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Synthetic returns on NIPA assets: An international comparison

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Abstract

The components of national income and product – such as consumption, investment, government purchases, exports, and imports – may be usefully viewed as nontraded assets that yield flows of 'dividends' over time. Many open questions in public finance and macroeconomic policy, such as the appropriate interest rate for discounting Social Security payments, depend critically on the risk and return properties of NIPA components. This paper presents some measurements on the risk and return of NIPA components, using the Campbell–Shiller (1988) model which assumes constant expected returns. We find that the returns to NIPA components are (i) more volatile than growth rates; and (ii) the returns to consumption, investment, and government purchases are very highly correlated with own-country output returns. The correlations between trade variables and output are weaker. Looking across countries, we find that the correlation between the returns on consumption and output are very similar to the correlation between the growth rates of these variables. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

The components of national income and product – such as consumption, investment, government purchases, exports, imports, labor and capital income – may usefully be viewed as 'dividends' on nontraded assets.[1] Many important questions in macroeconomics, international economics, public finance, portfolio theory and asset pricing depend on the properties of returns on these NIPA securities. Since explicit markets for NIPA assets do not presently exist, economic theory and measurement must be used to synthesize these returns so that their properties can be studied.

In this paper, we construct return measures for seven NIPA components in 11 OECD countries. Since the statistical properties of NIPA 'dividends' are traditionally viewed as very different across NIPA components and across countries, the current investigation focuses on how these differences in dividends translate into differences in returns. In line with this focus, we use the constant-expected-return model of Campbell and Shiller (1988) as our asset pricing model and we experiment with several different econometric models for the time series behavior of dividends.

The organization of our study is as follows. Section 2 discusses the wide range of substantive economic questions that depend importantly on the properties of returns on NIPA components. Section 3 provides a discussion of the conceptual issues involved in valuing NIPA assets. To illustrate the key empirical issues, this section also produces an initial set of empirical results for US GDP using three alternative time series models. The first model employs a univariate time series model, which is essentially the approach of Shiller (1993). The second approach assumes that the growth rates of US GDP and labor income follow a vector autoregressive process. The third approach assumes that GDP and labor income are cointegrated as in Baxter and Jermann (1997). Under the cointegration restriction, which involves a stationary ratio of labor income to output, there are two major results: (i) the return on US GDP is more volatile than when the univariate or VAR specification is used; and (ii) there is near-perfect correlation of the GDP return and the return on a security which has labor income as its dividend. Motivated by these results, Section 4 analyzes the cointegration properties of the NIPA components of all 11 countries. We begin with a discussion of the neoclassical theoretical mechanisms that lead labor income, consumption and investment to be cointegrated with GDP in a closed economy and then discuss the behavior of exports and imports. We then apply two different econometric methods to testing cointegration, beginning with the US and proceeding to other countries. This econometric evidence on

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[1] We use the terminology 'dividends' for the cash flows from the synthetic securities under study.

cointegration provides the basis for the econometric specifications that we subsequently use in computing returns to NIPA components. In Section 5, we discuss the variability and comovement of returns within and across countries. Section 6 concludes.

2. Motivating economic questions

A broad range of economic questions motivates our efforts to construct synthetic returns for NIPA components. Although the present paper will address only a subset of these questions, it is useful to begin by reviewing those areas of economics that will benefit from better understanding of the return characteristics of NIPA components.

2.1. Public policy

The tax receipts and expenditures of most governments are uncertain because these depend on the level of macroeconomic activity. In turn, this dependence raises the question of what risk-adjusted interest rate should be used to value streams of tax receipts and expenditures. For example, there is currently a great deal of debate in many countries about the nature of government retirement programs, such as the US social security system. To evaluate whether the rate of return on social security contributions earned by an individual is too low or the aggregate program is underfunded, it is necessary to know the appropriate interest rate for cash flows that depend on social security inflows, which in turn depend on aggregate labor income. There are two necessary parts of such an investigation. As in this paper, it would be necessary to generate synthetic returns: returns on social security tax payments and on social security program payments to individuals. Then, it would be necessary to deduce the extent to which the fluctuations in these returns is the type of risk that private markets reward with higher expected returns, which would involve studying the covariation of synthetic returns and observed returns on market assets.

2.2. Market creation

Shiller (1993) has proposed the creation of 'macro markets' on which actual NIPA securities might be traded. Generally, for several new markets on NIPA securities to be successful, then it must be the case that these new assets would be significantly different from each other and from existing markets. By generating synthetic NIPA security returns, we can provide some evidence on each of these questions.

2.3. *Macroeconomics and finance*

Synthetic returns on NIPA assets allow us to provide information about open economic questions that lie at the intersection of international economics, macroeconomics and finance. In this paper we will provide answers to three of these questions:

1. How different are the returns on US consumption and output? A standard stylized fact in business cycle research is that consumption is less volatile than output. Does this volatility difference for dividends carry over to returns on these assets?
2. How different are the returns on US and German output streams? New and old studies of the 'international diversification puzzle' new and old indicate that there is positive correlation of asset returns, but that there are nevertheless major motivations for diversification. Does the behavior of returns on NIPA output securities suggest the same result?
3. How different are US and German consumption streams? The literature on international business cycles has stressed that consumption is not that highly correlated across countries, which is a puzzle from the standpoint of the complete risk-sharing models of this research program. It is instructive to investigate whether this low correlation carries over to returns on NIPA consumption securities for various countries, which might be better indicators of the consumption construct in the international business cycle models.

2.4. *Financial econometrics*

Shiller (1993) and Baxter and Jermann (1997) have previously used the Campbell-Shiller approach to generate synthetic returns on NIPA assets for different countries. These earlier studies focused on a smaller set of NIPA claims and used very different dividend generating processes. Our study thus is concerned with the robustness of these earlier results, specifically studying the importance of multivariate modeling and of cointegration of dividend streams to statistical behavior of synthetic asset returns.

3. Conceptual issues and results for US GDP

The general framework that we use to compute returns on output and other NIPA components is the standard present value model. According to this model, the ex-dividend value of an asset that yields a stream of dividends D_t is given by

$$V_t = \mathrm{E}_t\left\{ \sum_{j=1}^{\infty} \beta^j \left(\frac{\Lambda_{t+j}}{\Lambda_t}\right) D_{t+j} \right\} \tag{1}$$

where Λ_t is a stochastic discount factor, which is sometimes referred to as the 'asset pricing kernel'. The one-period, gross, continuously compounded return to holding the asset from period $t-1$ to period t is given by

$$R_t = \log\left(\frac{V_t + D_t}{V_{t-1}}\right). \tag{2}$$

Within this asset-pricing framework, there are three main factors that determine an asset's value. Taking a standard covariance decomposition of Eq. (1), we have

$$\begin{aligned} V_t &= \mathrm{E}_t\left\{\sum_{j=1}^{\infty} \beta^j\left(\frac{\Lambda_{t+j}}{\Lambda_t}\right)D_{t+j}\right\} \\ &= \left\{\sum_{j=1}^{\infty} \beta^j \mathrm{E}_t\left(\frac{\Lambda_{t+j}}{\Lambda_t}\right)\mathrm{E}_t D_{t+j}\right\} + \sum_{j=1}^{\infty} \beta^j \operatorname{cov}_t\left(\frac{\Lambda_{t+j}}{\Lambda_t}, D_{t+j}\right). \end{aligned}$$

Thus, the valuation of the asset includes expected variations in cash flows, $\mathrm{E}_t D_{t+j}$, the term structure of interest rates, $\mathrm{E}_t\beta^j(\Lambda_{t+j}/\Lambda_t)$ and the riskiness of the cash flows, $\operatorname{cov}_t(\Lambda_{t+j}/\Lambda_t, D_{t+j})$. Consequently, returns capture changes in expectations of cash flows, changes in the term structure of interest rates, and changes in asset risk. Looking across assets, the standard theory highlights differences in the levels of risk as important for expected returns. Looking across countries, the standard theory allows for differences in the asset pricing kernel, if international capital market linkages are incomplete.

In this paper, we assume that expected returns are constant across time, across countries and across securities. This permits us to focus on the most basic determinant of prices and returns, which is changes in the expectations of cash flows.

3.1. Computing asset prices and returns

Our strategy for computing returns is based on the log-linear model of Campbell and Shiller (1988). We assume that 'dividends', D_t (which may be a vector of dividends for several assets), are generated by a state space system with possible trends and unit roots:

$$\begin{aligned} \log(D_t) &= \pi s_t + gt, \\ s_t &= M s_{t-1} + \varepsilon_t. \end{aligned} \tag{3}$$

With constant expected returns, the unexpected component of returns is due to revisions in the discounted value of expected future cash flows:

$$R_t - \bar{R} = (1-\gamma)\sum_{j=0}^{\infty} \gamma^j[\mathrm{E}_t \log(D_{t+j}) - \mathrm{E}_{t-1}\log(D_{t+j})] \tag{4}$$

where γ is a discount factor that is related to the expected return, $\bar{R}$, and other factors including the trend growth of dividends.[2] Combining Eq. (4) with the state-space model (3), unexpected returns can be written as[3]

$$R_t - \bar{R} = (1-\gamma)\sum_{j=0}^{\infty} \gamma^j \pi[M^j \varepsilon_t] = (1-\gamma)\pi[I - \gamma M]^{-1}\varepsilon_t.$$

In the remaining part of this section we investigate the implications for returns of alternative statistical models for 'dividends'. We will focus on US GDP for the remainder of this section. In subsequent sections, we will apply methods developed below for other NIPA components, both in the US and in several other countries.

