approx 0$. This special case makes sense because when $\gamma = 1$, value can be expressed as capitalized earnings, implying that the unexpected inflation driven component of earnings is merely noise and should have no weight in a valuation equation.

The rationale for SFAS 33 treating restatement effects of inflation as direct adjustments to stockholders' equity through comprehensive income rather than as a component of operating income relates to a perceived impropriety of aggregating presumed temporary restatement effects of inflation with core earnings. However, while our analysis lends some credence to the idea of separating comprehensive income into more persistent and more transitory components when realized inflation rates are employed, the key aspect is the predictability of inflation rates. There is no problem in aggregating the portion of the restatement attributable to expected inflation with operating earnings. The difficulty with aggregation arises when restatements are based on realized inflation in which case a further term is required to attenuate an over weighting of the unpredictable component of inflation rate changes.

3.3 Approximate Valuation

Rather than a full-scale adjustment for inflation using realized or time varying (conditional) expected inflation rates, it seems plausible for firms to capture the approximate effects of inflation through accounting policies that reflect the long run average (unconditional expectation) inflation rate; i.e., $\lim_{\tau \to \infty} \mathrm{E}_t\left(\tilde{\rho}_{t+\tau}\right) = \rho_0$. Specifically, the depreciation parameter could be set based on the long run average inflation rate; i.e., $\delta_t = \delta = \gamma \rho_0$ for all *t*. The valuation equation that results from this parameter choice assuming as usual no positive net present value investments is

$$V_t^n = oa_t + \alpha_1^n ox_t^a + \alpha_2^n oa_{t-1} \tag{7}$$

where:
$$\alpha_1^n = \Phi \gamma$$
$$\alpha_2^n = \Phi R\left(\gamma_t - \delta\right)$$

Ignoring the third term in (7), we obtain a parsimonious *approximation* of value as a convex combination of earnings and book values:[9]

$$\bar{V}_t^n = oa_t + \alpha_1 ox_t^a = k\left(\phi ox_t - c_t\right) + \left(1 - k\right) oa_t, \tag{8}$$

[9] This approach is similar to that used by Liu and Ohlson (2000).

where $k = (R-1)\alpha_1$ and $\phi = \frac{R}{R-1}$. The absolute valuation error of this approximation is

$$\left|V_t^n - \bar{V}_t^n\right| = \left|\alpha_2^n oa_{t-1}\right| = \lambda\gamma\left|\rho_t - \rho_0\right| oa_{t-1}.$$

It's obvious that the absolute valuation error is an increasing function of λ and the absolute deviation of ρ_t from its long run average ρ_0, and both variables are positively related to the volatility of inflation rates.

The above analysis suggests that in the United States and other developed countries where inflation is not very volatile, an accounting policy of dealing with inflation through adjustments based on long run average inflation may suffice. The criticism of proposals that would require price level adjusted financial statements generally has been that the costs of compliance outweigh the benefits. One way to think about this tradeoff is to consider whether the volatility of inflation rates has reached the point where errors in valuation due to policies based on long run average inflation rates have become large enough to mandate price level adjusted statements. We can speculate that this point has not been reached in more developed countries such as the United States, but has been reached in many less developed countries such as those in Latin America.

4. Accounting for Foreign Exchange

We now consider the interdependency between inflation accounting and foreign currency translation. An issue facing multinational companies is the translation of foreign transactions or financial statements of units operating in inflationary environments. For simplicity, we limit our attention to the problem of recasting accounting data pertaining to a single foreign subsidiary for which the functional currency is that of the country in which that subsidiary is located.[10] The cash flow dynamics in nominal units of foreign currency are the same as (CFN) where the superscript *n* is replaced by *f* to better distinguish foreign currency from domestic currency. That is

$$\begin{aligned} \tilde{cr}^f_{t+1} &= \gamma^f_{t+1} cr^f_t + \kappa^f_{t+1} ci^f_t + \tilde{\upsilon}_{1,t+1} \\ \tilde{ci}^f_{t+1} &= \omega^f_{t+1} ci^f_t + \tilde{\upsilon}_{2,t+1} \end{aligned} \quad \text{(CFF)}$$

where $\gamma^f_{t+1} = E_t(\rho^f_{t+1})\gamma$, $\kappa^f_{t+1} = E_t(\rho^f_{t+1})\kappa$, $\omega^f_{t+1} = E_t(\rho^f_{t+1})\omega$, and ρ^f_t is the foreign inflation rate. We further assume real interest rates in both countries are the same.

