NBER WORKING PAPER SERIES

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Working Paper 7796
http://www.nber.org/papers/w7796

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 2000

Prepared for the NBER-ISOM Conference held in Helsinki, Finland on June 16-17. Many thanks to conference participants in Helsinki for helpful comments on an earlier draft of this paper, especially our discussants, Robert King and Debbie Lucas. We also received helpful comments at an early stage of this work from Macro Brown Bag Lunch participants at the University of Chicago Graduate School of Business. Davis gratefully acknowledges financial support from the Graduate School of Business at the University of Chicago. The views expressed here are the authors' and do not necessarily reflect those of the National Bureau of Economic Research.

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JEL No. F30, G15, G11, G12, D52

ABSTRACT

This paper develops and implements a framework for quantifying the gains to international trade in risky financial assets. The framework can handle may agents, many assets, incomplete markets and limited participation in asset markets. It delivers closed-form analytic solutions for consumption, portfolio allocations, asset prices and the gains to trade.

We find enormous gains to trade when asset returns are calibrated to observed risk premia and all agents participate in asset markets. The gains-to-trade puzzle is closely related to, but distinct from, the equity premium puzzle. High risk aversion merely alters the form of the gains-to-trade puzzle, but limited participation in asset markets goes a long way towards addressing both puzzles.

We also identify three reasons for limited international risk sharing. First, the requirement that asset markets span the space of national output shocks fails in a serious way. Second, for many countries the cost of using financial assets to hedge national output shocks greatly exceeds the benefits. Third, limited asset market participation reduces the feasible gains from international risk sharing.

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> Do individuals do a good job of hedging risks *across countries*? Here the answer appears to be "no". This answer has come from both financial and macroeconomic research.
>
> — Karen Lewis, "Trying to Explain Home Bias in Equities and Consumption" (1999)

> [G]ains from [international] risksharing are quite sizeable for realistic assumptions ... For OECD countries they are equivalent to a permanent increase in tradables consumption in the range of 1.1 to ... 7.4%. ... If potential gains are so significant, the natural question that must be addressed in future research is why financial markets have not achieved more risksharing.
>
> — Eric van Wincoop, "How Big Are Potential Gains from International Risksharing?" (1999)

> [T]he large equity premium is still largely a mystery to economists.
>
> — Narayana R. Kocherlakota, "The Equity Premium: It's Still a Puzzle" (1996)

1 Introduction

This paper develops and implements a framework for quantifying the gains to international trade in risky financial assets. We focus on the incremental gains to trade in risky assets over and above the consumption-smoothing benefits of unrestricted borrowing and lending. To develop our framework, we consider consumption and portfolio choice in a dynamic model with many agents, many assets, incomplete markets and heterogeneity in the exposure to risky nontraded assets. To implement the framework, we fit the model to the first two moments of domestic and foreign asset returns and the covariance between asset returns and national output innovations. Our analysis intersects with much previous work on international risk sharing, portfolio allocation and the puzzlingly large return premia on equities and other risky securities.

As Van Wincoop (1999) and others show, there are sizeable unrealized gains to consumption risk sharing among countries. This conclusion raises a question: How large are the *feasible* gains to international risk sharing from a properly structured portfolio of *existing* financial assets? We find that the feasible gains are sharply limited by the incompleteness of financial markets. While feasible risk-sharing gains are nontrivial, they are modest and substantially smaller than the gains from complete international risk sharing.

Notwithstanding this conclusion, we also show that standard portfolio theory implies enormous gains from trade when asset returns are calibrated to observed risk premia. These gains are many, many times larger than the international risk sharing benefits found in our study or others. In fact, for several countries in our study the annual gains from trade in risky assets exceed national income! The huge theoretical gains arise from the returns to taking on market risk, not from risk-sharing benefits. Because these implied gains are implausibly large, they are a puzzle for the theory.

This gains-to-trade puzzle, as we call it, is closely related to the equity premium puzzle identified by Mehra and Prescott (1985) and subsequently studied by legions of researchers.[1] The gains-to-trade puzzle emerges when we interpret observed asset returns as the outcome of a free-trade regime, and we compute the counterfactual autarky equilibrium implied by the theory. Because standard dynamic equilibrium theory implies small risk premia, it also implies very large gains in moving from the (counterfactual) autarky equilibrium to the (observed) free-trade equilibrium.

The gains-to-trade puzzle can be restated in portfolio choice terms for an investor who faces exogenously given asset returns. That is, when calibrated to observed asset returns, the theory implies enormous gains from including risky assets in the average investor's portfolio. In addition, the theoretically optimal level of risky asset holdings for the average investor are an order of magnitude larger than observed holdings. This portfolio puzzle emerges in dramatic fashion even when we limit the portfolio choice menu to domestic equity. Unlike its close relatives, the gains-to-trade and equity premium puzzles, the portfolio puzzle does not hinge on an equilibrium theory of asset pricing behavior. Rather, given observed asset returns, the puzzle is that the level of risky asset holdings implied by the theory greatly exceeds observed holdings. Furthermore, the theory implies implausibly large foregone gains for the majority of the population that has modest holdings of risky financial assets.

In an effort to address the various puzzles and re-assess the gains to trade in risky financial assets, we modify the theoretical model to treat limited participation in asset markets. Many empirical studies document limited participation in asset markets, and several recent studies suggest that limited participation holds promise

[1] Standard dynamic equilibrium models, when calibrated to a reasonable degree of risk aversion, imply an expected return premium on equity securities that is much smaller than the equity premium observed in the data – hence, the equity premium puzzle.

for explaining observed risk premia.[2] We find that limited participation goes a long way toward simultaneously addressing the equity premium and gains-to-trade puzzles. It also delivers a more sensible perspective on the gains to international trade in risky financial assets and the feasible gains to international risk sharing.

Our analysis also sheds light on the large body of evidence against the hypothesis of international risk sharing.[3] This evidence has inspired many efforts to quantify the potential gains from international risk sharing. Studies in this vein compute the welfare benefits of full risk sharing among countries relative to autarky or observed consumption allocations. Van Wincoop (1999) reviews fourteen recent studies along these lines and analyzes why they differ in the estimated magnitude of the gains. He identifies the specification of the stochastic process for national output as a key factor in this regard. In particular, given reasonable values for risk aversion and the risk-free interest rate, studies that allow for a nonstationary output process find sizeable potential gains from international risk sharing.[4]

Like Van Wincoop, we read this body of work to say that the potential gains from international risk sharing are large – and largely unrealized.[5] As others have observed, this assessment raises the question of why the potential gains from international risk sharing are not more fully realized.

Incomplete financial markets provide one candidate explanation. That is, the financial instruments required to share risk internationally may not be available. We provide direct evidence on this point by quantifying the extent to which selected financial assets span the space of shocks to national output growth rates. Our empirical approach involves regressions of national output innovations on financial asset returns for portfolios comprised of domestic and world bond and equity indexes, a commodity price index and forward positions in foreign exchange markets. These assets can be traded at low cost in well-developed financial markets.

Little previous work on international risk sharing examines the covariance between financial asset returns and output innovations, although it is a central object in portfolio-based approaches to international risk sharing. For example, this co-

[2] For example, see Basak and Cuoco (1998), Constantinides, Donaldson and Mehra (1998), Brav, Constantinides and Gezcy (1999) and Vissing-Jorgenson (1999).

[3] Lewis (1999) provides an excellent synthesis of work in this general area.

[4] Van Wincoop (1999) also draws on evidence about long term growth behavior in DeLong (1988) to argue that a random walk or first-order autoregression in growth rates is a more appropriate specification than a stationary process or one that imposes cointegration between national and world outputs.

[5] While the evidence clearly rejects the full risk-sharing hypothesis, it is much less hostile to the view that high-frequency movements in national consumption are consistent with unrestricted trade in risk-free bonds. See, for example, Obsteld (1989), Kollman (1995) and Canova and Ravn (1996).

variance plays a key role in the theoretical analysis of Baxter and Jermann (1997). However, their empirical implementation considers returns on hypothetical assets that represent claims to the income streams generated by domestic capital stocks. As we show in section 2, much capital income is not securitized, so that the portfolio strategies envisioned by Baxter and Jermann are infeasible. This same point applies with even greater force to the numerous studies that treat all forms of wealth, including human capital, as marketable. In reality, only a small fraction of wealth is securitized. Hence, an evaluation of portfolio-based approaches to international risk sharing calls for a direct investigation of the covariance between national output innovations and financial asset returns. To the best of our knowledge, Botazzi et al. (1996) is the only previous study of international risk sharing to provide evidence on this issue.

From the vantage point of our theoretical model, the goodness of fit in a regression of output innovations on asset returns measures how effectively national output risk can be hedged by a properly structured asset portfolio. The theory tells us exactly how to construct the optimal portfolio as a function of the following objects: the covariance between national output innovations and asset returns, the size and persistence of national output innovations, the first two moments of asset returns, the risk-free rate of interest and the level of risk aversion.

The paper proceeds as follows. Section 2 considers some evidence on the importance of nontraded wealth and the correlation between returns on traded and nontraded assets. Section 3 sets forth our theoretical model of consumption, portfolio choice and trade in risky financial assets. The theoretical analysis shows how to quantitatively address the issues raised above. Next, section 4 describes the data on financial asset returns and country-level measures of output and price deflators. Using these data, section 5 investigates the covariance between output innovations and financial asset returns. Section 6 draws on empirical results in Sections 4 and 5 and theoretical results in Section 3 to compute portfolio allocations and the gains from trade under the assumption of full participation in asset markets. Section 7 considers limited participation in asset markets, and Section 8 concludes.

2 Some Evidence Regarding Nontraded Wealth

Most previous work on international risk sharing assumes that financial markets span the space of national output shocks. Baxter and Jermann (1997), who emphasize the nonmarketable nature of human capital, nevertheless assume that the set of financial assets available worldwide perfectly spans human capital risks. As a result, all wealth is effectively marketable in their analysis. Botazzi et al. (1996), in another study on the international sharing of labor income risks, also assume perfect spanning.

This spanning assumption fits poorly with several pieces of evidence. First, direct estimates find a low correlation between returns on nonmarketable human wealth and returns on financial assets. Under the assumption that labor income growth follows a random walk, Fama and Schwert (1977) find a near-zero correlation between aggregate equity and human capital returns in the United States. Botazzi et al. (1996) consider several countries and also find low correlations with returns on a broader portfolio of domestic assets. Davis and Willen (2000) consider the correlation between returns on financial assets and human capital for synthetic persons defined in terms of sex, birth cohort and educational attainment. The correlations with aggregate U.S. equity returns for these persons are centered near zero. In addition, the R^2 values in regressions of labor income innovations on a larger portfolio of asset returns seldom top ten percent. Even the returns on proprietary business wealth do not appear to be highly correlated with financial asset returns. In this regard, Heaton and Lucas (2000) report a value of .14 for the correlation between the growth rate of U.S. proprietary business income and the stock market rate of return.

Second, only a small fraction of wealth is securitized. Labor earnings, which acount for roughly seventy percent of national income, are not securitized. Outside the United States and a few other countries, only a modest fraction of business wealth is securitized. And, for the most part, (equity claims on) real estate assets are not securitized.

Table 1 provides some crude quantitative evidence on this matter. For selected countries, we estimate the percentages of business wealth and total wealth in the form of risky financial securities as of 1980 and 1990. We measure securitized wealth as the market capitalization of corporate equity and debt securities outstanding at the end of the indicated year.[6] We measure business wealth as the present value of future business income flows, discounted at the average annual rate of return on the country's stock market from 1980 to 1996. For 1981 through 1995, we use realized business income in the present value calculations. For later years, we use projected values assuming that business income grows at the same rate after 1995 as from 1980 to 1995.[7] To measure total wealth, we multiply business wealth by the reciprocal of

[6]Since it represents a securitized claim on future taxing capacity, one might argue for the inclusion of government debt in the measure of securitized wealth. Alternatively, one can argue that the return on (short-term) government debt is insensitive to shocks to the present value of future taxing capacity. Government debt can facilitate intertemporal consumption smoothing in this case, but it does not expand opportunities to share consumption risks associated with wealth shocks.

[7]Thus our procedure gives approximately the same answer as capitalizing a country's average realized business income at a discount rate equal to the difference between its realized stock market

capital's share of national income.