3.1.1. *The univariate approach*

This approach specifies that 'dividends' D_t follow a univariate stochastic process. Let Y_t denote GDP in period t, and let $y_t = \log Y_t$ with $\Delta y_t = y_t - y_{t-1}$. Since there is substantial econometric evidence that US GDP is a difference-stationary process (integrated of order one), we specify the process for GDP in first-difference form, as follows:

$$\Delta y_t = \mu(1-\rho) + \rho \Delta y_{t-1} + \varepsilon_t. \tag{5}$$

The mean growth rate of output is μ and the variance of the growth rate is

$$\mathrm{var}(\Delta y_t) = \left(\frac{1}{1-\rho^2}\right)\sigma_\varepsilon^2.$$

The Campbell–Shiller approximate return to output in period t, R_t, is given by

$$R_t - \bar{R} = (1-\gamma)\sum_{j=0}^{\infty} \gamma^j [\mathrm{E}_t y_{t+j} - \mathrm{E}_{t-1} y_{t+j}]. \tag{6}$$

According to Eq. (6), the period-t return on the asset known as 'GDP' depends on revisions in the entire expected future path of output. To make Eq. (6) operational, we must specify how these revisions in expectations are related to the fundamental shocks to the economy. Under the dividend process (5), the unexpected return is given by

$$\mathrm{R}_t - \bar{R} = \left(\frac{1}{1-\gamma\rho}\right)\varepsilon_t \tag{7}$$

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[2] This discount factor γ is distinct from β in Eq. (1). Campbell and Shiller (1988) discuss how it depends on the underlying discount factor and the expected growth rate of dividends.

[3] Note that the inverse is well defined so long as the eigenvalues of M are less than $1/\gamma$ in absolute value.

with variance

$$\mathrm{var}(R_t - \bar{R}) = \left(\frac{1}{1-\gamma\rho}\right)^2 \sigma_\varepsilon^2.$$

If there is no serial correlation in the growth rate of output ($\rho = 0$), then the variance of returns is equal to the variance of dividend growth. Thus, the Campbell–Shiller approximation captures a well-known result: with constant expected returns and random-walk dividends the asset price is proportional to the level of dividends, implying that the return is equal to the growth rate of dividends. When there is positive serial correlation and $\gamma \cong 1$, the volatility of returns exceeds the volatility of growth rates:

$$\frac{\mathrm{var}(R)}{\mathrm{var}(\Delta y)} = \frac{1-\rho^2}{(1-\gamma\rho)^2} \cong \frac{1+\rho}{1-\rho}. \tag{8}$$

Panel A of Table 1 presents the results of estimating Eq. (5) for the growth rate of US GDP using quarterly data from 1960:2–1996:1. The estimated autoregressive coefficient is $\hat{\rho} = 0.3152$. The equation explains about 9% of the variation in US GDP growth. The standard error of the regression is 0.009 – this standard error is an estimate of σ_ε, the standard deviation of the innovation to the GDP process.

The volatility and correlation properties of GDP growth and returns are summarized in Table 2. We used a value of $\gamma = 0.98$. The standard deviation of GDP growth is 0.95% per quarter, while the standard deviation of GDP returns computed with the univariate model is 1.31% per quarter. Thus, the univariate measure of GDP returns is $1.31/0.95 = 1.38$ times as volatile as the growth rate of GDP.

Eq. (8) can be used to give an idea of how the relative volatility of returns to growth rates varies with the autoregressive parameter ρ. Using Eq. (8) with our estimate $\hat{\rho} = 0.3152$, as for US GDP, then we obtain $\mathrm{var}(R)/\mathrm{var}(\Delta y) = (1 + 0.3152)/(1 - 0.3152) = 1.9206$, so that the ratio of standard deviations is about $\sqrt{1.9206} = 1.39$, which (when rounded to two decimal places) is close to the figure obtained above.

The growth rates of US real GDP and the computed returns on this series are displayed in Fig. 1. This figure shows graphically the facts that we just discussed: while returns are more volatile than growth rates, the two series move together strongly: their correlation is 0.95.

3.1.2. The VAR approach

Unlike the univariate approach to modeling the data-generating process for NIPA components, the VAR approach allows for dynamic inter-relationships between these components. Here, we will consider bivariate systems, in which

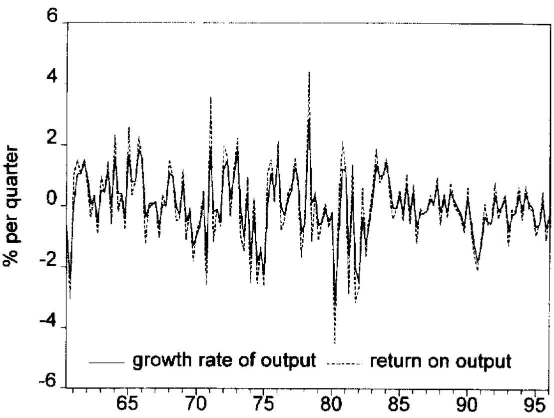

Fig. 1. US GDP: growth rate vs. returns.

GDP is paired with one other NIPA component for the purpose of estimating the dividend process. For the purpose of this section, GDP is paired with labor income. Let z_t denote the log of labor income in period t and let $\Delta z_t = z_t - z_{t-1}$ denote the growth rate of labor income between period $t-1$ and period t. As before, let y_t denote the log of GDP in period t and let Δy_t denote its growth rate. The estimated VAR is of the form:

$$\Delta y_t = k_y + \psi_{yy}\,\Delta y_{t-1} + \psi_{yz}\,\Delta z_{t-1} + \varepsilon_{yt},$$

$$\Delta z_t = k_z + \psi_{zy}\,\Delta y_{t-1} + \psi_{zz}\,\Delta z_{t-1} + \varepsilon_{zt}. \tag{9}$$

The results of the estimation of Eq. (9) are contained in Panel B of Table 1. The notable features of this vector-autoregression are that labor income growth has a higher predictable component than GDP growth: the adjusted R^2 is 0.42 for labor income growth, but only 0.12 for GDP growth. Labor income growth is a significant predictor of both GDP growth and labor income growth. Looking at the standard errors of the regressions, we see that the standard error for the output equation is essentially unchanged from the univariate specification: adopting a VAR specification has not much affected our estimate of the volatility of the shock process σ_{ε_y}. The standard error for the GDP growth equation is substantially higher than the standard error for the labor income equation: $\sigma_{\varepsilon_y} = 0.0089$ compared with $\sigma_{\varepsilon_z} = 0.0057$. That is: shocks to GDP growth are more volatile than the shocks to labor income growth.

Table 2 presents results on the volatility of returns on GDP computed using the VAR model for GDP growth and labor income growth.[4] The standard

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[4] Baxter and Jermann (1997), Bottazi et al. (1996) and Campell (1996) construct similar measures of returns on labor income and use these measures to discuss asset pricing issues.

Table 1
Alternative econometric specifications for U.S. GDP growth Quarterly data, 1960 : 2–1996 : 1 (standard errors in parentheses)

A. Univariate autoregression

$\Delta y_t = a + b\Delta y_{t-1} + \varepsilon_t$

Variable	Coefficient
Constant	0.0053
	(0.0010)
Δy_{t-1}	0.3152
	(0.0792)
Adjusted R-squared	0.0944
S.E. of regression	0.0090

B. Vector autoregression

$\Delta y_t = a_y + \psi_{yy}\Delta y_{t-1} + \psi_{yz}\Delta z_{t-1} + \varepsilon_{yt}$
$\Delta z_t = a_z + \psi_{zy}\Delta y_{t-1} + \psi_{zz}\Delta z_{t-1} + \varepsilon_{zt}$

	Equation	
Variable	Δy_t	Δz_t
Constant	0.0042	0.0028
	(0.0010)	(0.0007)
Δy_{t-1}	0.1162	0.0910
	(0.1238)	(0.0801)
Δz_{t-1}	0.3233	0.5644
	(0.1557)	(0.1007)
Adjusted R-squared	0.1153	0.4232
S.E. of regression	0.0089	0.0057

C. Vector-error-correction model

$\Delta y_t = a_y + \psi_{yy}\Delta y_{t-1} + \psi_{yz}\Delta z_{t-1} + b_y(z_{t-1} - y_{t-1}) + \varepsilon_{yt}$
$\Delta z_t = a_z + \psi_{zy}\Delta y_{t-1} + \psi_{zz}\Delta z_{t-1} + b_z(z_{t-1} - y_{t-1}) + \varepsilon_{zt}$

	Equation	
Variable	Δy_t	Δz_t
Constant	− 0.0272	− 0.0393
	(0.0228)	(0.0144)
Δy_{t-1}	0.0920	0.0586
	(0.1246)	(0.0788)
Δz_{t-1}	0.02789	0.5052
	(0.1585)	(0.1022)
$z_{t-1} - y_{t-1}$	− 0.0588	− 0.0785
	(0.0425)	(0.0269)
Adjusted R-squared	0.1210	0.4526
S.E. of regression	0.0089	0.0044

Table 2
Returns for U.S. GDP: Results for alternative econometric models

Measure of GDP return	Standard deviation: percent per quarter	Correlation between alternative measures of GDP returs:				Correlation between GDP and labor income returns
		Growth rate	Univariate	VAR	VECM	
Growth rate	0.95	1.00	0.95	0.91	0.86	0.77
Univariate	1.31		1.00	0.92	0.90	—
VAR	1.50			1.00	0.82	0.93
VECM	1.88				1.00	0.99

deviation of the GDP returns is 1.50% per quarter – higher than the standard deviation of returns computed using the univariate approach, and substantially higher than the growth rate of GDP. This table also shows that the VAR-based measure of GDP returns is highly correlated with returns computed with the univariate specification: the correlation coefficient is 0.92. The last column of Table 2 reports on the correlation between GDP returns and labor income returns under the alternative econometric specifications. For the VAR model, the correlation between GDP returns and labor income returns is 0.93. This is substantially higher than the correlation between the growth rates of these variables, which is only 0.77.