A well-known result in international finance is that, given risk neutrality, perfect markets, and no arbitrage in international financial markets, expected changes in exchange rates are driven by interest rate differentials, i.e., *Interest Rate Parity* holds. In our case, since real interest rates are the same, interest rate differential is equivalent to differential inflation expectations:

$$\frac{E_t(\tilde{s}_{t+1})}{s_t} = \frac{R^d_{t,t+1}}{R^d_{t,t+1}} = \frac{RE_t(\tilde{\rho}^d_{t+1})}{RE_t(\tilde{\rho}^f_{t+1})} = \frac{E_t(\tilde{\rho}^d_{t+1})}{E_t(\tilde{\rho}^f_{t+1})}, \quad \text{(IRP)}$$

where s_t denotes the rate of exchange from foreign to domestic currency at time *t*. (IRP) is a relatively mild condition that provides a useful correspondence between expected inflation rates and expected exchange rates that we exploit in our later analysis. Consistent with (IRP), we assume exchange rates follow the following process:

$$\tilde{s}_{t+1} = \frac{E_t(\tilde{\rho}^d_{t+1})}{E_t(\tilde{\rho}^f_{t+1})} s_t + \tilde{\xi}_{t+1} \quad (9)$$

[10] An obvious caveat is that multinational companies typically have subsidiaries in many countries where

where $\tilde{\xi}_{t+1}$ is mean zero random innovation to exchange rates. While in general nothing prevents exchange rates to be correlated with the foreign cash flows, because the correlations are value neutral,[11] we assume zero correlation for simplicity. To see this point, note the value of the foreign operation can be expressed as the translated foreign value:

$$V_t^d = s_t \sum_{\tau=1}^{\infty} \frac{E_t[\tilde{c}_{t+\tau}^f]}{R_{t,t+\tau}^f} \tag{10}$$

Apply (IRP) to equation (10), substitute domestic interest rates for foreign interest rates, we get:

$$V_t^d = \sum_{\tau=1}^{\infty} \frac{E_t[\tilde{c}_{t+\tau}^f] E_t[\tilde{s}_{t+\tau}^f]}{R_{t,t+\tau}^d} \tag{11}$$

However, by assumption of no arbitrage, the foreign security can also be directly valued by forecasting future translated foreign cash flows, i.e.,

$$V_t^d = \sum_{\tau=1}^{\infty} \frac{E_t[\tilde{s}_{t+\tau}^f \tilde{c}_{t+\tau}^f]}{R_{t,t+\tau}^d} \tag{12}$$

The fact that both (11) and (12) hold implies that the correlation between cash flows and exchange rates is value neutral, i.e., $\sum_{\tau=1}^{\infty} \frac{\text{cov}\left(\tilde{s}_{t+\tau}, \tilde{c}_{t+\tau}\right)}{R_{t,t+\tau}^d} = 0$.

4.1 Foreign Currency Translation with Historical Exchange Rates

Two distinct methods of foreign currency translation are reflected in SFAS 8 and SFAS 52. SFAS 8 takes a transactions approach in calling for translation using historical

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inflation rates are different. It would be interesting to consider conditions under which aggregation is possible without loss of value relevant information.

[11] See Liu (2003) for a detailed discussion of this point.

exchange rates. Within our model, this approach is equivalent to translating the cash flow dynamics given by (CFF) from foreign currency to domestic currency. Multiplying the same sides of (9) and (CFF) and collecting terms, we get the following cash flow dynamics denominated in domestic currency:

$$\begin{aligned} c\tilde{r}_{t+1}^{d} &= \gamma_{t+1}^{d} cr_t^{d} + \kappa_{t+1}^{d} ci_t^{d} + \tilde{\varepsilon}'_{1,t+1} \\ c\tilde{i}_{t+1}^{d} &= \omega_{t+1}^{d} ci_t^{d} + \tilde{\varepsilon}'_{2,t+1} \end{aligned} \tag{CFD}$$