The calculations and data underlying Table 1 can be criticized on several grounds, but there is no escaping the basic message: Securitized wealth accounts for a very small fraction of total wealth, perhaps around 10 percent for a few countries and less for others. The evidence in Heaton and Lucas (2000) suggests that roughly half of U.S. business wealth is securitized. We have not explored the reasons for the larger ratio of securitized assets to total business wealth in their study, but the discrepancy suggests that our figures for traded wealth in Table 1 may be too low. However, even if securitized assets account for half of total business wealth, a figure for capital's share of national income of .3 implies that securitized assets account for less than 15 percent of total wealth.[8]

The countries considered in Table 1 are among the most financially developed in the world. So, it is safe to presume that easily marketable assets account for even smaller percentages of business and total wealth in most other countries. Indeed, for most countries in the world, risky financial securities probably account for less than 5 percent of total wealth. Given this state of affairs, it would be rather remarkable if the available set of financial assets spanned the risks inherent in non-financial assets.

Of course, this spanning condition could hold, even when financial securities account for a small fraction of total wealth. For example, if a single factor drives most of the variation in returns on financial and non-financial forms of wealth, it matters little that most wealth is not securitized. More generally, if the same factors drive the returns to financial and non-financial wealth, then nonfinancial wealth is effectively marketable. While logically coherent, this argument has limited practical force in view of the low correlations between returns on financial assets and non-financial assets.

As a final point, if shocks to national income are spanned by available financial assets, we expect to find very high R^2 values in regressions of national output innovations on domestic and foreign asset returns. The empirical evidence reported in Section 5 says otherwise.

In summary, the evidence runs sharply counter to the perfect spanning assumption that underlies most previous work on international risk sharing. Motivated by this evidence, the next section develops a theoretical model of consumption and portolio choice that can easily handle small or large departures from the perfect spanning assumption.

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rate of return and its realized growth rate of business income.

[8]Less, because GDP measures do not impute the flow of consumption services derived from the stock of consumer durables. For the same reason, the total wealth measures in Table 1 implicitly exclude consumer durables.

3 A Model of Portfolio Choice and Trade in Risky Assets

This section develops our theoretical analysis. Our key assumption is that investors have exponential utility, which implies constant absolute risk aversion in the face of wealth shocks. Exponential utility leads to closed-form expressions for consumption, portfolio allocations, equilibrium asset returns and the gains to trade in a setting with many agents, many assets, incomplete financial markets and heterogeneity in exposure to undiversifiable risks. We also rely on normality of asset returns and endowment shocks, but this assumption is less essential. It can be relaxed while preserving the ability to derive closed-form solutions.[9]

Most dynamic analyses of consumption, portfolio choice and equilibrium asset pricing rely heavily on analytical or numerical approximation techniques to obtain solutions. This is especially true in the analysis of rich environments like ours that consider incomplete markets, many assets, many agents who differ in risk exposures and (in Section 7) limited participation in financial markets by some agents. In contrast, our approach relies on exponential preference specifications to obtain exact closed-form analytical solutions that are easy to compute and easy to interpret.

Our approach, too, is an approximation. In particular, exponential utility can be interpreted as a local approximation to preferences that display constant relative risk aversion. In calibrating the theoretical model, we assume that all agents have the same degree of relative risk aversion, and we approximate the corresponding exponential utility function using a country's per capita income level at the midpoint of our sample period. We could also approximate around the expected growth path of per capita income by allowing the risk aversion parameter in the exponential utility function to vary over time. However, in view of the modest average growth rates experienced by the countries in our sample (see Table 2 below), we opt for the simpler approach that specifies absolute risk aversion to be constant over time.

Like most work on international risk sharing, we consider an endowment economy.[10] We model the world economy as containing many countries, each of which is populated by many individuals who receive stochastic endowments of a single consumption good. We do not explicitly treat nontraded goods in the formal analysis, but the model can be interpreted to cover two special cases: perfect substitution between internationally traded and nontraded goods, or additive separability between

[9] For example, see Gron et al. (2000).

[10] Better risk sharing can lead to a more efficient allocation of factor inputs in a production economy. Obstfeld (1994) pursues this theme in the context of international risk sharing.

traded and nontraded goods. Our empirical work treats both cases.[11]

To reduce the notational burden, we assume that each country is populated by a fixed set of individuals who live forever. It is straightforward, but tedious, to consider overlapping generations of individuals with finite life spans.[12] Since life-cycle considerations play no essential role in this study, we opt for the simpler infinite-horizon formulation.

Our theoretical analysis and empirical investigation are directed to the gains from trade *among* countries. These gains make up only part of the benefits to domestic residents from trading risky foreign assets. In particular, trade in foreign assets can expand risk sharing opportunities within countries, whether or not the foreign assets are useful for risk sharing between countries. To evaluate the within-country consumption risk-sharing benefits of trade in foreign assets, it would be necessary to investigate the covariance between foreign asset returns and that part of individual-specific income innovations that cannot be hedged using domestic financial assets.

3.1 The economy

The world economy contains H investors indexed by h and G countries indexed by g. A country is a collection of investors $h \in g$. Each person lives forever and has preferences defined over current and future consumption of a single good.

A *consumption path* is a random vector $C^h = \left(\tilde{c}_t^h\right)_{t=0}^{\infty}$. Our most important condition pertains to preferences over these consumption paths.

Condition 1 *Agents have exponential utility given by*

$$U^h\left(C^h\right) = \mathrm{E}_t\left[\sum_{t=0}^{\infty}\left(\delta^h\right)^t\left(\frac{-1}{A^h}\right)\exp\left(-A^h c_t^h\right)\right]$$

where A^h is the coefficient of absolute risk aversion, and δ^h is the subjective rate of time preference.

Some additional notation related to aggregation over investors will be useful. Let $A^g = \left[(1/H^g)\sum_{h\in g}\left(1/A^h\right)\right]^{-1}$ be the harmonic mean of investor absolute risk aversion for country g, where H^g is its population size. Also, let $\delta^g = \Pi_{h\in g}\left(\delta^h\right)^{A^g/(A^h H^g)}$

[11] The more general nonseparable case would be a useful extension for future research. Van Wincoop (1999) contains a nice discussion of how the nonseparability of traded and nontraded goods affects the gains from risk sharing. His quantitative analysis indicates that nonseparability matters, but it is probably not a first-order issue.

[12] Davis and Willen (2000) consider finite lives with a known date of death. An earlier version of that paper considered stochastic mortality.

be the "average" subjective discount rate in country g. Here, and throughout the paper, variables with a "g" or "h" superscript refer to country- and investor-level quantities, respectively.

Condition 2 *Individuals can freely borrow or lend at a gross one-period rate of return, R_0. This risk-free rate of return is nonstochastic, although it may vary over time.*

Using the risk-free rate, define the present value operator,

$$\text{PDV}_t\left(\{z_s\}_{s=t}^{T}\right) = \sum_{s=t}^{T} \frac{1}{R_0^{s-t}} \text{E}_t\left(\tilde{z}_s\right), \tag{1}$$

where $\text{E}_t\left(\tilde{z}_s\right)$ denotes the expected value of $\tilde{z}_s$ conditional on information available at t. The further restriction to a constant risk-free rate embedded in (1) is easily relaxed at the cost of added notational complexity.

Individuals receive endowments of labor or other non-financial income, $\tilde{y}_t^h$, measured in units of the consumption good. Let $\tilde{Y}_t^h = \text{PDV}\left(\left\{\tilde{y}_s^h\right\}_{s=t}^{\infty}\right)$ be the present value of non-financial income, which includes labor income and proprietary business income. Each country also has marketable, securitized assets that generate stochastic income streams for their owners. Let $\mathbf{e}^g$ be the *per capita* value of these risky financial assets measured in units of the consumption good. $\mathbf{e}^g$ is the market value of securitized wealth, and $\tilde{Y}_t^g$ is the present value of nonmarketable income, discounted at the risk-free rate. Domestic output in period t equals the period-t payoff to risky financial assets plus non-financial income.

There are $J+1$ marketable assets in the world economy: J risky assets with gross one-period rates of return from $t-1$ to t given by $\mathbf{R}_t$ and a riskless asset with certain return R_0. Write the $(H+J)\times 1$ vector of nonmarketable income present values and marketable asset returns as $\mathbf{\Phi}_t = \left[\widetilde{Y}_t^1 \cdots \widetilde{Y}_t^H \quad \widetilde{R}_{1,t} \cdots \widetilde{R}_{J,t}\right]'$. Our last main condition involves the covariance matrix of $\mathbf{\Phi}_t$.

Condition 3 *Financial asset returns and the present value of non-financial income have a joint normal distribution. The joint covariance matrix of asset returns and endowment present values is nonstochastic:*

$$\mathbf{\Phi}_t \sim N\left(\text{E}\left(\mathbf{\Phi}_t\right), \text{cov}\left(\mathbf{\Phi}_t\right)\right)$$

where $\quad \text{cov}\left(\mathbf{\Phi}_t\right) = \left[\begin{array}{c|c} \mathbf{\Xi} & \boldsymbol{\beta} \\ \hline \boldsymbol{\beta}' & \mathbf{\Sigma} \end{array}\right].$

Investor h invests in a subset J^h of the J risky assets. Specifically, she chooses a J^h-dimensional portfolio of risky assets, $\boldsymbol{\omega}^h$, and invests ω_0^h in the riskless asset. The portfolio allocations $\boldsymbol{\omega}$ and ω_0 are measured in units of the consumption good. We state our propositions for the case of no further restrictions on $\boldsymbol{\omega}$, so that investors can adopt unlimited long or short positions on risky assets in J^h. However, it is not difficult to treat short-sale or other restrictions on risky asset holdings. Initially, we assume that everyone in country g trades the same set of assets, J^g, but Section 7 considers the situation in which some members of g invest in only a subset of assets in J^g.

We can now specify the *budget set* for person h in country g as

$$B^h(\mathbf{R}) = \left\{ \left(c_t^h, \omega_t^h\right)_{t=0}^{\infty} \ni \begin{array}{c} c_t^h + \sum_{j=0}^J \omega_{j,t}^h = y_t^h + \sum_{j=0}^J \omega_{j,t-1}^h R_{jt} \\ \omega_{j,t}^h = 0 \text{ if } j \notin J^g \\ \lim_{T\to\infty} \mathrm{PDV}\left(\left\{\sum_{j=0}^J \omega_{j,t}^h R_{jt}\right\}_{t=T}\right) = 0 \end{array} \right\}$$

The budget set incorporates a transversality condition, and it restricts trade by investor h to assets in J^g.

A bit more notation will prove useful. We will often refer to the J-dimensional vector of expected excess returns as $\mathbf{ER}$, which has representative element $\mathrm{E}\left(\tilde{R}_j\right) - R_0$. We also refer to the multivariate Sharpe ratio, $\mathbf{S} = \boldsymbol{\Sigma}^{-1/2}\mathbf{ER}$. *Per capita* country-level security holdings are $\omega_0^g = \sum_{h\in g} \omega_0^h / H^g$ and $\boldsymbol{\omega}^g = \sum_{h\in g} \boldsymbol{\omega}^h / H^g$. Asset prices and returns will generally differ between autarky and free trade. We shall often use g superscripts to denote autarky outcomes in country g. We let $\mathbf{e}_A^g$ denote the autarky value of securitized assets in country g, and $\mathbf{e}^g$ be the value of those same assets at world prices under free trade.

3.2 Theoretical Results

This section establishes that:

- Consumption is the annuity value of a broad definition of wealth. This implies that consumption innovations are linear in innovations to income and portfolio returns.
- We can decompose demand for risky assets into a 'risk-exploitation' component that depends on excess returns and risk aversion and a 'hedging' component that depends on the covariance between nonmarketable asset values and returns on risky financial assets.
- International trade in risky assets depends on the difference between the autarky price of risk and the world price of risk. A country will go (long) short in an asset if the autarky price of risk is below (above) the world price.

- Gains from trade rise in the square of the difference between autarky and world prices of risk.

- We can decompose the gains from trade into three components: a 'hedging benefit' that measures the potential reduction in the variance of national income made possible by an asset; a 'hedging cost' that measures the change in excess returns resulting from a hedge position; and a 'risk premium benefit' that measures the gains to taking on market risk.

Our first proposition converts a complex dynamic programming problem into a simple annuitization exercise. We use a broad wealth measure called 'generalized wealth' that incorporates future non-financial income, future wealth uncertainty, future excess returns on risky assets and the difference between an investor's subjective discount rate and the risk-free interest rate.[13] Proofs to the propositions appear in Appendix A.