3.1.3. Common trends in NIPA aggregates

Economists have long thought that certain ratios of NIPA components appear to be approximately constant over long horizons, even in the presence of long-run growth in the level of economic activity. If the level of NIPA components is taken to be a difference stationary stochastic process (integrated of order one), then the constancy of such great ratios implies that there is cointegration.[5] For example, if labor income and aggregate output (GDP) behave so that their ratio is stationary, then their logarithms are cointegrated with a cointegrating vector of [1, − 1] and share a common stochastic trend.

Baxter and Jermann (1997) have shown that cointegration can have dramatic implications for asset pricing. Continuing with the output and labor income example, suppose that $y_t = \tau_t + \xi_{yt}$ and $z_t = \tau_t + \xi_{zt}$, where $\tau_t = g + \tau_{t-1} + \eta_t$ is the common trend and η_t, ξ_{yt} and ξ_{zt} are mutually uncorrelated white noise disturbances. Then the returns on NIPA portfolios for consumption and income are

$$R_{yt} = \eta_t + (1 - \gamma)\xi_{yt},$$

$$R_{zt} = \eta_t + (1 - \gamma)\xi_{zt}.$$

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[5] See, for example, King et al. 1991.

Because variations in trend affect labor income and GDP similarly for all periods, the returns to these NIPA portfolios are affected similarly by trends. Further, the returns are dominated by the trend components, as we will see more explicitly below.

Fig. 2 plots the ratio of labor income to GDP for the US. This ratio shows little evidence of a trend: fluctuations in the ratio appear to return to a mean value that is constant over time. This suggests that labor income and output may be cointegrated. If labor income and GDP are cointegrated, then it is appropriate to estimate a vector-error-correction model (VECM) of the form

$$\begin{bmatrix} \Delta y_t \\ \Delta z_t \end{bmatrix} = \begin{bmatrix} k_y \\ k_z \end{bmatrix} + \begin{bmatrix} \psi_{yy}(L) & \psi_{yz}(L) \\ \psi_{zy}(L) & \psi_{zz}(L) \end{bmatrix} \begin{bmatrix} \Delta y_{t-1} \\ \Delta z_{t-1} \end{bmatrix} + \begin{bmatrix} b_y \\ b_z \end{bmatrix} [z_{t-1} - y_{t-1}] + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}. \tag{10}$$

While this empirical specification allows for richer dynamic interactions between labor income and GDP at various dates, it shares a key feature with the simple example discussed above: there is a common stochastic trend in labor income and GDP.

The results of estimating Eq. (10) are given in Panel C of Table 1. These results show that lagged labor income growth is important for predicting labor income growth, and is marginally important for predicting output growth as well. The error-correction term in the labor income growth equation appears to be significant, which lends support to the hypothesis of cointegration. In Section 3, we will provide formal econometric evidence on cointegration. For now, we will take the estimated process reported in Panel C of Table 1 and use it to compute returns for US GDP.

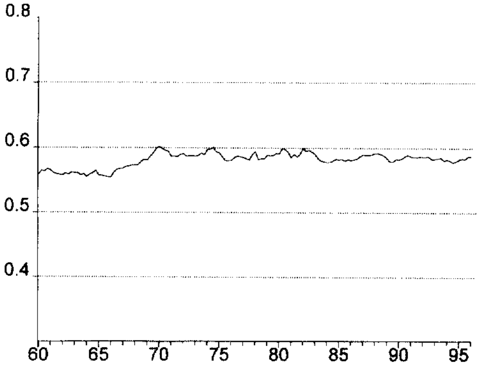

Fig. 2. US labor income as a fraction of GDP.

Table 2 contains information on the volatility and correlation of GDP returns computed using the vector-error-correction model (10). The volatility of GDP returns computed with the VECM specification is 1.88% per quarter: higher than return volatility computed with the VAR and univariate schemes, and nearly double the volatility of the growth rate of GDP.

It is instructive to investigate why the VECM returns are significantly more volatile than the VAR or univariate returns, since this will be a recurrent finding when we look at other NIPA components and other countries. The estimated VECM(1) for labor income and GDP takes the form (10) with estimates of the relevant parameters shown in panel C of Table 1. Relative to the estimated VAR, (i.e., the empirical specification with $b_y = b_z = 0$), there are three potential sources of volatility differences. First, the ψ parameters might be different across the VECM and the VAR. Second, the shocks ε might be different. Third, the addition of the cointegration terms and associated parameters could be leading to the altered volatility implications. To track down the main source, we conducted the following experiment. We estimated the VECM and then computed asset returns setting $b_y = b_z = 0$. We left the ψ parameters and the shocks ε at the VECM estimated values. The volatility of asset returns was much lower than in the VECM, and in fact was comparable to the levels found in the VAR. Thus, we conclude that it is mainly the cointegration restriction that leads to increased return volatility.

To see why this might occur, consider the alternative specification with the autoregressive parameters (ψ_{jk}) and the constant terms (k) set to zero:

$$\begin{bmatrix} \Delta y_t \\ \Delta z_t \end{bmatrix} = \begin{bmatrix} b_y \\ b_z \end{bmatrix} [z_{t-1} - y_{t-1}] + \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{zt} \end{bmatrix}. \tag{11}$$

Then, each growth rate is driven by a persistent component $[z_{t-1} - y_{t-1}]$ and a transitory one. We know that it is the persistent components of dividends that will have the important effects on returns. Further, labor's share is highly serially correlated with a first order autocorrelation of 0.95. The VECM estimates indicate that both b parameters are small and negative, so that labor's share exerts (i) a similar magnitude effect on return volatility; and (ii) the same sign effect on return volatility.[6]

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[6] The discussion in the main text proceeds as though the process for labor's share is not pinned down by the parameters in the simple specification (11). Writing out the level VAR implied by the above specification, we can determine that there are two eigenvalues, one of which is unity with the other being $1 + (b_z - b_y)$. Intuitively, a high level of $[z_{t-1} - y_{t-1}]$ must make the growth of labor income fall by more than the growth of GDP in order that labor share be stationary. Since labor income and GDP will each be linear combinations of canonical variables implied by these two eigenvalues and since cointegration implies that the coefficients on the unit eigenvalue must be the same, labor's share will evolve as a first order autoregression with parameter $\rho = (1 + b_z - b_y)$. In fact the estimated VECM system has an eigenvalue that is about 0.95.

The center panel of Table 2 shows that the returns generated from the VECM are highly correlated with the returns generated with the VAR and univariate methods. Finally, the last column of Table 2 shows that the correlation is 0.99 between returns to GDP and returns to labor income when the VECM specification is employed. This very high correlation arises in the VECM specification because this specification embeds the assumption that labor income and GDP share a common stochastic trend in these variables. Since the return computations are dominated by long-term, trend components, the fact that these two NIPA components share a common trend means that their returns will be very highly correlated if the econometric specification of the dividend process imposes the common trend assumption.

4. Cointegration: Theory and econometric evidence

The last section illustrated the importance of cointegration restrictions for the behavior of returns on NIPA 'assets'. Working from the observation that labor's share appears to be stationary in US data (Fig. 2), we estimated a VECM for labor income growth and GDP growth. We found that the returns to labor income and GDP were extremely highly correlated when the cointegration restriction was imposed.

Based on these considerations, this section undertakes a detailed econometric investigation of the cointegration properties of NIPA components for all 11 countries in our sample. Specifically, we focus on three related topics. First, we discuss the theoretical reasons that one might expect ratios of NIPA components to be stationary, even when there are deterministic or stochastic trends present in the levels of the variables. Second, we discuss some alternative econometric methods of evaluating whether these cointegration predictions are supported by the data. Third, we discuss the evidence on cointegration.

4.1. Theory

If we begin with an aggregate production function that is subject to technical progress, then it is well-known from the 1960s literature on economic growth that there can be stationary ratios even when there is trend growth. For example, if the production function is Cobb–Douglas, $Y_t = A_t N_t^{\alpha} K_t^{1-\alpha}$, and there are trends in labor input and productivity, then competitive factor markets imply that there will be a constant ratio α of labor income, Z_t, and aggregate output:

$$Z_t / Y_t = \alpha. \tag{12}$$

In our discussion of the US in Section 2 above, we have seen that one measure of labor's share looks fairly constant over 1960–1996. We used this to motivate a specific cointegration restriction between labor income and gross domestic product, which is that these are cointegrated with a cointegrating vector of [1, − 1] since Eq. (12) implies that $z_t = \log(Z_t)$ evolves according to $z_t - y_t = \log(\alpha)$. Since cointegration is a statement about the 'long run', we can interpret Eq. (12) as derived under the assumption of 'perfect competition in the long run', allowing for (i) short-run departures from perfect competition; and (ii) short-run departures from constant labor's share.