where $c\tilde{r}_{t+1}^{d} = \tilde{s}_{t+1} c\tilde{r}_{t+1}^{f}$, $c\tilde{i}_{t+1}^{d} = \tilde{s}_{t+1} c\tilde{i}_{t+1}^{f}$, $\gamma_{t+1}^{d} = E_t(\rho_{t+1}^{d})\gamma$, $\kappa_{t+1}^{d} = E_t(\rho_{t+1}^{d})\kappa$, $\omega_{t+1}^{d} = E_t(\rho_{t+1}^{d})\omega$,

and $\tilde{\varepsilon}'_{1,t+1}, \tilde{\varepsilon}'_{2,t+1}$ are noise terms with zero expectations.

It is immediately apparent from (CFD) that translation of foreign transactions undoes the effects of foreign country inflation, and incorporates domestic inflation in the cash flow dynamics. From Proposition 2 we know that parsimonious valuation is achievable if we adjust depreciation using expected domestic inflation, i.e., $\delta_t = \gamma E_{t-1}\left(\tilde{\rho}_t^{d}\right)$. This is what textbooks call the translate-restate approach for foreign currency translation under inflation. In a situation where domestic inflation is negligible, translation using historical rates simultaneously takes care of inflation and foreign exchange induced accounting problems. Instead of translating foreign transactions using historical exchange rates, alternatively, we could transform the foreign currency denominated cash flows into operating income and book value before translation into domestic currency and translate these accounting numbers using historical rates and obtain the same result. In applying this latter approach, however, a record must be kept as to the time cash investments in operating assets were made so that the elements of depreciation expense corresponding to those investments could be translated using the exchange rates prevailing at those times.

Another point worth noting pertains to whether the accounting policy chosen allows parsimonious valuation to be achieved in foreign currency terms as well as domestic currency terms. It is fairly transparent that the same depreciation parameter could not produce parsimonious valuation in both currencies. The parameter that would accomplish this in foreign currency terms is $\delta_t = \gamma_t = \gamma E_{t-1}(\tilde{\rho}_t^f)$, rather than $\delta_t = \gamma E_{t-1}\left(\tilde{\rho}_t^d\right)$ as indicated above after translation into domestic currency.

4.2 Foreign Translation With Current Exchange Rates

The more interesting case is where current exchange rates are employed in translating accounting data as called for under SFAS 52 when the functional currency is foreign currency. Translation using current rates is subtler than translation using historical rates because the former is essentially a mark-to-to market procedure, yet the accounting statements being translated are prepared under historical cost.

To begin, we reiterate the definitions of operating income and book value of operating assets in foreign currency:

$$ox_t^f = cr_t^f - (1-\delta_t)oa_{t-1}^f \qquad \text{(OXF)}$$

$$oa_t^f = oa_{t-1}^f + ox_t^f - c_t^f \qquad \text{(OAF)}$$

where we have added a superscript to operating income and book value to distinguish accounting in foreign currency from accounting in domestic currency terms. Translation using current rates means book value, operating income and cash flows are all translated at the spot exchange rates. Define translated book value as $oa_t^d = s_t oa_t^f$ and translated cash flows as $c_t^d = s_t c_t^f$. Comprehensive income is the sum of translated operating earnings and a translation gain or loss, $ox_t^d = s_t ox_t^f + (s_t - s_{t-1}) oa_{t-1}^f$. The recognition of translation gain or loss is essential to maintain the following clean surplus relation:

$$oa_t^d = oa_{t-1}^d + ox_t^d - c_t^d \tag{OAD}$$

Applying (OXF) to the definition of comprehensive income, we obtain the following expression for comprehensive income:

$$\begin{aligned} ox_t^d &= s_t ox_t^f + (s_t - s_{t-1}) oa_{t-1}^f \\ &= cr_t^d - (1-\delta_t)\frac{s_t}{s_{t-1}} oa_{t-1}^d + (s_t - s_{t-1})\frac{oa_{t-1}^d}{s_{t-1}} \\ &= cr_t^d - (1-\delta_t \frac{s_t}{s_{t-1}}) oa_{t-1}^d \end{aligned} \tag{OXD}$$

As shown above, domestic comprehensive income can be expressed as either cash revenues less depreciation plus translation gains or losses, or cash revenues less depreciation determined in a manner that also captures translation gains and losses. Not surprisingly, given the relationship between foreign exchange rates and relative inflation, these alternatives are similar to the inflation accounting alternatives considered in the Section 3.