Proposition 1 (Consumption and portfolio choice) *Under conditions 1, 2 and 3,*

$$c_t^h = aGW_t^h$$

where the marginal propensity to consume out of generalized wealth is $a = 1/\mathrm{PDV}\left(\{1\}_{s=t}^{\infty}\right) = (R_0 - 1)/R_0$. Generalized wealth *at time* t *is*

$$GW_t^h = \tilde{Y}_t^h + R_0\omega_{0,t}^h + \tilde{\mathbf{R}}_t\boldsymbol{\omega}^h + \frac{1}{R_0 - 1}\left(\mathbf{ER}'\boldsymbol{\omega}^h + \frac{1}{aA^h}\ln R_0\delta^g - \frac{aA^h}{2}\operatorname{var}\left(GW^h\right)\right) \quad (2)$$

Risky asset holdings are constant over time and given by $\boldsymbol{\omega}^h = (1/aA^h)\boldsymbol{\Sigma}^{-1}\mathbf{ER} - \boldsymbol{\Sigma}^{-1}\boldsymbol{\beta}^h$.

Thus, under our assumptions, consumption is simply the annuitized value of generalized wealth. To understand portfolio choice, consider an economy with only one risky asset, asset 1. Note that only the present discounted value of future non-financial income $\tilde{Y}_t^h$ and portfolio returns $\omega_{1,t-1}^h\tilde{R}_{1,t}$ are stochastic. Thus innovations to generalized wealth and consumption depend only on innovations to $\tilde{Y}_t^h$ and $\omega_{1,t-1}^h\tilde{R}_{1,t}$.

The Euler equation for risky financial assets relates consumption innovations to asset prices. Specifically,

$$ER_{1,t} = A^h \operatorname{cov}\left(\tilde{c}_t^h, \tilde{R}_{1,t}\right)$$

Using our characterization of consumption, substitute for $\tilde{c}_t^h$,

$$ER_{1,t} = aA^h \operatorname{cov}\left(\tilde{Y}_t^h + \omega_{1,t-1}^h\tilde{R}_{1,t}, \tilde{R}_{1,t}\right),$$

[13] See Davis and Willen (2000) for a detailed discussion and interpretation of generalized wealth.

and solve for individual demand, $\omega^h_{1,t-1}$:

$$\omega^h_{1,t-1} = \underbrace{\frac{1}{aA^h}\frac{ER_{1,t}}{\text{var}\left(\tilde{R}_{1,t}\right)}}_{\textit{Risk premium exploitation}} - \underbrace{\frac{\text{cov}\left(\tilde{Y}^h_t, \tilde{R}_{1,t}\right)}{\text{var}\left(\tilde{R}_{1,t}\right)}}_{\textit{Hedging}} \tag{3}$$

Equation 3 illustrates portfolio choice. All else equal, investment in a risky asset is increasing in the return ($ER_{1,t}$) and decreasing in absolute risk aversion (A^h), the marginal propensity to consume out of wealth (a) and the covariance between nonmarketable wealth and the return ($\text{cov}\left(\tilde{Y}^h_t, \tilde{R}_{1,t}\right)$). The size of the asset position is also decreasing in risk ($\text{var}\left(\tilde{R}_{1,t}\right)$).

To analyze international trade in risky assets, we borrow a device from classical trade theory – the Law of Comparative Advantage.[14] We will show that equation 3 implies a law of comparative advantage that relates net national demand for risky financial assets to the difference between the price of risk (i.e., Sharpe ratio) in world markets and the price of risk under autarky.

First, we define autarky.

Definition 1 *Under "autarky", a country can trade the consumption good and freely engage in international borrowing and lending, but it cannot trade risky assets internationally.*

Note two important things about our definition of "autarky." First, it only applies to risky assets. We assume that countries face the same riskless rate under autarky and free trade. Second, our definition of autarky does not prohibit within-country trade in risky financial assets.[15]

It will be helpful to spell out certain relationships between asset prices and returns across trade regimes. By definition, the gross return on asset j is $\tilde{R}_{j,t} = \left(\tilde{\pi}_{j,t} + \tilde{d}_{j,t}\right)/\pi_{j,t-1}$, where $\tilde{d}_{j,t}$ is the payoff at t, and $\tilde{\pi}_{j,t}$ is the ex-dividend asset price at t. Under our assumptions, equilibrium implies that $\tilde{\pi}_{j,t} = \text{PDV}\left(\{d_{j,s}\}^\infty_{s=t+1}\right) + k$, where k is a deterministic term. Thus $\tilde{R}_{j,t} = \left(\text{PDV}\left(\{d_{j,s}\}^\infty_{s=t}\right) + k\right)/\pi_{j,t-1}$, and innovations to returns are given by $\left[\text{PDV}\left(\{d_{j,s}\}^\infty_{s=t}\right) - \text{E}_{t-1}\left(\text{PDV}\left(\{d_{j,s}\}^\infty_{s=t}\right)\right)\right]/\pi_{j,t-1}$.

[14] For related statements of the Law of Comparative Advantage, see Svensson (1988) and chapter 5 in Obstfeld and Rogoff (1996).

[15] This has no effect on net national demand. As we mentioned before, our empirical work considers country-level data, so we cannot address within-country risk-sharing benefits in this study. For some calculations of the within-country risk-sharing benefits of financial assets, see Davis and Willen (2000)

The numerator depends only on the dividend process and the riskless rate, both of which we assume to be invariant across trade regimes. So, asset prices and returns are related across trade regimes as follows:

$$R_{j,t-1} - \mathrm{E}\left(R_{j,t-1}\right) = \frac{\pi^{g}_{j,t-1}}{\pi_{j,t-1}} \left(R^{g}_{j,t-1} - \mathrm{E}\left(R^{g}_{j,t-1}\right)\right) \tag{4}$$

Now, to illustrate the analysis, consider the case of a single risky marketable asset. Let $\sigma_1 = \mathrm{std}\left(\tilde{R}_{1,t}\right)$ be the standard deviation of returns on the asset at world prices (i.e., under free trade). Summing equation (3) across agents in country g, we can express national demand for the asset under free trade as a function of the world Sharpe ratio:

$$\omega^{g}_{1,t-1} = \left(1/\sigma_1\right) \left[\frac{1}{aA^g} S_1 - \frac{\mathrm{cov}\left(\tilde{Y}^{h}_{t}, \tilde{R}_{1,t}\right)}{\sigma_1}\right] \tag{5}$$

Under autarky, aggregate demand in the same way and equate to supply to obtain

$$e^{g}_{A,1,t-1} = \left(1/\,\mathrm{std}\left(\tilde{R}^{g}_{t}\right)\right) \left[\frac{1}{aA^g} S^{g}_{1} - \frac{\mathrm{cov}\left(\tilde{Y}^{h}_{t}, \tilde{R}^{g}_{1,t}\right)}{\mathrm{std}\left(\tilde{R}^{g}_{1,t}\right)}\right].$$

Solving for the autarky Sharpe ratio,

$$S^{g}_{1} = aA^g \left(\mathrm{std}\left(\tilde{R}^{g}_{1,t}\right) e^{g}_{A,1,t-1} + \frac{\mathrm{cov}\left(\tilde{Y}^{h}_{t}, \tilde{R}^{g}_{1,t}\right)}{\mathrm{std}\left(\tilde{R}^{g}_{1,t}\right)}\right). \tag{6}$$

Equation (4) implies that we can rewrite (6) using free-trade outcomes:[16]

$$S^{g}_{1} = aA^g \left(\sigma_1 e^{g}_{1,t-1} + \frac{\mathrm{cov}\left(\tilde{Y}^{h}_{t}, \tilde{R}_{1,t}\right)}{\sigma_1}\right).$$

Solving for $\mathrm{cov}\left(\tilde{Y}^{h}_{t}, \tilde{R}_{1,t}\right)/\sigma_1$ and substituting into equation (5), we have

$$\omega^{g}_{1,t-1} - e^{g}_{1,t-1} = \frac{1}{aA^g \sigma_1} \left(S_1 - S^{g}_{1}\right) \tag{7}$$

In words, the net national demand for the risky asset under free trade is proportional to the difference between the world and autarky Sharpe ratios.

Proposition 2 generalizes the foregoing argument to the multi-asset case.

[16]Specifically, it implies that $\mathrm{var}\left(\tilde{R}_{1,t}\right) = \left(\pi^{g}_{1,t-1}/\pi_{1,t-1}\right)^2 \mathrm{var}\left(\tilde{R}^{g}_{1,t}\right)$, for example.

Proposition 2 (Law of Comparative Advantage for Risky Assets) *Under conditons 1, 2 and 3, the autarky Sharpe ratio is*

$$\mathbf{S}^g = aA^g \operatorname{var}\left(\tilde{\mathbf{R}}\right)^{-1/2} \operatorname{cov}\left(\mathbf{e}^g\tilde{\mathbf{R}} + \tilde{Y}^g, \tilde{\mathbf{R}}\right)$$

$\mathbf{S}^g$ *can be calculated using world returns (as in the formula above) or autarky returns. Furthermore, the net national demand for risky assets in country* g *can be written*

$$\boldsymbol{\omega}^g - \mathbf{e}^g = \frac{1}{aA^g}\boldsymbol{\Sigma}^{-1/2}\left(\mathbf{S} - \mathbf{S}^g\right). \tag{8}$$

We now introduce a welfare measure for the gains from trade in risky assets. We then state a proposition that gives an expression for these gains.

Definition 2 *Consider two consumption profiles,* C^h *and* $\hat{C}^h$*. Suppose investor* h *consumes* C^h*.* GFT^h *is the amount of the consumption good that we need to give to investor* h *on every date and in every state to make her as well off as she would be if she consumed* $\hat{C}^h$*. That is,*

$$U^h\left(C^h + GFT^h\right) = U^h\left(\hat{C}^h\right)$$

GFT stands for gains from trade – we will typically think of C^h and $\hat{C}^h$ as consumption under more and less restrictive trade regimes, respectively.

Proposition 3 (Gains from Trade in Risky Financial Assets) *Investors in country* g *initially trade assets* $\mathbf{x}$ *internationally and assets* $\mathbf{z}$ *domestically. Suppose that international trade in assets* $\mathbf{z}$ *is now allowed in country* g*. Let* $\tilde{\mathbf{R}}_{z|x} = \tilde{\mathbf{R}}_z - \operatorname{E}\left(\tilde{\mathbf{R}}_z|\tilde{\mathbf{R}}_x\right)$ *be the part of returns on assets* $\mathbf{z}$ *that are orthogonal to returns on* $\mathbf{x}$*. Under conditions 1, 2 and 3, the gains from trade are*

$$GFT^g = \left(\frac{1}{R_0}\right)\frac{1}{2aA^g}\left(\mathbf{S}_{z|x} - \mathbf{S}^g_{z|x}\right)'\left(\mathbf{S}_{z|x} - \mathbf{S}^g_{z|x}\right) \tag{9}$$

And the present discounted value of the increase in consumption is

$$\operatorname{PDV}(GFT) = \left(\frac{1}{R_0 - 1}\right)\frac{1}{2aA^g}\left(\mathbf{S}_{z|x} - \mathbf{S}^g_{z|x}\right)'\left(\mathbf{S}_{z|x} - \mathbf{S}^g_{z|x}\right) \tag{10}$$

Thus the gains from trading risky assets are increasing in the size of the difference between world and autarky Sharpe ratios, regardless of the sign. For example, when there is only one risky financial asset, the per capita benefit of international trade for country g is

$$GFT^g = \left(\frac{1}{R_0}\right)\frac{1}{2aA^g}\left(S_1 - S_1^g\right)^2$$

In a classical mean-variance setting, an investor is endowed with a lump of wealth, so that the no-trade price of risk is zero. Hence, in the classical setting the gains from trade can be calculated in terms of the observed Sharpe ratio, S, on a new asset without reference to the asset's autarky Sharpe Ratio, S^g. Implicitly, $S^g = 0$ in the classical setting.[17]

To more fully understand the gains from trade in risky assets, expand the quadratic expression $(S_1 - S_1^g)^2$ and substitute in the equation for the autarky Sharpe ratio:

$$GFT^g = \left(\frac{1}{R_0}\right)\left[\underbrace{\frac{1}{2aA^g}\frac{ER_1^2}{\sigma_1^2}}_{\textit{Risk premium benefit}} - \underbrace{ER_1\frac{\beta_1^g}{\sigma_1^2}}_{\textit{Hedging cost}} + \underbrace{\frac{aA^g}{2}\frac{(\beta_1^g)^2}{\sigma_1^2}}_{\textit{Hedging benefit}}\right] \tag{11}$$

This expression additively decomposes the gains from trade into three pieces. The *risk premium benefit* is proportional to the square of the reciprocal of absolute risk aversion. The "hedging cost" is the change in excess returns that results from minimizing the variance of consumption. If the world Sharpe ratio on the asset and its covariance with domestic non-financial wealth are both positive, this effect reduces the gains from trade. However, if the covariance is negative, the "cost" will be negative, and this term will add to the gains from trade. The "hedging benefit" reflects the lower variance of consumption available from hedging shocks to Y^g. This term is always positive. However, the hedging benefit need not exceed the hedging cost. That is, it is not always optimal to hedge a position, even if it is possible to do so.