4.1.1. *The cointegration of investment and output*

Working with the Cobb–Douglas production function, the comparable efficiency condition for capital implies that

$$(1-\alpha)\left(\frac{Y_t}{K_t}\right) = Q_t$$

where Q_t is the real rental price of capital, which is a combination of the real interest rate and the depreciation in the basic model. Combining the assumption of a stationary rental price with an assumption that the ratio of investment to capital is stationary in the long run, we derive the implication that

$$\log(I_t) - \log(Y_t) = \log(1-\alpha) - \log(Q_t) + \log(I_t/K_t)$$

so that the investment–output ratio is also stationary or, equivalently, investment and output are cointegrated with the [1, − 1] cointegrating vector. Violation of this cointegration restriction could thus arise from fiscal and technical factors that made the rental price of capital nonstationary, such as permanent changes in the taxation of capital or the real price of capital.

4.1.2. *Government and consumption shares in the closed economy*

With a stationary investment–output ratio, the closed economy identity $Y_t = C_t + I_t + G_t$ indicates that there is an important linkage between stationarity of the consumption ratio and the government spending ratio. If there are only stationary variations in government's share, then consumption and output will also be cointegrated with the [1, − 1] cointegrating vector.

4.1.3. *Export and import shares*

The trade shares of GDP appear to contain upward trends for many countries. Unlike the other NIPA components, there are no natural bounds on the trade shares. For example, simple accounting suggests that consumption and investment must account for less than 100% of output over long horizons. By contrast, exports and imports can account for greater than 100% of output when output is measured as a 'value added' concept like GDP or GNP. In Hong Kong, for example, the share of exports in GDP exceeds 100% by a substantial amount. In the US, to take a less dramatic example, the shares of each of exports and imports in US GDP have risen from about 5% in 1960 to about 10% today.

Based on this a priori reasoning, we do not expect to find a great deal of support for cointegration between output on the one hand, and exports or imports on the other.

4.2. Econometrics

To investigate these long-run relations, we will use the following econometric methods. First, we will produce standard augmented Dickey and Fuller (1979) tests on the constructed ratios. Second, using the local-to-unity asymptotic method developed in Stock (1991), we will produce a 95% confidence interval on the largest root of the associated univariate autoregression. Third, we will produce a likelihood ratio test of cointegration – for the cointegrating vector [1, − 1] – using the approach of Horvath and Watson (1995). Before presenting the results of this information for our various countries, we next provide a discussion of these various econometric approaches. For expositional purposes, we continue to use the relationship between US labor income and GDP as our example.

4.2.1. The ADF test

A direct approach to determining whether a 'great ratio' is stationary is to perform a unit root test, for example the ADF test, on the constructed ratio. That is, we form the variable $x_t = z_t - y_t$, which is the log of the ratio displayed in Fig. 2 above. This log ratio is a highly persistent series (it has a first-order serial correlation coefficient of 0.94), which ranges between a minimum of $-0.590 = \log(0.554)$ and a maximum of $-0.509 = \log(0.601)$.

The Augmented-Dickey–Fuller (ADF) regression then takes the form

$$\Delta x_t = \underline{x} + \phi(L)\Delta x_{t-1} + bx_{t-1} + \varepsilon_t$$

where $\underline{x}$ is a constant term and $\phi(L)$ is a polynomial in the lag operator. With our application of the ADF test, the null hypothesis is that the share x_t contains both a deterministic trend (with an average growth rate given by $\underline{x}/(1-\phi(1))$) and a stochastic trend (a random walk).

If there is a significantly negative value of b then we conclude that this null hypothesis is rejected against an alternative in which the ratio is stationary with a mean value of $\underline{x}/(1-b)$. For our example of labor income and with four lags, the point estimate of b is -0.0539, with an ADF 't' statistic of -2.03. Using conventional significance levels, one cannot reject the hypothesis of a unit root in the log ratio with the ADF 't' test, however, since the test falls below the critical value which is -2.8821 at the 5% level.[7] But ADF tests have known

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[7] The 1% critical value is -3.4779 and the 10% critical value is -2.5776.

problems in terms of low power against an alternative hypothesis that the variable is stationary with a highly persistent temporary component.

4.2.2. *The Stock confidence intervals on the autoregressive largest root*

We can rearrange the Dickey–Fuller regression as

$$\phi^*(L)x_t = \bar{x} + \varepsilon_t$$

where $\bar{x}$ is a transformed constant term and $\phi^*(L) = (1 - L)(1 - \phi(L)) + bL$. The polynomial $\phi^*(L)$ may be factored into $(1 - \rho L)r(L)$, with ρ being the largest autoregressive root and $r(L)$ capturing the remaining stationary dynamics. Stock (1991) shows how to compute a confidence interval for ρ based on the Dickey–Fuller regression (more specifically, on the ADF statistic).

The Stock confidence intervals aids us in thinking about the persistence of x_t, moving the discussion from 'stationary or not?' to 'how persistent are variations in the ratio of labor income to GDP (i.e., in x_t)?'. In our context, we are interested in the estimated value of $\hat{\rho}$ and the associated Stock confidence interval for reasons developed in Section 2 above: if there is a persistent movement in x_t which predicts output and labor growth, then this implies (i) that output and labor income returns may respond a lot when variations to shocks to x_t; and (ii) if ρ is very large, then the series may not be cointegrated, leading to relatively smaller correlations between output and labor returns.

Mechanically, to compute the confidence interval, we must only use the Dicky–Fuller 't' statistic on b, together with the look-up table given in Stock for the specified sample size. However, for completeness, we also add a point estimate of ρ: we estimate $\phi^*(L)$ and compute the largest autoregressive root.

4.2.3. *The Horvath–Watson test*

The information on cointegration that we have so far produced is based on the univariate properties of $x_t = z_t - y_t$. The bivariate error-correction model estimated in Section 2, however, took the form:

$$\begin{aligned} \Delta z_t &= k_z + \psi_{zz}\Delta z_{t-1} + \psi_{zy}\,\Delta y_{t-1} + b_z(z_{t-1} - y_{t-1}) + \varepsilon_{zt}, \\ \Delta y_t &= k_y + \psi_{yz}\Delta z_{t-1} + \psi_{yy}\,\Delta y_{t-1} + b_y(z_{t-1} - y_{t-1}) + \varepsilon_{yt}. \end{aligned} \tag{13}$$

In the VECM, cointegration means that both of the parameters b_x and b_y cannot be zero.

If the VECM is the data-generating-process, then we can work out the implications for the preceding Dickey–Fuller regression:

$$\begin{aligned} \Delta x_t = (k_z - k_y) &+ (\psi_{zz} - \psi_{yz})\,\Delta x_{t-1} + h\,\Delta y_{t-1} \\ &+ (b_z - b_y)x_{t-1} + (\varepsilon_{zt} - \varepsilon_{yt}) \end{aligned}$$

where $h = [(\psi_{zz} - \psi_{yz}) - (\psi_{zy} - \psi_{yy})]$. Thus, the VECM indicates (i) the Dickey–Fuller regression is potentially misspecified if $h \neq 0$; and (ii) that the coefficient $b = (b_z - b_y)$ could be zero if the series were cointegrated. Accordingly, we also explore the stationarity of the 'great ratios' in the VECM context.

The textbook cointegration approach is to estimate the cointegrating vector (e.g., Hamilton, 1994). In our context, the cointegrating vector is hypothesized to be $[1, -1]$, so that the alternative approach suggested by Horvath Michael and Watson (1995) is appropriate. The Horvath–Watson test is a likelihood ratio test, which takes as its null that there is no cointegration ($b_z = 0, b_y = 0$). As in standard settings, we compute the likelihood ratio L as twice the difference in the likelihoods of the unrestricted model (the VECM without restrictions on b_z and b_y) and the restricted model (the VECM with ($b_z = 0, b_y = 0$) or equivalently a VAR). Large values of L are evidence against the null hypothesis of no cointegration, i.e., are interpreted as evidence for cointegration. If the series were not integrated, then this would be a standard setting in which L would be a χ^2 distribution with two degrees of freedom (since there are two restrictions being tested). As with standard unit root tests, however, there is a nonstandard distribution of L because the null hypothesis involves x_t being an integrated series. Horvath and Watson (1995) derive the relevant distribution theory and tabulate the critical values of the L statistic. With two restrictions, a 10% critical value for L is about 8, which is much larger than the $\chi^2(2)$ critical value of about 4.6.

4.3. Empirical results

In discussing the empirical results on cointegration of NIPA components, we begin with the US and then proceed to the other ten countries in our international sample. Overall, while we find that the results are somewhat mixed, we find patterns in the US and other countries that we use to structure the time series models that are used to produce estimates of returns presented in Section 5 below.

4.3.1. Results for the US

Fig. 3 and Tables 3 and 4 provide information on the cointegration behavior of the US components. We discuss each of these in turn.

4.3.1.1. Labor income and GDP. Since we used it as our example above, it is convenient to begin with a discussion of labor income and GDP, i.e., labor's share. In Fig. 3, panel F, we see a somewhat different picture of the behavior of labor share's share due to a difference in scaling: in effect, we are now focusing in on it very closely so that we see that: it has increased a few percentage points through time over the 1960–1996 sample period.