In turn, domestic abnormal earnings are defined as $ox_{t,d}^a = ox_t^d - (R_{t-1,t}^d - 1) oa_{t-1}^d$. We can now show the following:

PROPOSITION 3. *Given (IFP), (CFF), (OAF), (OXF) with depreciation policy parameters δ_t, for all t, and no positive net present value investments, then*

$$V_t^d = s_t V_t^f = oa_t^d + \alpha_1^d ox_{t,d}^a + \alpha_2^d oa_{t-1}^d, \tag{13}$$

$$\text{where:} \quad \begin{aligned} \alpha_1^d &= \Phi\gamma \\ \alpha_2^d &= \Phi R\left(\gamma_t^d - \frac{s_t}{s_{t-1}}\delta_t\right) \end{aligned}$$

The above coefficient for lagged book value implies that a depreciation policy based on $\delta_t = \gamma_t^d \frac{s_{t-1}}{s_t} = \frac{s_{t-1}}{s_t} E_{t-1}\left(\tilde{\rho}_t^d\right)\gamma$ generates parsimonious valuation from the domestic perspective.

The accounting policy we derive above is referred to by textbooks as the restate-translate approach. To see the intuition behind the restate-translate approach as depicted above, we now impose a stronger condition for exchange rates than (IRP). In particular, we now assume that *Purchasing Power Parity* holds:

$$\frac{\tilde{s}_{t+1}}{s_t} = \frac{\tilde{\rho}_{t+1}^d}{\tilde{\rho}_{t+1}^f} \qquad \text{(PPP)}$$

(PPP) states that *realized* fluctuations in exchange rates are driven by *realized* inflation rates. It is a much stronger condition than (IRP) because it requires perfect markets and no arbitrage in not only financial markets but markets for commodities as well. Given (PPP), the depreciation parameter that achieves parsimonious valuation can be expressed as $\delta_t = \frac{E_{t-1}\left(\tilde{\rho}_t^d\right)}{\rho_t^d}\rho_t^f\gamma$. In a regime where domestic inflation has low volatility such that $\frac{E_{t-1}\left(\tilde{\rho}_t^d\right)}{\rho_t^d} \approx 1$, this depreciation policy is reduced to adjusting for the foreign realized inflation rate, i.e., $\delta_t = \rho_t^f\gamma$, which is exactly what textbooks recommend. We note again that in general parsimonious valuation can not be achieve simultaneously in both foreign and domestic currency terms, because $\frac{E_{t-1}\left(\tilde{\rho}_t^d\right)}{\rho_t^d}\rho_t^f \neq E_{t-1}\left(\tilde{\rho}_t^f\right)$.

The policy implied by (PPP) and negligible domestic inflation volatility is similar to the policy that achieves parsimonious valuation in foreign currency denominated book value and comprehensive income as constructively established by Proposition 2. The difference is the use of the realized inflation rate in place of the expected inflation rate. Recall that when we used the realized inflation rate in Section 3, we lost parsimonious valuation. This does not occur here because of the inverse relationship between the realized inflation rate and the realized exchange rate. In effect, the unpredictable components of these rates offset each other.

5. Concluding Remarks

The results of our analysis of inflation accounting and foreign currency translation have pricing implications for components of comprehensive income. Proposition 2 suggests that restatements of operating assets for expected inflation can be aggregated with operating income in a parsimonious accounting representation of equity value. Accordingly, if such restatements appeared separate from operating income, then, depending on the efficacy of our model, one might predict similar coefficients in empirical tests relating these accounting variables to prices.

However, we also observe that when realized inflation rates are employed to restate operating assets, the portion of the restatement stemming from unexpected inflation cannot be aggregated with operating income without adding a further term in an accounting representation of equity value. In this case, comprehensive income can be decomposed into two components with different valuation coefficients (one component more transitory than the other) though these components relate to the predictability of inflation rates rather than simply a separation of restatements for inflation and operating income.