The following proposition generalizes this result to the multi-asset case.

Proposition 4 (Decomposition of Gains from Trade) *Under the assumptions and conditions of Proposition 3, the gains from trade for country g can be decomposed as follows:*

$$GFT^g = \left(\frac{1}{R_0}\right)\left[\underbrace{\frac{1}{2aA^g}\mathbf{ER}'_{z|x}\mathbf{\Sigma}_{z|x}^{-1}\mathbf{ER}_{z|x}}_{\text{Risk premium benefit}} - \underbrace{\mathbf{ER}'_{z|x}\mathbf{\Sigma}_{z|x}^{-1}\boldsymbol{\beta}^g}_{\text{Hedging cost}} + \underbrace{\frac{aA^g}{2}\boldsymbol{\beta}^{g\prime}\mathbf{\Sigma}_{z|x}^{-1}\boldsymbol{\beta}^g}_{\text{Hedging benefit}}\right]$$

[17] See Huberman and Kandel (1987) and, in the context of international asset trade, Bekaert and Urias (1995). These authors develop tests for whether a new asset changes the span based on the observed Sharpe ratio of the new asset.

4 Data Description and Output Specifications

4.1 Output and Price Deflators

For output and consumption measures, we rely on the UN System of National Accounts (SNA), which contain data disaggregated by broad industry categories. We use the industry breakdown to construct measures of tradable consumption and GDP, as described in Appendix B. We consider annual observations from 1970 to 1995, which is the time period covered by our data on asset returns.

Nominal GDP and consumption measures are initially expressed in local currency units. As the deflator for total (tradable) GDP, we use the ratio of nominal to real final (tradable) consumption expenditures of resident households.[18] Appendix B provides details. After deflating each nominal GDP measure by its respective price deflator, we convert local currency units to U.S. dollars at contemporaneous exchange rates. For easy comparisons, we express real output measures in 1990 dollars. We convert real output to per capita values using population data from the International Monetary Fund's International Financial Statistics (IFS).

The stochastic process for output in our theoretical model implies an empirical specification in natural units rather than logs. In practice, we carry out our empirical investigations using measures in both natural units and natural logs.

We initially set out to fit simple ARIMA models for each country's per capita output measures. However, with very few exceptions, one cannot reject the hypothesis that the first-differenced output and log output measures are serially uncorrelated in our sample period. Hence, we specified each national output process as a separately estimated random walk with drift.[19] Table 2 reports parameter estimates for these random walk specifications and p-values for the null hypothesis of no serial correlation in the differenced values. Using the national output innovations implied by these specifications and a risk-free interest rate of 2.5 percent per year, we construct the innovations to $\tilde{Y}_t^g$ for each country g and year t.

4.2 Financial Asset Returns

We consider returns on financial assets that represent broad claims and that trade at low cost in liquid financial markets. In particular, we allow each country to trade a composite world equity index, a composite world government bond index and a

[18] Consumption of private non-profit organizations is ignored.

[19] We experimented with linear time trends in the random walk specifications for tradable and total output, but only two countries (Canada and Greece) had trends that were statistically significant at the 10 percent level.

commodity index. In addition, we allow each country to take a position in the foreign exchange market for its own currency, as explained below.[20] Where data are available over the entire 1970-95 sample period, we also allow each country to trade domestic equity and government bond indexes. Data on asset returns come from several sources, as described in Appendix B.

Asset returns for the composite world indexes are initially denominated in dollars. We convert these returns into local currency units using period-end exchange rates, and we convert the local currency payoff into a real consumption payoff using the price deflator for the country's total (or tradable) consumption. These deflators also serve to convert nominal returns on domestic equity and bonds into real returns. The nominal dollar return on the commodity price index is simply the annual log difference in the index value, which we convert to a real domestic consumption payoff in the same way as with world equities and bonds. Since the exchange rate conversions and price deflators differ among countries, returns on a given asset also differ by country.

We also consider the return on a forward position in the foreign exchange market. Subject to data availability, we construct the forward position as $\log\left(FR_{t,t+1}/SR_{t+1}\right)$, where $FR_{t,t+1}$ is the forward rate against the U.S. Dollar on the last trading day of year t for the last trading day of year $t+1$, and SR_{t+1} is the spot rate on the last trading day of year $t+1$. An investor who takes a long position in domestic currency then reaps a positive (negative) payoff when the forward rate is greater (less) than the corresponding spot rate. We constructed the forward position payoff in this way for Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, and the United Kingdom. For other countries, we constructed the payoff to a rolling position in three-month-ahead forward exchange contracts as explained in Appendix B.

Tables 3 - 5 report summary statistics on domestic real returns for each country and asset considered in this study. As Table 3 shows, mean returns on the world equity and bond indexes differ considerably among countries because of movements in real exchange rates. For example, the mean real return on the world index in long term government bonds is 6.8 percent per year for an Icelandic investor (in units of his domestic consumption good) but a comparatively paltry 1.2 percent per year for a Japanese investor. Similarly, the mean real return on the world equity index is 10.9 percent for the Icelandic investor but only 4.3 percent for the Japanese investor. These large differences in mean returns on the same asset underscore the importance of measuring country-specific rates of return when studying the gains to international trade in risky financial assets.

[20]Returns on corporate bonds turned out to be highly collinear with returns on long-term government bonds, so we dropped corporate bonds from further study.

Table 4 reports real returns on own-country equity and bond indexes. Mean domestic returns on the own-country equity index range from 5.3 percent in Italy to 13.9 percent in Sweden. For most countries, annual returns on the own-country equity index are substantially more volatile than domestic returns on the world equity index. Own-country equity holdings are more risky in this sense, despite the added exposure to real exchange rate movements implied by a foreign equity position. However, in most countries returns on own-country government bonds are less volatile than domestic returns on the world bond index.

Table 5 shows that annual returns on the commodity index are nearly as variable as the world equity index, but mean commodity returns are negative. This result suggests that a commodity exporting country can hedge a large portion of national output risk at attractive terms by adopting a short position in the commodities market. In contrast, mean returns on a long position in domestic currency against the U.S. dollar are positive, but modest.

For each asset and country, we calculated the Ljung-Box Q statistic for the null hypothesis of no autocorrelation in domestic real returns. These tests show almost no evidence against the null with respect to own-country and world equity and bond returns. This pattern suggests that our assumption of no predictable movements in expected returns does little violence to the data on bond and equity returns.[21] However, as Table 5 shows, there is considerable evidence against the null hypothesis of serially uncorrelated returns for the commodity price index and the exchange rate position.[22] Neither our theoretical model nor empirical specifications allow for predictable movements in the expected returns on risky assets. This issue is potentially important for the gains from trade in risky financial assets, but it is beyond the scope of this paper.

5 Covariance between Output Innovations and Asset Returns

Table 6 reports regressions of log output innovations on domestic equity and government bond returns based on the simple random walk output specifications. The

[21] Several studies that consider longer samples and more refined testing procedures find evidence of predictable movements in expected returns on U.S. equities. See Chapter 7 in Campbell, Lo and MacKinlay (1997).

[22] Because there is a large common component across countries in the returns on the commodity index and foreign exchange positions, it is not appropriate to interpret each regression as providing independent evidence against the null.

chief message in this table is clear: own-country asset returns are nearly uncorrelated with innovations in total and tradable output in most countries. Adjusted R^2 values exceed 10 percent for only 3 or 4 of 14 countries, and they never exceed 17 percent.[23] This message is quite similar to results in Bottazzi et al. (1996), who consider the correlation between labor income innovations and domestic asset returns.

A secondary message in Table 6 is that output innovations tend to covary positively with own-country equity returns and negatively with own-country bond returns. The modest explanatory power in these regressions comes principally from the bond asset, not the equity asset. To gauge the magnitude of the covariances, consider the case of Austria. According to Table 6, the regression coefficient on the Austrian bond index is -0.086 with a t-statistic of 2.0. Conditional on the Austrian equity return, a 13 percent real return on the Austrian bond index (one standard deviation above its mean according to Table 4) corresponds to an output innovation of about 1.1 percent. For most other countries, the point estimates imply smaller covariances.

Results are highly varied for larger asset portfolios that expand the regressor list to include returns on world equities, world bonds, the commodity price index and the foreign exchange position. Table 7 shows results for innovations in total log output, and Table 8 considers innovations in the log of tradables output.[24]

For the expanded asset portfolios, the adjusted R^2 values exceed 25 percent for several countries: Australia, Austria, Belgium and Finland using either output measure and Canada using the tradables measure. No single asset accounts for the improved fit in these regressions, but the commodity price and foreign exchange positions play an important role for many countries. Conditional on other asset returns, 7 of 14 countries exhibit a statistically significant positive covariance between national output innovations and returns on a forward foreign exchange position. The commodity index is statistically significant in the traded output regressions for 8 of 18 countries.

In summary, these regression results support three inferences. First, the returns on broad domestic equity and bond positions are nearly uncorrelated with innovations in national output and tradables output. Second, for many countries, international trade

[23]Unreported regression results for output measured in natural units are very similar and, in fact, tend to show slightly poorer fits.

[24]Our regression specifications consider foreign asset returns of the form, $R^f_{t+1}(SR_{t,t+1}/SR_t)$, where R^f_{t+1} is the return in foreign curency units. We could instead consider fully hedged returns of the form, $R^f_{t+1}(FR_{t,t+1}/SR_t)$. Appendix B shows that a specification with fully hedged returns is equivalent, up to a linear approximation, to our specification. Our specification has two additional attractions. First, it allows investors to adopt arbitrary long or short positions in the foreign exchange market, which might be useful for hedging domestic output shocks or for exploiting the forward premium in the foreign exchange market. Second, our approach conserves on degrees of freedom when there are multiple assets.

in risky financial assets can considerably expand the scope for hedging national output risks. Third, international trade in risky financial assets does not allow countries to fully hedge national output risks. Put differently, available financial assets do not appear to span the space of national output shocks.

6 Trade in Risky Assets with Full Participation

We now compute optimal portfolio allocations and quantify the gains to international trade in risky finanical assets. All calculations assume a riskless real interest rate of 2.5 percent per year, so that $R_0 = 1.025$. We set the expected returns on risky assets and the covariance matrix of returns to their sample values, but we consider the sensitivity of our main results to alternative assumptions about the size of the equity premium. Unless noted otherwise, we use a relative risk aversion level of 3. To calibrate the implied absolute risk aversion coefficients, we multiply the relative risk aversion level by the reciprocal of a country's per capita real income in 1983, the midpoint of our sample period.

6.1 Portfolio Allocations

As a first exercise, we calculate the optimal portfolio for investors who hold domestic equity as the only risky financial asset. The restriction to domestic equity in this exercise simplifies the presentation but is not essential for the points at hand. We relax this restriction when we compute the gains from trade.

We calculate portfolio allocations and related quantities for the case of perfect substitution between traded and nontraded goods and for the case of additive separability. We also consider two alternatives regarding the covariance between output innovations and equity returns. One alternative uses the sample covariance between the country's output innovations and its equity returns. In line with the regression results in section 5, the sample covariances are small or even negative. We also consider a second alternative in which we reset the covariance so that output innovations are perfectly correlated with own-country equity returns.

Tables 9 and 10 report results for the perfect substitution and additive separability cases, respectively. The first column in each table shows the Observed Sharpe Ratio for own-country equity returns based on the summary statistics reported in Table 4. The Autarky Sharpe Ratios report the price of risk for domestic equity implied by the theory (Proposition 2) under the assumption of no international trade in risky assets. The Optimal Equity Position and the Hedge Portion for the average investor are calculated according to the portfolio allocation formula in Proposition 1, assuming that investors trade domestic equity at observed prices. The "average investor" means one who has the same absolute risk aversion and the same covariance between income and asset returns as the corresponding values specified for the investor's country.

Several results stand out in Tables 9 and 10:

- Autarky Sharpe Ratios are near zero for every country when using the sample covariance between output innovations and equity returns. This is the well-known equity premium puzzle implied by standard dynamic equilibrium theory. Like Campbell (1999, Table 5), we find that this puzzle holds in every country we consider, not just the United States.

- The discrepancy between the Observed and Autarky Sharpe Ratios narrows when we assume that output innovations are perfectly correlated with equity returns, but the gap remains very large. Thus high correlation between returns on nonmarketable assets and traded equity claims reduces the the implied equity premium, but it does not make the puzzle go away.