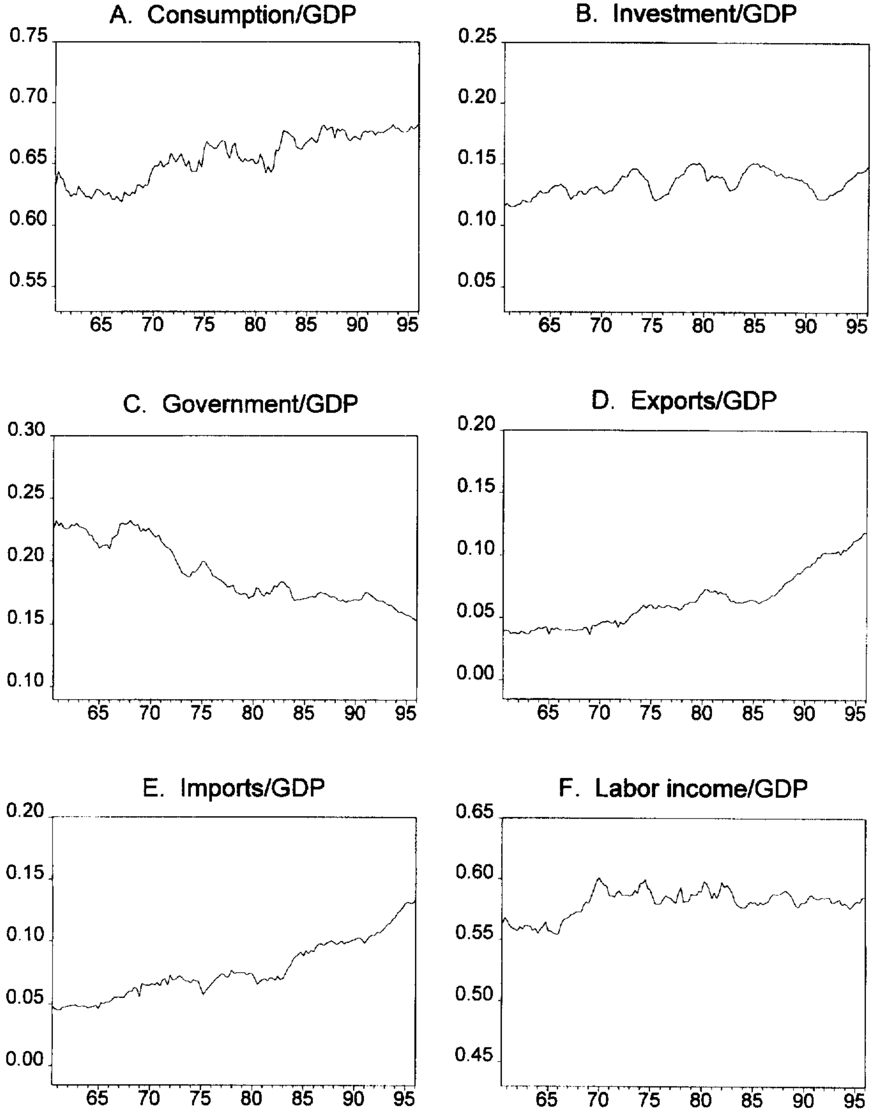

Fig. 3. NIPA ratios for the US.

In Table 3, correspondingly, we see that there is some evidence against cointegration between labor income and GDP, which is that the Dickey–Fuller '*t*' statistic for labor's share has a value of − 2.03, which falls below the 5% critical value (in absolute value). Yet, the associated Stock confidence intervals

Table 3
Unit root test results for U.S. NIPA shares $\Delta x_t = \underline{x} + \phi(L)\Delta x_{t-1} + bx_{t-1} + \varepsilon_t$

(1)	(2)	(3)	(4)	(5)	(6)
NIPA component	Estimate of b	Dickey-Fuller t-statistic	Largest AR root	Stock (1991) 95% confidence interval for largest root	
				Lower limit	Upper limit
Consumption	– 0.019	– 0.936	0.98	0.97	1.03
Investment	– 0.071*	– 3.199	0.85	0.78	0.99
Government	– 0.008	– 0.880	0.99	0.97	1.03
Exports	0.004	0.469	1.00	1.00	1.04
Imports	0.000	– 0.001	1.00	1.00	1.03
Labor income	– 0.054	– 2.031	0.94	0.90	1.02

*Significantly different from zero at 5% confidence level.

Note: This table presents results for tests of the hypothesis that the ratio of particular NIPA components to GNP are integrated of order 1 (i.e., contain unit roots). An estimate of b that is significantly less than zero indicates rejection of this hypothesis, meaning that the ratio in question can be viewed as a stationary random variable.

Table 4
Horvath–Watson test for null hypothesis of no cointegration with GDP

	Consumption	Investment	Government	Exports	Imports	Labor
Australia	8.89	6.12	13.66	1.03	3.29	5.89
p-value	0.07	0.21	0.01	0.87	0.53	0.23
Canada	14.80	20.59	7.92	7.62	21.77	11.03
p-value	0.01	0.01	0.11	0.12	0.01	0.03
France	8.99	8.70	15.15	4.18	4.03	3.38
p-value	0.07	0.08	0.01	0.40	0.42	0.51
Germany	10.91	7.86	1.77	1.80	1.43	10.87
p-value	0.03	0.11	0.76	0.75	0.81	0.03
Italy	11.22	3.31	13.07	0.11	2.28	1.86
p-value	0.03	0.52	0.01	0.99	0.68	0.74
Japan	8.53	9.72	20.33	20.94	15.11	87.31
p-value	0.09	0.05	0.01	0.01	0.01	0.01
Netherlands	5.23	9.58	0.25	1.74	1.95	6.49
p-value	0.29	0.06	0.97	0.76	0.73	0.18
Spain	3.55	6.23	3.75	0.85	1.44	N/A
p-value	0.49	0.20	0.46	0.89	0.81	
Switzerland	5.75	3.98	5.14	1.62	0.60	N/A
p-value	0.24	0.43	0.30	0.78	0.93	
U.K.	0.53	5.47	2.02	1.30	1.50	N/A
p-value	0.94	0.26	0.72	0.83	0.80	
U.S.	2.49	9.46	5.18	4.58	6.40	11.94
p-value	0.64	0.06	0.29	0.36	0.19	0.02

on the largest autoregressive root contain a wide range of highly persistent but ultimately stationary variations, $0.90 \leqslant \rho \leqslant 1.02$. Thus, this univariate evidence on labor's share is also consistent with a cointegration perspective.

The bivariate Horvath–Watson test for US labor income and GDP, presented in the last row of Table 4, provides support for using a cointegration specification such as Eq. (10) in Section 2. According to the Horvath–Watson test, we strongly reject the null hypothesis of no cointegration ($b_z = 0, b_y = 0$). The likelihood ratio statistic, $L = 11.9$ which has a p-value of about 0.02.

4.3.1.2. Investment and GDP. The evidence for cointegration of investment and GDP is the most consistently strong for any of our US NIPA components. As shown in Table 3, the ADF 't-statistic' is -3.20, which is greater than the 5% critical value of -2.88. The 95% confidence interval on the largest autoregressive root correspondingly does not include the value 1.0 (which corresponds to a unit root): rather, $0.78 \leqslant \rho \leqslant 0.99$. Table 4-2 reports that the cointegration test statistic is $L = 9.46$, which has a p-value of about 0.05. All of these statistics accord with the visual impression, in panel B of Fig. 3, that the investment-to-GDP ratio is subject to persistent, but ultimately temporary deviations from its mean.

4.3.1.3. Consumption, government purchases and GDP. There is more mixed evidence on the cointegration of consumption with GDP and government purchases with GDP. In each case, there is a distinct trend in the series that is graphed in Fig. 3 (panel A is consumption and panel B is government). Over our sample, consumption has risen from about 63% of GDP to about 68% of GDP while the share of government purchases in GDP have declined from about 22% to about 15%. As shown in Table 3, the ADF regressions estimate small values of b, which lead to estimated 't-statistics' that are each about -0.90. The associated Stock confidence intervals in are $0.966 \leqslant \rho \leqslant 1.032$ for both consumption and government purchases.[8] The Horvath–Watson likelihood ratio statistics in Table 4b are also consistent with no cointegration, with $L = 2.49$ having a p-value of 0.64 for consumption and $L = 5.18$ having a p-value of 0.29 for government purchases.

At the same time, the evolution in these shares over our sample period seems relatively small in comparison with the major changes in the level of economic activity. Although these econometric tests suggest potential nonstationarity for some of these NIPA shares, the range of variation in these shares is small. Further, economic theory suggests that there cannot be great variation over long horizons in the GDP shares of consumption, investment, and labor income. If we also believe that there cannot be substantial long-term variation in the

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[8] The confidence intervals are the same despite small differences in the 't' statistic because we used the confidence inteval for the closest element in Stock's (1991) lookup table.

NIPA share of net exports, then the share of government purchases in GDP is bounded by movements in the shares of these other components.

4.3.1.4. Exports, imports and GDP. Although economic theory places some natural bounds on the range of variation for most NIPA shares, there are weaker restrictions on the NIPA shares of exports and imports. In fact, most countries have experienced trend growth in their export and import shares. This is certainly true in the US, as shown in Fig. 3. It is also true in many of the other OECD countries in our sample, and also for a large majority of other developed and developing countries.

Our econometric tests support our 'prior' that export and import shares are likely nonstationary. The Stock 95% confidence intervals for exports and imports reported in Table 3 do not contain any points in the region below 1.00. The Horvath–Watson tests reported in Table 4 similarly provide no evidence against the null hypotheses of no cointegration between GDP and the trade variables.