Under purchasing power parity, this caveat does not apply to foreign currency translation gains and losses when current exchange rates are employed because the effect of unpredictable components of the inflation rate and exchange rate offset. Thus, at least in this case, translation gains and losses can be aggregated with operating income without loss of parsimony provided the depreciation parameter is chosen in an appropriate manner. We, however, point out that this observation may only have empirical relevance when accounting data are measured over sufficiently long horizons, because the purchasing power parity has been found rarely holds for shorter horizons.[12]

As is the case with most accounting valuation models, we have imposed considerable structure. The crucial aspect is whether the insights obtained would continue to prevail in a qualitative sense as this structure is relaxed to accommodate the richness of practice. It seems likely that whether value relevant information is lost when inflation restatements or translation gains and losses are aggregated with operating income, at least up to a reasonable approximation, has mostly to do with the predictability of future inflation even in more complex settings than that considered here.

Although we gain considerable modeling advantage from the combination of an AR(1) process for net operating cash flows (cash revenues in the model) and declining balance depreciation, the principal feature lies in being able to relate depreciation to the decay in future cash flows, a property that could conceivably be derived from other assumptions involving finite lived assets and straight line depreciation.[13] The Markov property of cash flow and inflation processes in general is useful in limiting temporal deviations from parsimony to just one lagged term, which seems enough to make the point in the sense that current book value and income may not contain enough information. It is unclear what further insights might be gained by relaxing this property.

More limiting in our view is the restriction to a single operating unit. Even if with multiple units the mix of operating units remains the same, changing expectations suggests the prospect that aggregation across units would result in a loss of value relevant information. Such a result may recommend segment reporting where segments distinguish subsidiaries by the countries in which they are sited. We commend resolution of this issue to future research.

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[12] See Adler and Dumas (1983) for a comprehensive review.
[13] See the appendix in Feltham and Ohlson (1996).

Appendix

1. Proof of Observation 1:

(CFR) implies expected cash receipts and cash investments are:

$$E_t[\tilde{cr}_{t+\tau}] = (\gamma)^\tau cr_t + \kappa \frac{(\omega)^\tau - (\gamma)^\tau}{\omega - \gamma} ci_t$$
$$E_t[\tilde{ci}_{t+\tau}] = (\omega)^\tau ci_t$$

Substituting the above two expressions into (PVR) provides:

$$V_t = \sum_{\tau=1}^{\infty} R^{-\tau}[E_t[\tilde{cr}_{t+\tau}] - E_t[\tilde{ci}_{t+\tau}]]$$
$$= \Phi\gamma cr_t + \kappa \frac{1}{\omega - \gamma}[\frac{\omega}{R-\omega} - \frac{\gamma}{R-\gamma}]ci_t - \frac{\omega}{R-\omega} ci_t$$
$$= \Phi(\gamma cr_t + \kappa ci_t) + (\Phi\kappa - 1)\frac{\omega}{R-\omega} ci_t$$

Define $\beta = \frac{\Phi\kappa - 1}{R-\omega}$, and we obtain equation (1):

$$V_t = \Phi(\gamma cr_t + \kappa ci_t) + \beta(\omega ci_t)$$

QED.

2. Proof of Proposition 1:

This proof demonstrates that (2) is equivalent to (1):

$$V_t = oa_t + \alpha_1 ox_t^a + \alpha_2 oa_{t-1} + \alpha_3 ci_t$$

Substitute $ox_t^a = cr_t - (R-\delta)oa_{t-1}$, $oa_t = \delta oa_{t-1} + ci_t$ and the valuation loadings

$\alpha_1 = \Phi\gamma,\ \alpha_2 = \Phi R(\gamma - \delta),\ and\ \alpha_3 = \frac{R}{(R-\omega)}(\Phi\kappa - 1)$ into the above equation, we get

$$V_t = \delta oa_{t-1} + ci_t + \Phi\gamma[cr_t - (R-\delta)oa_{t-1}] + \Phi R(\gamma - \delta)oa_{t-1} + (\Phi\kappa - 1)\frac{R}{R-\omega}ci_t$$
$$= \Phi\gamma cr_t + [\delta - \Phi\gamma(R-\delta) + \Phi R(\gamma-\delta)]oa_{t-1} + (1+\beta R)ci_t$$
$$= \Phi\gamma cr_t + (\Phi\kappa + \beta\omega)ci_t$$

QED.