- According to the theoretically optimal portfolio, the average investor adopts a very large long position in *own* equity in every country. Using the Estimated Covariance, this long position amounts to roughly half a million 1990 dollars per person in the United States. This equity position is simply gargantuan relative to the holdings of the typical household (see, e.g., Heaton and Lucas, 2000). It is also an order of magnitude larger than the per capita value of the U.S. stock market.[25]

- This huge equity position reflects the desire to exploit the large observed risk premium on equities. To see this point, note that the Hedge Portions are uniformly modest in magnitude when we use the Observed Covariance. The Hedge Portions are large and negative under the Perfect Correlation assumption, especially in the case of perfect substitutes, but the Optimal Equity Position remains positive and quite large in every country save Italy.

Tables 9 and 10 highlight the enormous gap between the Optimal Equity Position implied by the theory and observed holdings of risky securities. This portfolio puzzle can be interpreted as the flip side of the equity premium puzzle. To see this point directly, recall from Proposition 2 that the optimal holdings of domestic equity are

[25] The market value of equities held by U.S. households at the end of 1999 is 13.3 trillion dollars (Poterba, 2000, Table 1). Dividing this figure by 270 million persons yields a per capita equity holding of about 49,000 dollars.

proportional to the difference between the Observed Sharpe Ratio and the Autarky Sharpe Ratio. We use data to compute the Observed Sharpe Ratio, but we rely on theory (and data) to compute the Autarky Sharpe Ratio. Because the theory delivers small values for the equilibrium price of risk, it also implies large long positions in domestic equity.

Another way to appreciate these puzzles is to consider the relationship between the Autarky and Free-Trade Sharpe Ratios implied by the theory. Suppose, for the sake of discussion, that output innovations are imperfectly correlated across countries and that equity represents a claim to GDP. Then, provided that risk tolerance levels are not too dissimilar across countries, the theory implies that the Autarky Sharpe Ratio for domestic equity *exceeds* the corresponding Free-Trade Sharpe Ratio for every country.[26] However, we find the opposite relationship when we interpret the Observed Sharpe Ratios as the outcome of free trade in risky financial assets. The theory fares no better if we reinterpret the Observed Sharpe Ratios as autarky outcomes, because then the theoretical Sharpe Ratio is much smaller then the observed ratio in every country.

6.2 The Gains from Trade

Tables 11 and 12 report the annual gains from trade in risky assets, expressed as a percentage of per capita income, for the average investor in each country. In calculating these gains, we set expected returns and the covariance matrix of returns to their sample values. We also set the covariance between output innovations and asset returns to their sample values. As before, we consider two alternatives regarding the treatment of traded and nontraded goods.

The welfare measures in Tables 11 and 12 answer two conceptually distinct questions. First, what are the gains to the average investor in each country caused by a switch from autarky to free trade in risky financial assets? Second, how large are the gains that accrue to a single investor, with average characteristics, who expands his portfolio choice menu to include domestic and foreign risky assets? The first question involves a change in regime regime and, hence, its answer rests on a theory of equilibrium. The second question pertains to individual decision making at exogenously determined asset prices and, hence, its answer requires only a theory of portfolio allocation. We can interpret the welfare entries in Tables 11 and 12 as answers to both of these questions, so long as we bear in mind that one interpretation rests on an

[26] If one country is much more risk tolerant than others, then its Sharpe Ratio may be smaller under autarky than under free trade. However, the theory still predicts larger Sharpe Ratios under autarky for the other countries.

equilibrium theory of asset pricing while the other does not.

We decompose the gains to trade along two dimensions. One dimension involves the set of assets included in the investor's portfolio choice menu. That is, we compute the gains to international trade for investors who trade only domestic equities and bonds, and we also compute the marginal benefits of trading foreign assets (world equity and bond indexes, the commodity index and the foreign exchange position). The second dimension makes use of Proposition 4 to decompose the gains into three pieces. The hedging benefit (HB) reflects the variance reduction achieved by the hedge portfolio.[27] The hedging cost (HC) is welfare reducing when the optimal hedge portfolio involves a short position in assets with positive excess returns. The risk premium (RP) benefit reflects the gains to adopting a long position in risky assets in order to exploit excess returns. In other words, it captures the rewards to taking on market risk.

We now summarize the main points contained in Tables 11 and 12.

- The theoretical gains to international trade in risky financial assets are enormous. Consider Australia as an example. Under additive separability (Table 12), the annual gains to trading domestic equity and bonds amount to 27.7 percent of income for an average Australian investor. The incremental benefit of trade in foreign assets amounts to another 28.4 percent of annual income. For several countries, the opportunity to trade risky financial assets is worth more to the average investor than per capita national income.

- These huge gains reflect enormous benefits from exploiting the return premium on risky assets. Of course, the calculations that deliver these huge gains reflect particular assumptions about risk aversion, asset returns and participation in financial markets. We explore the sensitivity of the welfare results to these assumptions below.

- While the pure hedging benefits of trade in risky assets are tiny in comparison to the risk premium benefits, they are not trivial. They amount to one-half percent of income or more for most countries under perfect substitutability, and somewhat less under additive separability.

- For many countries, the hedging cost is negative. This means that the average investor's hedge portfolio is an asset fund with a positive excess return. Put differently, it means that trade in risky assets offers the opportunity for

[27]The HB term captures only the between-country component of risk-sharing. It does not capture any within-country risk-sharing benefits afforded by trade in risky foreign (or domestic) assets.

the investor to reduce overall income and consumption variability while also increasing expected income and consumption.

6.3 International Risk Sharing

We now focus on the issue of international risk sharing. As discussed in the Introduction, previous work finds that potential gains from international risk sharing are large, and largely unrealized. According to Van Wincoop (1999) and Athanasoulis and Van Wincoop (2000), the annual gains to full international risk sharing are roughly 1-2 percent of GDP for wealthy countries and three or four times as much for a broader set of countries.

One possible explanation for the failure to achieve these gains is that financial markets do not span the space of national output innovations. If the spanning requirement fails in a serious way, then feasible gains to international risk sharing are considerably smaller than potential gains. The results in Section 5 (Tables 7 through 9) confirm that incomplete financial markets sharply limit the risk sharing gains from a properly structured portfolio of financial assets. This inference follows because the R-squared values are far below unity in regressions of national output innovations on asset returns. Thus much of the stochastic variation in national output lies outside the span of assets.[28] In this sense, incomplete financial markets are part of the explanation for limited international risk sharing.

However, three aspects of Tables 11 and 12 imply that market incompleteness is at best a partial explanation for the lack of international risk sharing. First, as we remarked above, the hedging benefits that can be achieved by a properly structured asset portfolio are nontrivial. While a formal analysis of the issue is beyond the scope of this study, the feasible hedging benefits in Tables 11 and 12 appear larger than the risk-sharing gains achieved in practice. Perhaps transactions costs in financial markets can account for the failure to achieve hedging benefits of the magnitudes reported in Tables 11 and 12. However, the hedging benefits become much larger if, following Baxter and Jermann (1997), we assume that national output innovations are highly positively correlated with domestic equity returns.

Second, for many countries the cost of hedging national output innovations greatly exceeds the benefits. These costs take the form of negative excess returns on the hedge portfolio. Consider the example of Australia in the perfect substitution case (Table 11). The lower variance of consumption and wealth afforded by the hedge portfolio

[28] Of course, one can argue that we fail to consider the "right" assets. We do not dismiss the possibility that other financial assets might offer additional hedging opportunities, but our asset menu includes the leading candidates that can be traded in liquid markets.

is worth 1.3 percent of income for the average Australian investor. But the cost of achieving this variance reduction amounts to 5.0 percent of income.

This aspect of our results shows that the failure to achieve greater international risk sharing is related to the puzzlingly large return premia on risky assets. Consider the situation for a country with an equity premium of several percentage points and a modest positive correlation between national outut innovations and domestic equity returns. The average investor in such a country can achieve some hedging benefits by adopting a short position in domestic equity, but only at the cost of large negative excess returns. Given this situation, the average investor adopts a long, not short, position in domestic equity, unless he is extremely risk averse. If the equity premium were very small, as implied by standard dynamic equilibrium theory, then the hedging costs would also be very small, and the investor would instead adopt a short position in domestic equity. Thus the puzzling lack of international risk sharing is connected to the puzzling large return premia on risky assets.

Third, Tables 11 and 12 show that standard portfolio allocation implies enormous benefits of investment in risky financial assets, domestic and foreign. These huge gains predominantly reflect the returns to taking on market risk, not the benefits of hedging. Most real-world investors do not adopt portfolios that lead to the benefits reported in Tables 11 and 12. Given the size of these benefits, it will be a challenge to rationalize the failure of investors to behave according to the theory by appealing to the costs of transacting in financial markets.

In summary, our analysis identifies three distinct reasons for the lack of international risk sharing. First, the spanning requirement for financial markets fails in a serious way, which sharply limits the gains from a portfolio-based approach to international risk sharing. Second, for many countries the cost of using financial assets to hedge national output shocks exceeds the benefits. This fact partly reflects the puzzling large return premia on risky assets. Third, investors do not behave in the manner implied by standard portfolio allocation theory. The unrealized gains of optimal portfolio allocations are enormous, according to the theory.

6.4 Sensitivity to Risk Aversion and the Equity Premium

We now consider the sensitivity of our welfare results to assumptions about risk aversion and the equity premium. To streamline the presentation, we return to the simple case for which the portfolio choice menu includes only one risky asset, domestic equity.

Figures 1 and 2 show how the benefits of trade in domestic equity vary with risk aversion and the size of the equity premium. The figures show the GDP-weighted average welfare effects, as a percentage of income, for the 18 countries in our sample. We compute the welfare gains under the assumption of perfect correlation between natonal output innovations and domestic equity returns, but the figures are also informative about the near-zero correlation case that holds in our sample. Given a zero correlation between output innovations and equity returns, the hedge portfolio vanishes, so that we can read the total benefits of the optimal portfolio from the "Risk Premium Benefit".

The figures show that the benefits of an optimal equity position are very large unless risk aversion is much greater than three, or unless the equity premium is much smaller than historical returns suggest. Given historical equity premia, perfect correlation between returns and output innovations and perfect substitutability between traded and nontraded goods, it takes a risk aversion level in the neighborhood of 10 to push the benefits of the optimal equity position below one percent of income. It takes much greater risk aversion to push the benefits down to modest levels, if we assume low correlation between returns and output innovations or additive separability bwetween traded and nontraded goods.

Even a relative risk aversion level of 10, let alone 30 or 40, is very difficult to reconcile with other findings in the literature on international risk sharing. The consumption and output-based research summarized by Lewis (1999) and Van Wincoop (1999) finds international risk sharing gains on the order of a few percent of GDP for relative risk aversion levels in the neighborhood of 3. If relative risk aversion levels are in fact several times larger than 3, then so are the gains to international risk sharing implied by this work. Unrealized gains of such large magnitudes are highly implausible. Hence, we conclude that high risk aversion alone cannot rationalize the set of puzzles related to international risk sharing, portfolio allocation and asset pricing.

The figures also show that the gains from an optimal portfolio position decline rapidly with the equity premium. Given uncertainty about the true equity premium, this result implies that Tables 11 and 12 may substantially overstate the welfare benefits of an optimal portfolio and the gains to international trade in risky financial assets. Likewise, Tables 9 and 10 may substantially overstate the size of the optimal long position in equities. However, Figures 1 and 2 also imply that overstated equity premia cannot be the full explanation for the portfolio puzzle and the gains-to-trade puzzle. Suppose that true equity premia are only 60 percent as large as the historical premia, and consider the most favorable case for the theory – perfect substitution between traded and nontraded goods and perfect correlation between output innovations and equity returns. Under these assumptions and a relative risk aversion of three, the benefits of an optimal equity position still exceed 7 percent of income. Relaxing the perfect correlation or perfect substitution assumption implies even larger benefits. Hence, we conclude that overstated risk premia cannot rationalize the set of puzzles related to international risk sharing, portfolio allocation and asset pricing.