4.3.2. Results from the rest of the OECD

In addition to the US results that we have already discussed, Table 4 provides evidence on the cointegration properties of NIPA components for the ten other countries in the OECD. Overall, the strongest support for cointegration is for consumption, investment, government purchases, and labor income. However, this support is not uniform across countries. Based on these econometric results and the theory described above, we will impose cointegration within each country for GDP with consumption, investment, government purchases, and labor income. Our reason for doing this is that we wish to employ an econometric specification that restricts the range of variation in the GDP shares of these variables. The cointegration restriction is a strong one – it specifies that these shares will always return to a constant, long-run level. We could imagine other econometric specifications which would allow permanent, small shifts in the long-run values of these shares, while constraining the shares ultimately to lie within a specified, narrow band. This would involve something like a cointegrating relationship with mean shifts, but would also mean estimating more parameters. In particular, this alternative specification would not look like an unrestricted VAR – such a model does not have the restrictions necessary to ensure that NIPA shares remain bounded between zero and one. For the sake of parsimony, therefore, we adopt the cointegration restriction for the aforementioned variables. We will not impose cointegration for GDP with exports or imports.

5. Synthetic returns: Evidence and implications

In this section, we investigate the variability and comovement properties of returns on NIPA components: we concentrate on our preferred econometric specifications, but also discuss the robustness of results along these lines.[9] Three subsections highlight three features of the synthetic return series: (i) the volatility of synthetic returns, using the volatility of growth rates and of country stock returns as reference points; (ii) the correlation of synthetic returns on NIPA components with synthetic returns on GDP within each countries; and (iii) the cross-country correlation of synthetic returns, using the cross-country correlation of growth rates as a reference measure. We relate each of these properties to substantive economic and econometric questions introduced in Section 2 of the paper.

5.1. *Volatility of returns*

We are interested in two basic questions about the volatility of the return series that we have generated. First, how does the volatility of returns compare with the volatility of growth rates? Second, how important is the choice of the econometric model to our volatility estimate?

5.1.1. *Comparing growth rate and return volatility*

Fig. 4 plots the volatility (standard deviation, measured in percentage points per quarter) of the growth rates of the NIPA components together with the volatility of returns. For comparison, we also plot the volatility of stock returns in each country. Some general patterns concerning the relative volatility of growth rates and returns emerge as we look across each of these components, within each country.

In general, the volatility of returns for output and consumption exceeds the volatility of growth rates of these variables. By contrast, investment growth is typically more volatile than investment returns. There is no consistent pattern for government purchases. Turning to the trade variables, both growth rates and returns are substantially more volatile than for the other NIPA components. There is no clear pattern in the relationship between growth rates and returns, even within a country. For example, in Australia, Canada, and France, the volatility of export growth exceeds the volatility of export returns, while the reverse is true for imports.

A striking feature of Fig. 4 is the fact that returns on NIPA components are at best half as volatile as stock returns. Many economists, e.g., Black (1987), view the stock return as the return to the capital stock. We might view this NIPA component as inherently about as volatile as labor income, which we studied

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[9] Based on the analysis and discussion of Section 4, we estimate bivariate VECMs involving GDP for those variables for which the cointegration restriction appears reasonable: consumption, investment, and government purchases. For exports and imports, cointegration does not appear reasonable, so we estimate a bivariate VAR (with output) for these variables.

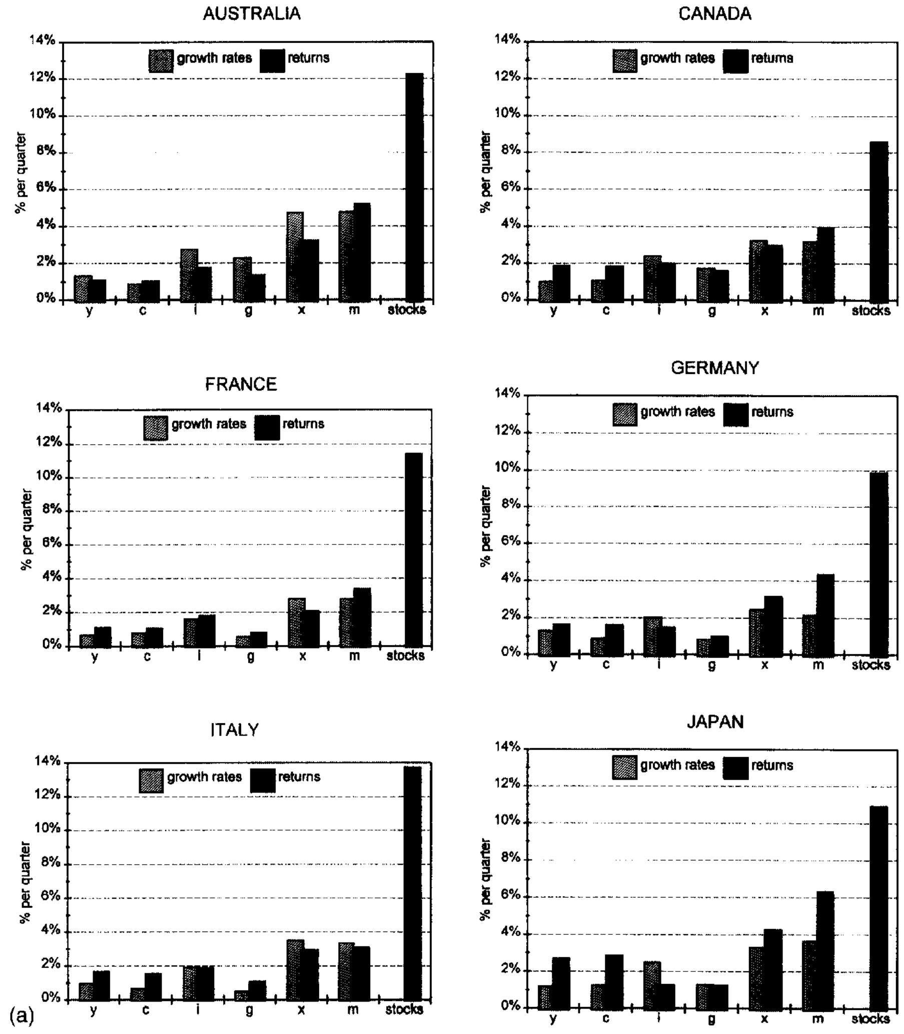

Fig. 4. Volatility of NIPA components: Growth rates vs. returns.

(for the US) in Section 2. However, the returns to labor income and the other NIPA components is estimated, using our methodology, to be much less volatile than stock market returns. One reason we might expect this is that the correct 'measure' of the stock market is the unlevered stock market – stocks and corporate bonds taken together. Adding together stocks and bonds would result in a somewhat lower estimate of the volatility of the unlevered stock market.

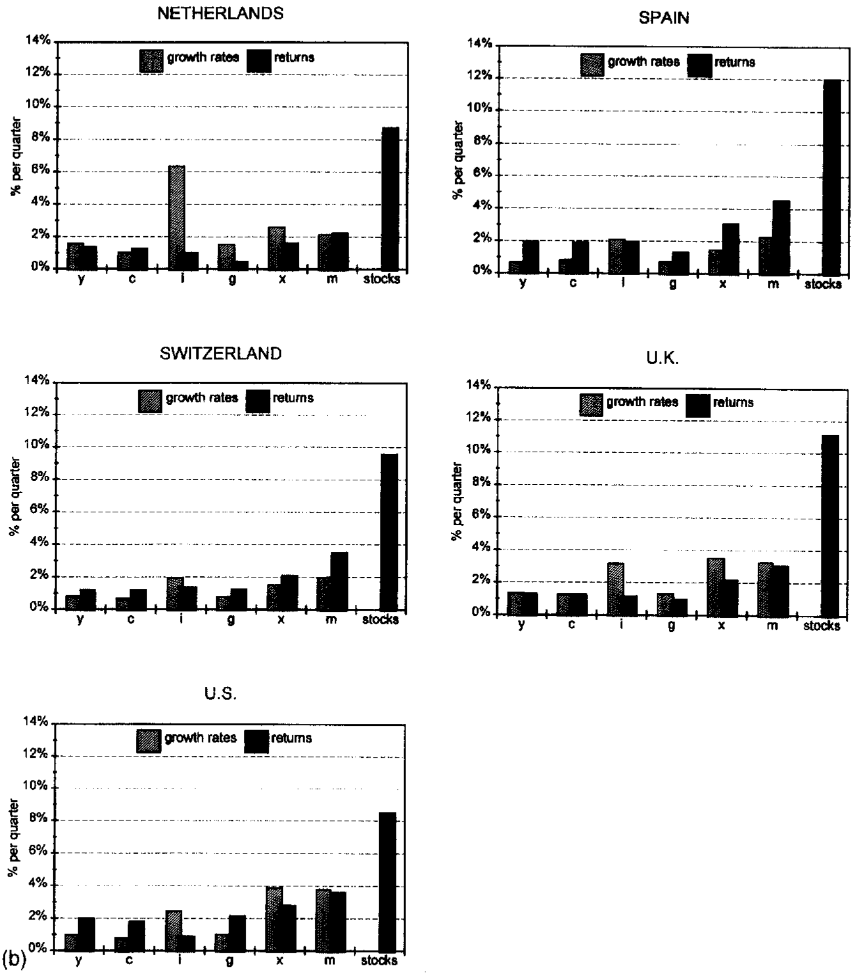

Fig. 4. Continued

However, given traditional ‘leverage ratios’, it would still be substantially more volatile than our estimated returns to the NIPA components.