3. *Proof of Proposition 2:*

This proof demonstrates that equation (5) is equivalent to equation (4).

Recall cash flow valuation in Observation (2) is

$$V_t^n = \Phi_t[\gamma_t cr_t^n + \kappa_t ci_t^n] + \beta_t[\omega_t ci_t^n] == \Phi\gamma cr_t^n + (\Phi\kappa + \beta\omega)ci_t^n$$

The valuation represented in accounting number of equation (5) is

$$V_t^n = oa_t + \alpha_1^n ox_t^a + \alpha_2^n oa_{t-1} + \alpha_3^n ci_t^n$$

Substituting $ox_t^a = cr_t^n - (R_{t-1,t} - \delta_t)oa_{t-1}$, $oa_t = \delta_t oa_{t-1} + ci_t^n$ and the valuation loadings,

$\alpha_1^n = \Phi\gamma$, $\alpha_2^n = \Phi R(\gamma_t - \delta_t)$, *and* $\alpha_3^n = \frac{R}{(R-\omega)}(\Phi\kappa - 1)$, into the above equation, we get

$$V_t^n = \delta_t oa_{t-1} + ci_t^n + \Phi\gamma[cr_t^n - (R_{t-1,t} - \delta_t)oa_{t-1}] + \Phi R(\gamma_t - \delta_t)oa_{t-1} + (\Phi\kappa - 1)\frac{R}{R-\omega}ci_t^n$$
$$= \Phi\gamma cr_t^n + [\delta_t - \Phi\gamma(R_{t-1,t} - \delta_t) + \Phi R(\gamma_t - \delta_t)]oa_{t-1} + (1+\beta R)ci_t^n$$
$$= \Phi\gamma cr_t^n + (\Phi\kappa + \beta\omega)ci_t^n$$

QED.

4. *Proof of Proposition 3*:

Suppose both domestic and foreign economies experience inflation with inflation rates ρ_t^d and ρ_t^f, respectively. The valuation in domestic currency is equal to the valuation in foreign currency multiplied by the exchange rate at time t.

$$V_t^d = s_t(oa_t^f + \alpha_1^f ox_{t,f}^a + \alpha_2^f oa_{t-1}^f)$$

with $\alpha_1^f = \Phi\gamma,\ \alpha_2^f = \Phi R(\gamma_t^f - \delta_t),\ \alpha_3^f = \frac{R}{(R-\omega)}(\Phi\kappa - 1)$

To extend this equation, we need to recall three conditions:

1) From (OXD), we get the domestic abnormal earnings representation

$$ox_{t,d}^a = cr_t^d - (R_{t-1,t}^d - \delta_t \frac{s_t}{s_{t-1}})oa_{t-1}^d,$$

2) Foreign abnormal earnings are $ox_{t,f}^a = cr_t^f - (R_{t-1,t}^f - \delta_t)oa_{t-1}^f$.

3) Under current method translation, $oa_t^d = s_t oa_t^f$, for all t.

Using the three conditions above, we get $s_t ox_{t,f}^a = ox_{t,d}^a - R_{t-1,t}^f s_t oa_{t-1}^f + R_{t-1,t}^d s_{t-1} oa_{t-1}^f$.

Plugging back to the valuation equation leads to

$$V_t^d = oa_t^d + \alpha_1^f (ox_{t,d}^a - R_{t-1,t}^f s_t oa_{t-1}^f + R_{t-1,t}^d s_{t-1} oa_{t-1}^f) + \alpha_2^f s_t oa_{t-1}^f$$
$$= oa_t^d + \alpha_1^f ox_{t,d}^a - \Phi\gamma R_{t-1,t}^f s_t oa_{t-1}^f + \Phi\gamma R_{t-1,t}^d s_{t-1} oa_{t-1}^f + \Phi R(\gamma_t^f - \delta_t) s_t oa_{t-1}^f$$
$$= oa_t^d + \alpha_1^f ox_{t,d}^a + \Phi R(\gamma_t^d - \frac{s_t}{s_{t-1}}\delta_t^f)oa_{t-1}^d$$
$$where\ \gamma_t^d = \gamma E_{t-1}(\rho_t^d)$$

QED.

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