7 Limited Participation

Much recent work in finance and macroeconomics stresses that most households have little or no risky asset holdings, and that stock ownership is highly concentrated. Poterba (2000), for example, reports that the top 5 percent of households ranked by stock ownership hold 86.1 percent of all common stock. By contrast, the 5 percent of households ranked by home ownership account for only 50.1 percent of housing equity.[29] Human capital is also much less concentrated than stock ownership. In light of these facts, researchers have explored the possibility that concentrated equity ownership and limited participation in financial markets may resolve some asset pricing puzzles.[30]

Following this lead, we show that limited participation goes a long way towards simultaneously addressing the equity premium and gains-to-trade puzzles. Recall from Proposition 2 that, according to the theory, a country takes a long net position in its own equity if the autarky Sharpe ratio for its domestic equity is lower than the corresponding world Sharpe ratio. In Section 6 we showed that the autarky Sharpe ratios under full participation are dramatically smaller than observed Sharpe ratios. Proposition 3 tells us that this large gap implies large gains from trade.

We now consider how limited participation affects autarky Sharpe ratios and, consequently, the gains to trade in risky financial assets. Recall from Proposition 2 that the autarky Sharpe ratio in the one-asset case is

$$S_1^g = aA^g\sigma_1^{-1}\left[e_1^g\sigma_1^2 + \operatorname{cov}\left(\tilde{Y}^g, \tilde{R}_1\right)\right] \tag{12}$$

Now assume that only a fraction, τ, of the population trades risky assets. Let A_τ^g be the harmonic mean of risk aversion for asset market participants ("traders"), and let $\tilde{Y}_\tau^g$ be the per trader present value of non-financial income. The autarky Sharpe ratio

[29] Since the homeowners are ranked by housing equity not by stock ownership, 50.1 percent is an upper bound on the housing equity owned by the 5 percent of the population that owns 86.1 percent of the common stock.

[30] Mankiw and Zeldes (1991), Vissing-Jorgensen (1999) and Brav, Constantinides and Geczy (2000) find that pricing assets using the consumption behavior of stockholders rather than the population as a whole provides more realistic asset prices. Saito (1995), Basak and Cuoco (1998), Constantinides, Donaldson and Mehra (1999) and Heaton and Lucas (1999) consider general equilibrium models with various forms of restricted participation and also generate more realistic asset prices.

for domestic equity now becomes

$$S_1^g = \underbrace{aA_\tau^g}_{\substack{\text{(1) Risk aversion} \\ \text{of traders}}} \times \sigma_1^{-1} \left[\underbrace{\frac{e_1^g}{\tau}}_{\substack{\text{(2) Financial} \\ \text{wealth per} \\ \text{Trader}}} \times \sigma_1^2 + \underbrace{\text{cov}\left(\tilde{Y}_\tau^g, \tilde{R}_1\right)}_{\substack{\text{(3) Covarariance} \\ \text{of non-financial} \\ \text{wealth for traders}}} \right] \tag{13}$$

Comparing equations (12) and (13), we see that limited participation affects the Sharpe ratio in three ways. First, if mean absolute risk aversion among traders is lower than the population average, then limited participation lowers the autarky Sharpe ratio (term (1)). Second, rather than spreading the risk of financial assets across the whole population, limited participation concentrates it among traders (term (2)). Third, if the traders' covariance of non-financial wealth with the risky asset is higher than the covariance for the population as a whole, the Sharpe ratio will be higher, too.[31]

To illustrate how limited participation bears on the equity premium and gains-to-trade puzzles, we calibrate equation (13). We consider the U.S. economy and make the following assumptions. First, we assume that "traders" own all risky financial assets, which we take to be either 5 or 15 percent of total national wealth. Second, in calibrating absolute risk aversion to a relative risk aversion of three, we assume that the remaining wealth is equally distributed among all agents, including traders. It follows that the percentage of total wealth owned by traders in our calibration equals $95\tau + 5$ or $85\tau + 15$. Third, we assume that the market value of risky financial assets amounts to 50,000 dollars per person. Fourth, based on Table 4, we set the standard deviation of equity returns to 17.6 percent. Finally, we set the covariance between equity returns and non-financial wealth for traders to zero.

Given these assumptions, Figure 3 shows how the autarky Sharpe ratio and the gains from trade vary with the participation rate, τ. The welfare benefits of trade in the top panel are scaled by total population, so it is necessary to divide by the participation rate to obtain the welfare benefits per trader.

[31] Davis and Willen (2000) find that the covariance between human capital and equity returns rises with education. Other studies find that asset market participation rises with education. Together, these two pieces of evidence suggest that the third effect of limited participation raises the Sharpe ratio. We do not include this effect in our calculations below.

The lower panel of Figure 3 shows that limited participation has a powerful effect on the Sharpe Ratio when participation rates are low. In thinking about how to gauge the appropriate participation rate, it is useful to recall the discussion of Tables 9 and 10 in Section 6.1. Only a small percentage of households have risky asset holdings anywhere near the magnitudes implied by the theory, although a much larger fraction of households have modest holdings of risky assets (e.g., Heaton and Lucas, 2000). However, households with small risky asset holdings are not "participating" in the sense implied by the theory, and they are certainly not exposed to equity risk to any substantial degree. The upshot of these remarks is that a value of τ in the neighborhood of .1 is a reasonable choice. This choice corresponds to a 14.5 or 23.5 percent figure for traders' share of total wealth. A value for τ in this neighborhood leads to a big increase in the theoretical Sharpe Ratio, relative to the full participation benchmark, although it is still well below the observed U.S. Sharpe Ratio.

The top panel of Figure 3 shows that the gains from trade fall off very rapidly as we reduce the participation rate. In fact, as we move away from full participation, the gains from trade decline more than in proportion to the decline in participation. This result can be understood by recognizing the two channels through which limited participation reduces the gains from trade. First, there is a direct mechanical effect of lower participation. People who do not participate in asset markets cannot partake in the gains from trade. Second, as equity holdings become more concentrated among fewer investors, the autarky Sharpe Ratio rises, which reduces the gains available to any particular investor. In the neighborhood of $\tau = .1$, the gains from trade in risky assets are rather modest.

8 Concluding Remarks

We find enormous gains from trade when asset returns are calibrated to observed risk premia and all agents participate in asset markets. This gains-to-trade puzzle is closely related to the celebrated equity premium puzzle. In particular, for reasonable degrees of risk aversion, the huge theoretical gains to trade arise from the rewards to taking on market risk, not from the benefits of international risk sharing.

While the two puzzles are related, they are also distinct. One can rationalize the equity premium puzzle in standard models by assuming very high risk aversion. However, this "solution" merely alters the form of the gains-to-trade puzzle, because highly risk averse investors perceive very large rewards to international risk sharing. So the gains-to-trade puzzle remains.

In an effort to address the puzzles, we consider a version of our theoretical framework with limited participation in the markets for risky financial assets. We show that limited participation goes a long way to addressing the equity premium and gains-to-trade puzzles, given a reasonable degree of risk aversion and empirically plausible values for the participation rate, the first two moments of equity returns and other quantities. This result suggests that limited participation is a promising avenue for explaining the equity premium and gains-to-trade puzzles, but more research on this topic is clearly warranted before reaching any strong conclusions.

Our analysis also sheds light on the puzzling lack of international risk sharing. Van Wincoop (1999), among others, makes a compelling case that the potential gains to international risk sharing are sizeable, but largely unrealized. We identify three distinct reasons for limited international risk sharing. First, the requirement that financial markets span the space of national output shocks fails in a serious way. This failure sharply limits the gains from a portfolio-based approach to international risk sharing. Second, for many countries the cost of using financial assets to hedge national output shocks greatly exceeds the benefits. This fact reflects the puzzlingly large return premia on risky assets, and it suggests that a full resolution to international risk sharing puzzles requires the development of more successful asset pricing theories. Third, investors do not behave in the manner implied by standard portfolio theory. This point is usually cast in terms of "home bias" in observed asset portfolios relative to the internationally diversified portfolios predicted by the theory.

We do not resolve the home bias puzzle, but we point out that standard portfolio theory also implies a puzzlingly high *level* of risky asset holdings relative to the observed holdings of the average investor. Furthermore, the theory implies implausibly large foregone gains for the majority of the population that has modest holdings of risky financial assets. We think this puzzle has a simple resolution. Specifically, few investors have enough liquid wealth to adopt the risky asset positions implied by the theory, nor can they borrow at the risk-free rate. If borrowing rates are comparable to the expected return on equities, for example, then the apparent excess returns offered by equity vanish, and so do the large gains from a theoretically optimal portfolio. While this explanation is not deep, it helps understand limited participation in risky asset markets. Of course, households that do not participate in asset markets cannot pursue a portfolio-based approach to international risk sharing.

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9 Appendix A. Proofs to Theoretical Propositions

Proof: (Proposition 1) Davis and Willen (2000) provide a constructive proof in the finite-horizon case that converges to the consumption and portfolio allocation solutions stated in Proposition 1 as the horizon goes to infinity. It can be shown directly that the infinite-horizon solutions satisfy the Euler Equation, sequential budget constraints and transversality condition. The text shows this in the one-asset case for the portfolio allocation rule. □

Proof: (Proposition 2) The text proves the one-asset case. The multi-asset case is a straightforward generalization.□

To prove Proposition 3, we need the following two Lemmas.

Lemma 1 (Variance decomposition of generalized wealth) *Under conditions 1, 2 and 3, the weighted-average variance of generalized wealth in country g can be decomposed as follows:*

$$\frac{1}{H^g}\sum_{h\in g} aA^h \operatorname{var}\left(\tilde{GW}^h\right) = \frac{1}{H^g}\sum_{h\in g} aA^h \operatorname{var}\left(\tilde{Y}^h - \mathrm{E}\left(\tilde{Y}^h|\tilde{\mathbf{R}}\right)\right) + \frac{1}{aA^g}\mathbf{S}'\mathbf{S}, \qquad (14)$$

where $\tilde{Y}^h - \mathrm{E}\left(\tilde{Y}^h|\tilde{\mathbf{R}}\right)$ *is the residual in a projection of the endowment present value on contemporaneous asset returns.*

Proof: Consider the one-asset case. The multi-asset case is a simple generalization. Substituting in the optimal solution, we get:

$$\operatorname{var}\left(\tilde{GW}^h\right) = \operatorname{var}\left(\tilde{y} - \frac{\beta_1^h}{\sigma_1^2}\tilde{R}_1 + \frac{ER_1}{aA^h\sigma_1^2}\tilde{R}_1\right)$$

It is easy to see that: $\tilde{y} - \frac{\beta_1^h}{\sigma_1^2}\tilde{R}_1 = \tilde{y} - \mathrm{E}\left(\tilde{y}|\tilde{R}_1\right)$ giving:

$$\operatorname{var}\left(\tilde{GW}^h\right) = \operatorname{var}\left(\tilde{y} - \mathrm{E}\left(\tilde{y}|\tilde{R}_1\right)\right) + \left(\frac{1}{aA^h}\right)^2 \frac{ER_1}{\sigma_1^2}$$

Taking the weighted sum, we get

$$\frac{1}{H^g}\sum_{h\in g} aA^h \operatorname{var}\left(\tilde{GW}^h\right) = \frac{1}{H^g}\sum_{h\in g} aA^h \operatorname{var}\left(\tilde{y}^h - \mathrm{E}\left(\tilde{y}^h|\tilde{R}_1\right)\right) + \frac{1}{H^g}\sum_{h\in g}\left(\frac{1}{aA^h}\right)\frac{ER_1}{\sigma_1^2}$$

Noting that $\frac{1}{H^g}\sum_{h\in g}\frac{1}{aA^h} = \frac{1}{aA^g}$ and using the definition of the Sharpe ratio gives the solution □

Lemma 2 *Consider an economy with assets $\tilde{\mathbf{R}}_z = \mathbf{C}\tilde{\mathbf{R}}_x$ where C is any square, non-singular $(J \times J)$ matrix. An individual's portfolio will have the same cost and distribution, regardless of whether he faces $\tilde{\mathbf{R}}_z$ or $\mathbf{C}\tilde{\mathbf{R}}_x$.*

Proof: Let a 'z' subscript denote moments with respect to assets $\tilde{\mathbf{R}}_z$ and so on. It is easy to see that: $\mathbf{\Sigma}_z = \mathbf{C}\Sigma_x\mathbf{C}'$, $\boldsymbol{\beta}_z = \mathbf{C}\boldsymbol{\beta}_x$. The excess returns will be: $\mathbf{ER}_z = \mathbf{CER}_x$ and the excess return on the optimal portfolio will be $\mathbf{ER}_z'\boldsymbol{\omega}_z^h = \frac{1}{A^h}\mathbf{ER}_z'\mathbf{\Sigma}_z^{-1}\mathbf{ER}_z - \mathbf{ER}_z'\mathbf{\Sigma}_z^{-1}\boldsymbol{\beta}_g$. Substituting in the expressions above, we get the same excess return as in the untransformed economy. Similarly substituting into $\tilde{\mathbf{R}}_z'\boldsymbol{\omega}_z^h = \frac{1}{A^h}\tilde{\mathbf{R}}_z'\mathbf{\Sigma}_z^{-1}\mathbf{ER}_z - \mathbf{z}'\mathbf{\Sigma}_z^{-1}\boldsymbol{\beta}_g$ gives the same portfolio payoff distribution as the untransformed economy. □

Proof: (Proposition 3) The Euler equation tells us that $\exp\left(-A^h c_t^h\right) = \delta^h R_{0,t+1}\,\mathrm{E}\left(\exp\left(-A^h \tilde{c}_{t+1}^h\right)\right)$ which implies that:

$$-\frac{\left(\delta^h\right)^\tau}{A^h}\mathrm{E}\left(\exp\left(-A^h\tilde{c}_\tau^h\right)\right) = -\frac{1}{A^h}\Pi_{s=1}^{\tau}\frac{1}{R_{0,s}}\exp\left(-A^h c_t^h\right)$$

Which implies that $U^h\left(C^h\right) = -\frac{1}{A^h}\,\mathrm{PDV}_t\left(\{\mathbf{1}\}_{s=t}^{\infty}\right)\exp -A^h c_0^h$. It is easy to see that: $U^h\left(C^h + GFT^h\right) = -\frac{1}{A^h}\,\mathrm{PDV}_t\left(\{\mathbf{1}\}_{s=t}^{\infty}\right)\exp -A^h\left(c_0^h + \theta\right)$. Setting $U^h\left(C+\theta\right) = U^h\left(C^*\right)$, we solve for GFT^h which is:

$$GFT_t^h = \left(\hat{c}_t^h - c_t^h\right)$$

So $\frac{1}{a}GFT_t^h = G\hat{W}_t^h - GW_t^h$.