5.1.2. *Comparing volatility estimates across econometric specifications*

Fig. 5 displays information on how return volatility estimates for output (GDP) differ across econometric specifications for each of our 11 countries, continuing to use the estimate of output growth as a benchmark in each country. The first two measures are those discussed above: a univariate specification of the process for output, and a bivariate VECM model with consumption and

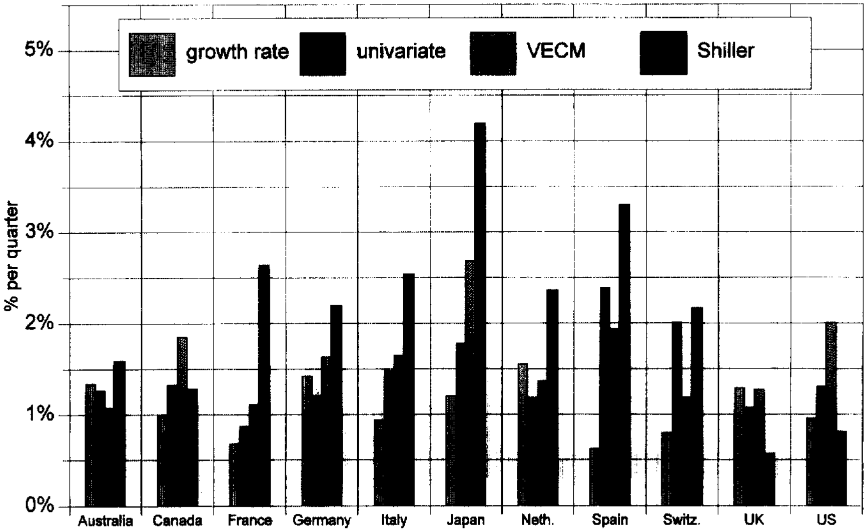

Fig. 5. Volatility under alternative econometric specifications.

output.[10] The third measure is due to Shiller (1993) who employs a univariate specification using annual data from the Summers and Heston World Tables which cover a longer sample period than ours.[11] For most countries, output returns are more volatile than growth rates, which is consistent with results reported earlier. There are important differences in our estimates relative to those of Shiller as well. Most countries show a larger volatility with the VECM specification than with the univariate specification, as with the US result reported in Section 3 above. However, in several countries, the two specifications produce very similar results or reverse results.

5.2. *Within-country correlations of returns*

How similar are the returns on the seven NIPA components within each of our 11 countries? Fig. 6 provides the answer to this question. In each panel, the

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[10] Alternative choices of the second variable, e.g., output–investment or output–government purchases, did not lead to significant differences in estimated volatility.

[11] We have transformed Shiller's estimates of annual volatility to a quarterly frequency. This is accomplished as follows. Consider constructing an annual return by adding together four quarterly returns, where all returns are expressed in percentage points. Denote the quarterly returns by x_1, x_2, x_3, x_4. Assume that the quarterly returns are independently distributed over time with variance σ_x^2. Then the variance of the annual return is $\mathrm{var}(x_1 + x_2 + x_3 + x_4) = 4\sigma_x^2$. Thus the standard deviation of the annual return is $2\sigma_x$. We therefore transformed Shiller's standard deviations for annual returns to standard deviations for quarterly returns by dividing by 2.

grey element is the correlation of the component's growth rate with the growth rate of GDP and the black element is the correlation of the component's return with the return on GDP.

The returns on consumption, investment, and government purchases are very highly correlated with the returns to output for all the countries in our sample.

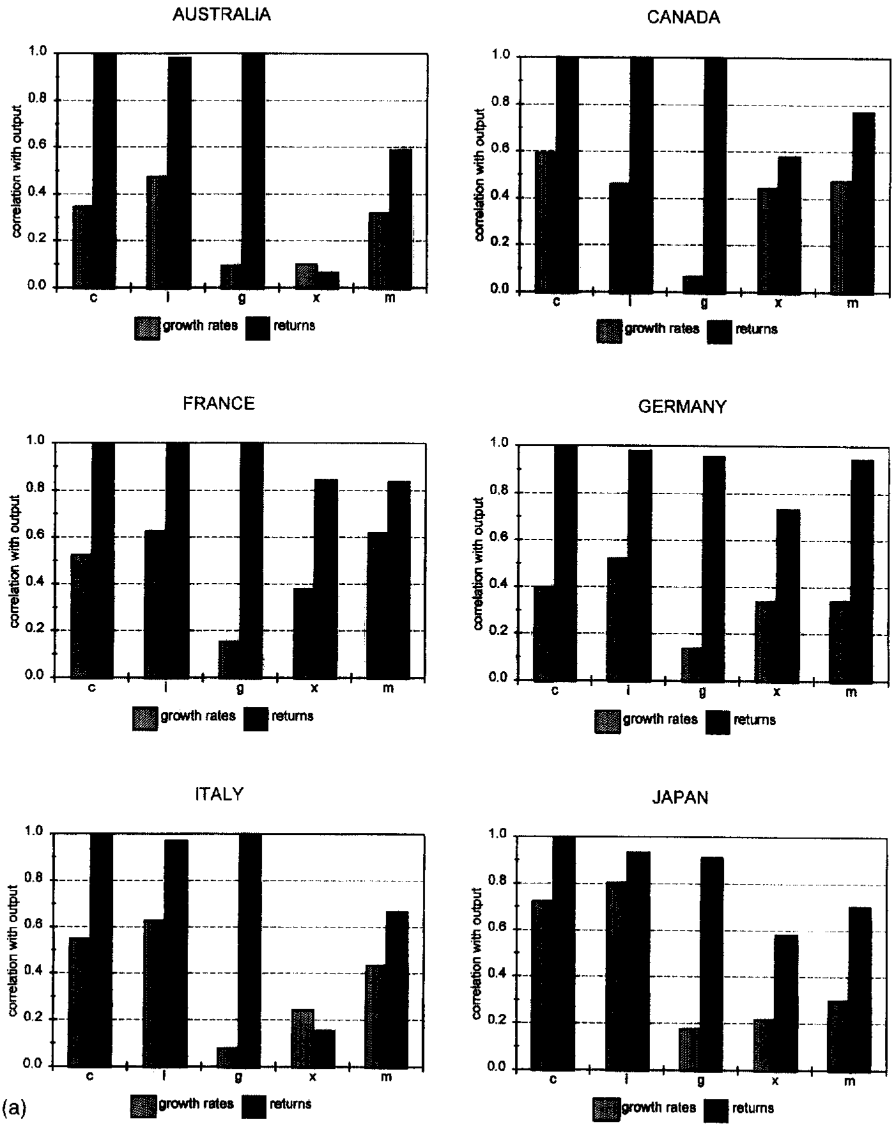

Fig. 6. Correlations of NIPA components: growth rates vs. returns.

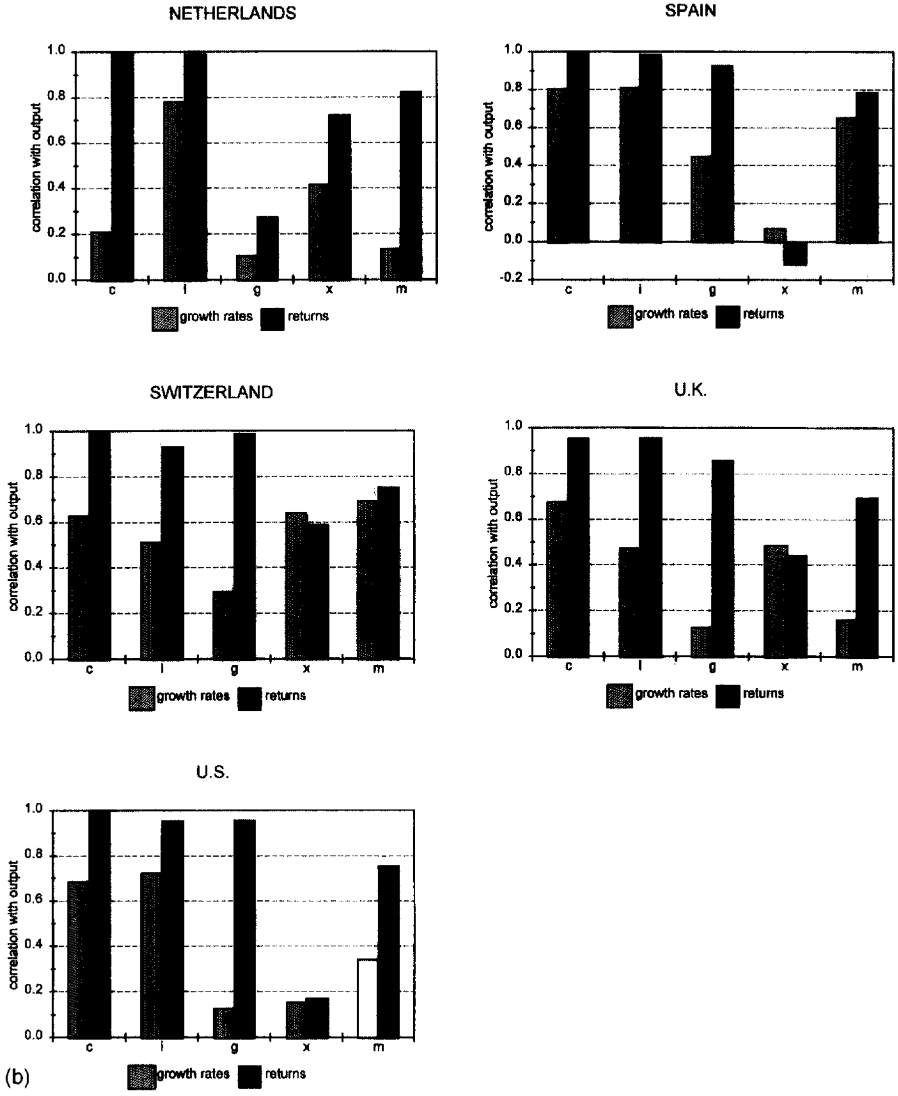

Fig. 6. Continued

This pattern emerges even though the growth rates of these variables are much less highly correlated. In Australia, for example, the correlation between the growth rates of output and consumption is 0.34, while the correlation between the returns on these NIPA comparisons rounds to 1.00. This pattern of high correlations between output on the one hand, and consumption, investment, and government purchases on the other, arises because of the cointegration restrictions between these variables. As discussed in Sections 3 and 4, these returns are dominated by long-run, or 'trend' components. Two variables that share a common trend will therefore tend to have returns that are highly correlated.

A surprising property of Fig. 6 is that returns on exports and imports are – for the most part – highly positively correlated with the returns on own-country output, even though we did not impose cointegration restrictions for these variables. In particular, it is quite generally true that the correlation of returns exceeds the correlation of growth rates.

5.2.1. *Asset-pricing implications*

The fact that there are such high correlations between synthetic returns on consumption and output is interesting from the perspective of the literature on the equity premium puzzle, since it suggests that treating consumption and output as stochastically similar may be a useful approximation in some contexts. However, more elaborate explanations of the equity premium puzzle that stress the differing stochastic behavior of consumption, output and dividends also typically involve time-varying expected returns in an essential manner.

5.2.2. *Financial market implications*

It is conventional wisdom that new financial markets prosper when two related conditions are fulfilled. The first is that a particular new market must be different from existing ones; the second is that one new market must be different from other new ones. Thus, if new markets are introduced along the lines suggested by Shiller (1993) there appears to be little reason for separate markets on consumption, investment and output. For those countries with low correlation for exports or imports, there may be more potential for multiple new markets.

5.2.3. *Financial econometrics implications*

Our discussion above stresses three points about cointegration. First, one might expect some series – like labor income and GDP – to be cointegrated. Second, when ratios are formed and inspected using visual or statistical methods, ratios appear to be relatively stationary but to display some variability. Third, it is hard to determine econometrically whether two variables do in fact share a common trend. For this reason, we also estimated returns without the cointegration restrictions on consumption, investment, government purchases and output without imposing the cointegration restriction. For those series for which cointegration was a reasonable description, we found that there was little substantive difference in the behavior of returns. That is: it did not matter much for correlations whether we imposed the cointegration restriction for consumption, investment, and government purchases. However, for the trade series, where we were more suspicious of the cointegration restriction on theoretical and empirical grounds, the imposition of the cointegration assumption mattered substantially for the results, but there was no simple pattern of effect.

5.3. *Cross-country correlations of returns*

Our focus on a battery of OECD countries permits us to investigate how the returns on NIPA assets are correlated across countries. As discussed in Section 2 above, the nature of cross-country correlations of national economic activity and of security returns has received substantial attention in international economics, so that we organize our discussion around these two sets of topics. By focusing on the changes in the permanent components of national output and other NIPA components in constructing returns, we anticipated that we would produce a substantially higher correlation than was present for raw growth rates. That is: by filtering out the changes in transitory components, we anticipated that returns would be more correlated than growth rates.

In turn, these anticipations are related to the international diversification and international consumption-correlation puzzles discussed in Section 2 above. If international economic activity had an important common 'trend' component, but output growth was the change in this trend plus noise, then cross-country correlations of output growth might be lower than changes in returns. There would accordingly be less motivation for international diversification than suggested by international business cycle comovement. Correspondingly, the return or permanent components of consumption might be positively correlated, as predicted by theory, and measured consumption growth much less so due to transitory noise.

However, as Fig. 7 shows, the international data are dramatically different: each panel plots the correlation of growth rates of an NIPA component against the correlation of that component's returns for each pair of countries.[12] These scatter plots show that there is little tendency for the correlations of output returns to exceed the correlations of growth rates – if anything, the reverse appears to be true (growth rates are somewhat more highly correlated than returns). Further, this is true for every NIPA component plotted in Fig. 7. These empirical results thus deepen the international diversification and international consumption-correlation puzzles discussed in Section 2 above.

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[12] There are $N = 11$ countries in our sample, so there are $N(N - 1)/2 = 55$ pairwise combinations (55 points on the graph).

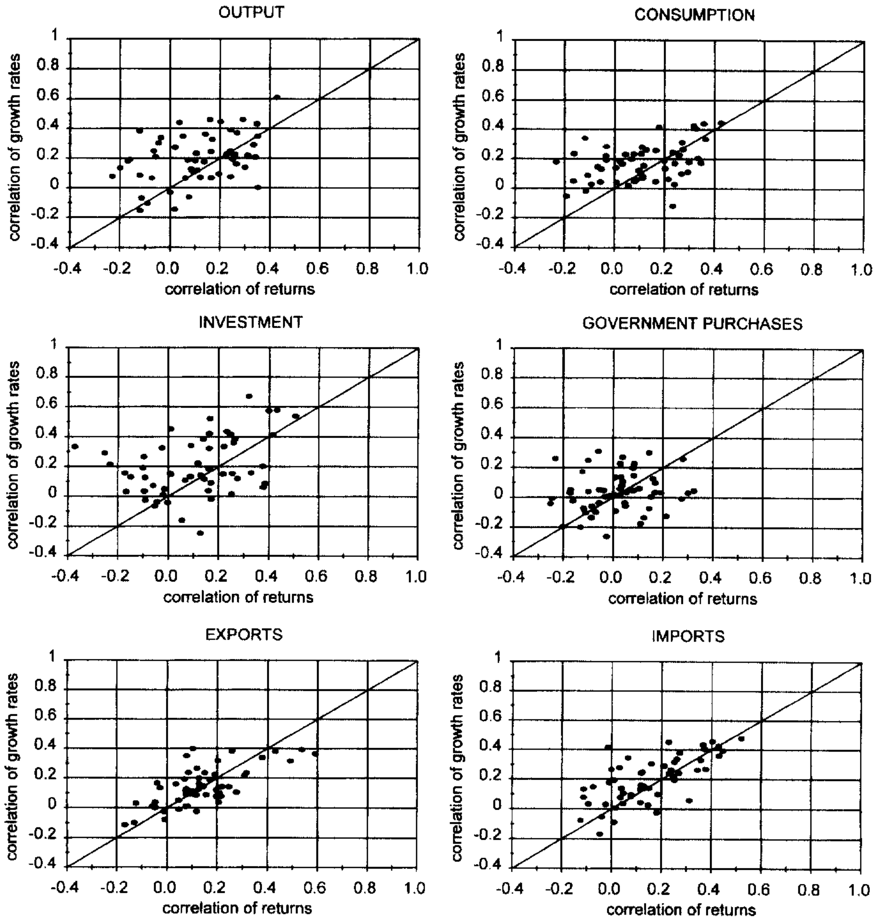

Fig. 7. Corss-country correlations of NIPA components: growth rates vs. returns.

6. Conclusions

Although applications of asset pricing theory have concentrated nearly exclusively on financial assets traded in secondary markets, the largest components of world wealth take the form of nontraded assets. In this paper, we explore methods for determining the risk and return characteristics of one important class of nontraded assets: the components of the national income and product accounts. Working within the constant-expected-return framework of Campbell and Shiller (1988), we investigate the implications of alternative econometric specifications of the dividend process for the within-country and cross-country behavior of NIPA returns. We find that cointegration restrictions are important for the behavior of returns. In particular, for NIPA components which appear to share common stochastic trends, we find that returns on these components are extremely highly correlated. This finding is in line with prior findings by Baxter and Jermann (1997). More generally, we find that returns on consumption and output tend to be more volatile than the growth rates of these variables, while the converse is true for investment. Growth rates and returns on exports and imports tend to be highly volatile. Looking across countries, we find a wide range of variation in estimated return volatilities for specific NIPA components. Further, we find no tendency for cross-country returns on a particular NIPA component (e.g., consumption) to be more or less highly correlated than the growth rates. Our estimated returns on GDP and other NIPA components are much less volatile than the returns on national stock markets.

Much remains to be done in future work. One open question is how the incorporation of time variation in expected returns might affect our results. The answer will be sensitive to assumptions about the degree of financial integration between countries, since this assumption will determine whether different countries share a common asset-pricing kernel. A second question pertains to the relationship between our 'synthetic' returns on NIPA components and the returns on traded financial assets. In particular, we would like to construct measures of unlevered stock markets for comparison with returns to a 'capital income' component of national income. Finally, there are many applied problems that require as input a 'risk-adjusted discount factor' to be used in discounting cash flows that depend on NIPA components. The example of Social Security solvency springs immediately to mind, but there are many other potential applications. We view these applications as exciting possibilities for future research.

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