Now consider the one-asset case. Taking differences in generalized wealth gives and using the decomposition of the variance of generalized wealth gives:

$$G\hat{W}_t^h - GW_t^h = \frac{1}{R_0}\left[\frac{ER_1}{aA^h\sigma_1}\left(S_1 - S_1^g\right) - \frac{1}{2aA^h}S^2 + \frac{1}{2aA^h}\left(S^g\right)^2\right]$$

Reorganizing, we get:

$$G\hat{W}_t^h - GW_t^h = \frac{1}{R_0}\frac{1}{2aA^h}\left(S_1^2 - 2S_1S_1^g + \left(S_1^g\right)^2\right)$$

which is the solution.

For multiple assets, replace the new asset with its orthogonal projection. By Lemma 2 this has no effect on the consumption outcomes. Then follow the above steps. □

10 Appendix B. Further Data Description

10.1 National Income Accounts Data

Following Van Wincoop (1999), we categorize output and expenditures as indicated in Tables B.1 and B.2.

Table B.1: Output Category Classification (T is tradable)

Category	Classification
Agriculture, forestry	**T**
Mining, quarrying	**T**
Manufacturing	**T**
Electricity, gas, water	N
Construction	N
Trade, restaurants, hotels	N
Transportation, storage, and communication	N
FIRE, business services	N
Community, social, and business services	N

Table B.2: Consumption Category Classification (T is tradable)

Category	Subcategory	Classification
Food	Food	**T**
	Non-alcoholic beverages	**T**
	Alcoholic beverages	**T**
	Tobacco	**T**
Clothing		**T**
Rent, fuel, power		N
Furniture, HH operation	Household operation	N
	Other	**T**
Medical care		N
Transportation, communication	Personal transportation equip.	**T**
	Other	N
Education, entertainment		N
Misc. goods and services		N
Consumption of non-profits		N

Unfortunately, the breakdown of Furniture and Household Operation category into subcategories is not available for some countries, so we classify the entire category as tradable. The same is true for the broad category of transportation and communication. We sometimes lack the finer breakdown for food as well, although all of its subcategories are tradable.

For some countries, the SNA provides several overlapping constant-price consumption series each indexed to a different base year (all are fixed-weight quantity indices). In these cases we chain link the different constant-price series together, using the most recent weights available. The table B.3 below lists the sample of countries and the range of years used for each series - nominal GDP, nominal consumption, and real consumption. For the real consumption series, we also list the base years used for each country and the range of years used for each base year.

The footnotes to table B.3 indicate that there are quite a few countries where some of the more finely disaggregated tradables consumption categories are missing. In these cases we use the more highly aggregated consumption categories in the tradables/nontradables classification.

Table B.3 Country Sample and Years Used

Country	Years of Nominal GDP	Years of Nominal Cons.	Base Year and Years of Real Consumption[1]
Australia	70-95	70-95[2]	1979(70-76), 1984(76-80), 1989(80-95)[3]
Austria	70-95[4]	70-95	1976(70-76), 1993(76-95)
Belgium	70-95	70-95	1980(70-80), 1990(80-95)
Canada	70-92	70-95[5]	1986(70-95)[6]
Denmark	70-95	70-95	1980(70-95)
Finland	70-95	70-95	1980(70-75), 1990(75-95)
France	77-95	70-95	1980(70-95)
W. Germany	70-93	70-94[7]	1991(70-94)[8]
Greece	70-95	70-95	1970(70-95)
Iceland	73-94	77-95	1980(77-90), 1990(90-95)
Italy	70-95	70-95	1990(70-95)
Japan	70-95	70-95[9]	1990(70-95)[10]
Luxembourg	70-95	70-91[11]	1985(70-91)[12]
Netherlands	70-95	70-95[13]	1980(70-77), 1990(77-95)[14]
Norway	70-95	70-95[15]	1970(70-75), 1975(75-78), 1990(78-95)[16]
Sweden	70-94	70-95	1980(70-85), 1985(85-91), 1991(91-95)
UK	70-94	70-94	1990(70-94)
US	70-94	70-95	1992(70-95)

Notes to Table B.3.

1. The base year to which real consumption is indexed is in parentheses and the years indexed to that base year are next to the parentheses.
2. Missing category (1B) in 1995, and missing category (4B).
3. Same as previous footnote.
4. Missing category (2), mining and quarrying.
5. Missing category (1B) in 1994-5, and missing category (4B).
6. Same as previous footnote.
7. Categories (1A)- (1C) are aggregated, so we avoid using the more finely disaggregated breakdown of category (1) when calculating computing the average world price level and country weight. Also missing category (4B).
8. Same as previous footnote.
9. Missing all the more finely disaggregated categories; we only have data on broad categories (1), (2), (4), and (6).
10. Same as previous footnote.
11. Missing categories (4B) and (6A)
12. Same as previous footnote.
13. Data is available on the more finely disaggregated breakdown from 1985-1995 only. We use the broader tradables categories when constructing the country weight.
14. Same are previous footnote.
15. Missing all the more finely disaggregated categories; we only have data on broad categories (1), (2), (4), and (6).
16. Same as previous footnote.

10.2 Financial Data

10.2.1 Stock Returns

Stock returns data are from Morgan Stanley Capital International, extracted from the Ibbotson's database. The database contains data on the national stock indices of 14 out of the 18 countries in our sample, as well as a value-weighted "world" stock index containing the stock returns of about 22 nations. The time series generally begin in 1970. We use the total returns series, which include dividend reinvestment.

10.2.2 Government Bond Returns

Long-term goverment bonds are also from Ibbotson's, and are calculated using data on yields from the IMF. We use the total returns series, which include capital appreciation as well as coupon payments. The database contains total returns series for 11 out of the 18 countries in our sample; the time series generally start in 1957.

Ibbotson's does not produce a world return series for government bonds, and unfortunately, we were unable to obtain data on the market value of outstanding long-term government bonds to contruct a proper value-weighted index. We construct a "world" value-weighted government bond return using the market value of total government debt as the value weight. We convert from local currencies into dollars using period-end exchange rates. The data on the market value of government debt comes from the IMF's IFS. The world bond return is constructed in dollar terms, before it is converted into each country's local currency and deflated.

10.2.3 Commodity Prices

The Goldman Sachs commodity price index is extracted from DRI (pneumonic GSCIX@1960 and GSCIX in the @INDEX/DATA module). As noted in the text, the nominal rate of return is simply the log difference between the price of the index on the last day of the previous year minus the price of the index on the last day of the current year.

10.2.4 Short Term Interest Rates

Data on short term rates are from the IFS. If available, we use data on the treasury bill interest rate. If not available, we use the money market rate or discount rate.

10.2.5 Exchange Rates

We obtained data on spot exchange rates from IFS. The data on one-year-ahead forward exchange rates are from the Harris Bank weekly review obtained from Chris Telmer at http://bertha.gsia.cmu.edu/files/fx/. These data are available for 8 of the 18 countries in our sample (Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, and the UK.) For 6 additional countries (Australia, Austria, Denmark, Finland, Norway, and Sweden), we obtained data on three-month-ahead forward rates from DRI. The mnemonics follow the pattern LB@CXXX from the @IMF module, where XXX is the country number - 193 for Australia, for example,

Some additional notation is helpful for describing returns on the rolling forward position. Let $FR_{t,q,q+1}$ be the three-month-ahead forward rate in domestic currency units per dollar at the beginning of quarter q in year t, let $SR_{t,q+1}$ be the corresponding spot rate of exchange at the end of quarter q in year t, and let $r_{t,q}$ be the three-month gross real rate of return on short-term government debt during quarter q of year t. The domestic real rate of return on this rolling forward position during year t is then given by:

$$\log\left(\frac{FR_{t,0,1}}{SR_{t,1}}\right)r_{t,2}r_{t,3}r_{t,4}+\log\left(\frac{FR_{t,1,2}}{SR_{t,2}}\right)r_{t,3}r_{t,4}+\log\left(\frac{FR_{t,2,3}}{SR_{t,3}}\right)r_{t,4}+\log\left(\frac{FR_{t,3,4}}{SR_{t,4}}\right).$$

11 Appendix C. Hedged Versus Unhedged Returns in the Regression Specifications

The regressions in Tables 7 and 8 specify returns on world bonds, world equities and commodity prices in unhedged form. By including the returns on a forward position in the foreign exchange market as a separate regressor, these regressions are equivalent, up to a linear approximation, to a regression that specifies foreign asset returns in fully hedged form.

To see this point, consider our specification with one risky foreign asset plus the return on the forward position.[32]

$$\tilde{Y}^g_{t+1}=\alpha_a+\beta_a\left(R^f_{t+1}\frac{SR_{t+1}}{SR_t}\right)+\gamma_a\left(\frac{FR_{t,t+1}}{SR_{t+1}}\right)+u_{t+1}.$$

Take a Taylor series expansion of $R^f_{t+1}(SR_{t+1}/SR_t)$ around the unconditional means of R^f_{t+1} and (SR_{t+1}/SR_t), and sweep the invariant terms into a new constant:

$$\begin{aligned}\tilde{Y}^g_{t+1} &= \alpha_{a'}+\beta_a E\left(R^f_{t+1}\right)\frac{SR_{t+1}}{SR_t}+\beta_a E\left(\frac{SR_{t+1}}{SR_t}\right)R^f_{t+1}\\ &\quad+\gamma_a\left(\frac{FR_{t,t+1}}{SR_{t+1}}\right)+\frac{\beta_a}{2}\operatorname{cov}\left(R^f_{t+1},\frac{FR_{t,t+1}}{SR_{t+1}}\right)+u_{t+1},\end{aligned}$$

or, sweeping the expectation terms into a new set of coefficients:

$$\begin{aligned}\tilde{Y}^g_{t+1} &= \alpha_{a'}+\beta_{a'}\frac{SR_{t+1}}{SR_t}+\beta_{a''}R^f_{t+1}+\gamma_a\frac{FR_{t,t+1}}{SR_{t+1}}+\\ &\quad\frac{\beta_a}{2}\operatorname{cov}\left(R^f_{t+1},\frac{FR_{t,t+1}}{SR_{t+1}}\right)+u_{t+1},\end{aligned}$$

The higher order terms of this Taylor series expansion are zero, so this expansion is exact.

An alternative regression that specifies the foreign asset return in hedged form is

$$\tilde{Y}^g_{t+1}=\alpha_b+\beta_b\left(R^f_{t+1}\frac{FR_{t,t+1}}{SR_t}\right)+u_{t+1}$$

[32] We approximate the log transformation by $\frac{FR_{t,t+1}}{SR_{t+1}}\approx 1+\log\left(\frac{FR_{t,t+1}}{SR_{t+1}}\right)$, for example.

Use the fact that $R^f_{t+1}(FR_{t,t+1}/SR_t) = R^f_{t+1}(FR_{t,t+1}/SR_{t+1})(SR_{t+1}/SR_t)$, and take a Taylor series expansion similar to the previous one. After again re-labelling the constant and regression coefficients, we have:

$$\begin{aligned}\tilde{Y}^g_{t+1} \quad = \quad & \alpha_{b'} + \beta_{b'} \frac{SR_{t+1}}{SR_t} + \beta_{b''} R^f_{t+1} + \beta_{b'''} \frac{FR_{t,t+1}}{SR_{t+1}} + \\ & \ldots \text{covariance terms} \ldots + u_{t+1}.\end{aligned}$$

We can now see that the same variables entering this equation also enter into the linear approximation to the equation we estimate. There are some additional covariance terms in this equation, but if those terms do not vary much over time, they will be swept into the constant. (Condition 3 in our theoretical model assumes that all higher moments are time invariant.) Thus our specification approximately nests a specification with fully hedged returns on foreign assets. However, our specification also allows the coefficient on $FR_{t,t+1}/SR_{t+1}$ to differ in an arbitrary way from the coefficient on R^f_{t+1}, unlike a specification that imposes full hedging.

Two other points are worth mentioning. First, the linear approximation formulas suggest that we should include SR_{t+1}/SR_t as a separate regressor in our specifications. However, the returns on this position and the forward position, $FR_{t,t+1}/SR_{t+1}$, are highly collinear (correlations ranging from .95 to .98 across countries), so we do not include them. Second, according to the theory an investor generally wants to include risky assets in hedged and unhedged form. But specifying the regression equations in this way would use up additional degrees of freedom and probably lead to imprecisely estimated slope coefficients. Our specification can be interpreted as a linear approximation to this more general specification, but it conserves on degrees of freedom.

Table 1: Risky Financial Securities as a Percentage of Wealth

Country	Avg. Stock Market Rate of Return, 1980-1996	Avg. Growth Rate of Capital Income, 1980-1995	Capital's Share of National Income 1980	Capital's Share of National Income 1990	Securities Value as Percent of Business Wealth 1980	Securities Value as Percent of Business Wealth 1990	Securities Value as Percent of Total Wealth 1980	Securities Value as Percent of Total Wealth 1990
Austria	14.24	5.38	0.28	0.30	0.87	2.85	0.25	0.86
Belgium	21.96	6.81	0.28	0.35	9.91	14.79	2.75	5.20
Canada	10.48	4.94	0.30	0.27	9.06	10.17	2.72	2.70
France	18.92	7.91	0.25	0.30	5.01	11.91	1.26	3.60
Germany, W.	16.22	6.31	0.24	0.30	18.82	23.64	4.53	7.01
Italy	17.75	10.45	0.42	0.43	1.22	1.81	0.52	0.78
Japan	11.29	2.62	0.33	0.32	15.35	36.32	5.09	11.45
Netherlands	20.23	5.31	0.27	0.35	15.88	28.14	4.25	9.71
UK	18.30	9.90	0.20	0.25	19.36	32.03	3.87	7.94
US	16.15	7.05	0.24	0.26	20.37	28.06	4.84	7.26

Notes:

1. Data on rates of return are from Morgan Stanley Capital International (MSCI). Market capitalization values are from the Ibbotson's database. Stock market capitalization values are from the Financial Times, and corporate bond capitalizations are from Salomon Brothers. See Section 4 and Appendix B for a description.

2. Capital's share is business income as a percent of net domestic product less indirect business taxes. Business income is business gross operating surplus net of depreciation. These data, which we describe more fully in Section 4 and Appendix

B, are from the UN System of National Accounts.

3. We measure business wealth as the present value of future business income flows, discounted at the country's average annual stock market rate of return from 1981 to 1996. We use observed values of business income through 1995 (1994 for Germany and Sweden). For later years, we use projected values based on the assumption that business income grows at the own-country average rate from 1981 to 1995.

4. We measure total wealth as business wealth times the reciprocal of capital's share of national income in the same year.

5. The last four columns report the market value of business equity and debt securities at year end as a percentage of business and total wealth in 1980 and 1990.

Table 2: Summary Statistics for Random Walk Output Specifications

	Per Capita Real Output				Natural Log of Per Capita Real Output					
	Total		*Traded*		*Total*			*Traded*		
	Drift	Std. Dev.	Drift	Std. Dev.	Drift	Std. Dev.	Q-Statistic p-Value	Drift	Std. Dev.	Q-Statistic p-value
Australia	255	393	8	213	1.6	2.5	0.40	0.2	5.1	0.84
Austria	454	363	51	163	2.6	2.3	0.85	1.1	3.3	0.31
Belgium	357	400	22	204	2.1	2.4	0.37	0.5	4.5	0.54
Canada	319	587	13	316	2.0	3.4	0.31	0.4	7.0	0.57
Denmark	391	534	102	150	1.6	2.3	0.09	2.0	2.9	0.52
Finland	419	1081	102	479	2.2	4.6	0.00	1.6	7.3	0.01
France	302	373	-7	168	1.5	1.8	0.10	-0.1	3.1	0.42
Germany, W.	495	548	63	292	2.4	2.5	0.19	0.9	3.9	0.62
Greece	112	217	13	115	2.1	4.1	0.24	0.8	6.0	0.91
Iceland	162	1228	-12	406	0.7	5.1	0.61	-0.2	6.9	0.08
Italy	381	350	65	165	2.5	2.3	0.48	1.5	3.8	0.65
Japan	487	495	51	311	2.4	2.5	0.24	0.7	4.6	0.37
Luxembourg	657	1304	-43	979	2.9	6.6	0.84	-0.6	14.4	0.57
Netherlands	284	311	46	186	1.6	1.8	0.31	1.0	3.8	0.05
Norway	568	678	149	690	2.4	2.6	0.30	2.4	8.5	0.30
Sweden	179	699	30	371	0.8	2.8	0.17	0.5	6.3	0.10
UK	304	384	41	175	2.1	2.6	0.27	1.1	4.4	0.36
US	289	443	29	218	1.5	2.4	0.29	0.6	4.6	0.32
World	355	323	36	168	1.9	1.8		0.7	3.3	

Notes:

1. Table entries report the mean drift and the standard deviation of the innovations for random walk specifications fit to various measures of per capita real output. The output measures in natural units are expressed in 1990 U.S. dollars. See the text for an explanation of how we deflated nominal output series and converted to dollars.

2. The Ljung-Box Q test for autocorrelation is taken out to 6 lags. The p-value is the marginal significance level in a test of the null hypothesis of no serial correlation in the first difference of the output measure. Unreported results for per capita output in natural units are very similar.

3. The bottom row shows the real GDP-weighted average of the country-level statistics.

Table 3: **Domestic Real Returns on World Equity and Bond Indexes, 1970 to 1995**

	Equity				**Bonds**			
	All		*Traded*		*All*		*Traded*	
Country	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Australia	7.8	20.4	8.1	20.1	4.8	17.0	5.1	16.9
Austria	5.5	21.3	6.5	21.2	2.5	13.7	3.5	13.6
Belgium	6.4	21.5	7.0	21.5	3.4	14.5	4.0	14.5
Canada	9.4	17.7	9.4	17.8	6.4	13.4	6.4	13.6
Denmark	5.9	21.2	6.8	21.2	2.9	14.2	3.8	13.9
Finland	6.4	21.1	7.0	20.6	3.4	16.3	4.0	16.4
France	6.5	20.2	6.9	20.2	3.5	13.6	3.8	13.4
Germany, W.	6.7	22.1	7.1	22.1	3.5	13.3	3.9	13.1
Greece	7.7	21.9	7.5	22.1	4.7	14.2	4.5	14.5
Iceland	10.9	19.9	11.4	21.0	6.8	18.3	7.3	20.4
Italy	7.0	18.6	7.6	18.8	4.0	13.0	4.6	13.2
Japan	4.3	19.2	4.5	19.8	1.2	13.5	1.5	13.8
Luxembourg	6.4	22.1	6.8	22.0	2.4	12.9	2.8	12.6
Netherlands	6.1	21.3	6.8	21.3	3.1	14.1	3.8	14.0
Norway	6.6	20.4	6.6	20.4	3.6	14.5	3.5	14.6
Sweden	7.0	20.1	8.0	19.8	3.5	15.6	4.5	15.8
UK	6.8	21.4	7.4	21.8	3.3	15.7	4.0	15.8
US	7.9	17.6	8.6	17.8	5.5	12.1	6.2	12.1

1. The annual percentage return is computed as the world return in dollars converted to local currency using contemporaneous exchange rates, and deflated by the country's consumption price deflator for all goods or tradable goods only.

2. Ljung-Box Q tests out to 6 lags were computed for all asset returns reported. None of the p-values were below 0.2.

Table 4: **Domestic Real Returns on Own Equity and Bond Indexes, 1970 to 1995**

	Equity				**Bonds**			
	All		*Traded*		*All*		*Traded*	
Country	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Australia	7.8	27.9	8.0	27.6	3.7	16.3	4.0	16.2
Austria	6.5	32.1	7.5	31.9	4.9	8.1	5.8	8.1
Belgium	10.6	24.2	11.2	23.6	5.0	9.6	5.5	9.2
Canada	6.3	17.1	6.2	17.0	4.9	10.5	4.8	10.9
Denmark	11.8	35.7	12.6	35.5	.	.	.	.
France	8.8	28.0	9.1	27.8	4.3	12.0	4.6	11.6
Germany, W.	9.3	26.7	9.7	26.7	5.3	8.1	5.7	7.8
Italy	5.3	36.5	5.9	36.8	3.8	21.1	4.4	21.2
Japan	10.9	30.7	11.2	31.2	3.7	8.9	3.9	9.5
Netherlands	11.2	22.9	11.9	23.0	4.6	8.9	5.3	9.0
Norway	12.3	49.2	12.3	49.3	.	.	.	.
Sweden	13.9	28.6	14.9	28.5	.	.	.	.
UK	11.6	33.7	12.2	33.8	4.9	18.1	5.5	18.1
US	7.4	17.0	8.1	17.4	5.1	13.3	5.9	13.4

Notes:

1. The annual percentage return is computed as the own-currency return, deflated by the country's consumption price deflator for all goods or tradable goods only.
2. Ljung-Box Q tests out to 6 lags were computed for all asset returns reported. None of the p-values were below 0.1, except for the West German government bond return.

Table 5: **Domestic Real Returns on the Commodity Price Index and the Foreign Exchange Position, 1970 to 1995**

	Commodity	Price	Index	Exchange	Rate	Position
Country	Mean	Std. Dev.	Q-Stat p-value[1]	Mean	Std. Dev.	Q-Stat p-value
Australia	-3.2	16.5	0.10	2.3	8.3	0.16
Austria	-5.5	18.2	0.01	2.6	12.8	0.10
Belgium	-4.6	19.5	0.02	2.9	12.9	0.04
Canada	-1.6	18.5	0.01	0.2	5.3	0.50
Denmark	-5.1	17.9	0.02	3.7	12.4	0.04
Finland	-4.6	17.8	0.06	4.9	9.9	0.00
France	-4.5	18.2	0.06	2.6	11.9	0.09
Germany, W.	-5.0	18.8	0.01	2.1	12.9	0.27
Greece	-3.3	18.7	0.03	.	.	.
Iceland	-3.7	21.8	0.39	.	.	.
Italy	-4.0	19.1	0.25	2.4	11.8	0.01
Japan	-6.7	21.7	0.01	2.8	13.3	0.60
Luxembourg	-5.2	20.8	0.01	.	.	.
Netherlands	-4.9	18.8	0.01	1.8	13.2	0.15
Norway	-4.4	17.4	0.01	3.9	11.2	0.03
Sweden	-4.1	19.1	0.15	1.9	12.5	0.14
UK	-4.3	19.5	0.19	1.5	13.3	0.46
US	-2.4	17.5	0.01	.	.	.

1. The annual percentage return on the commodity price index is computed as the world return in dollars converted to local currency using contemporaneous exchange rates, and deflated by the country's consumption price deflator for all goods.

2. The annual percentage return for the foreign exchange position is a domestic real return. See the text for an explanation of how this return is calculated.

3. The Ljung-Box Q test is taken out to 6 lags.

Table 6: Regressions of Log Output Innovations on Domestic Asset Returns, 1971-1995

	Total GDP				*Traded GDP*				
	Own	Own			Own	Own			
Country	Bond	Equity	R-Sq.	R-Sq. Adj.	Bond	Equity	R-Sq.	R-Sq. Adj.	Obs
Australia	-0.064	0.022	0.19	0.11	-0.121	0.045	0.16	0.09	25
	(0.029)	(0.016)			(0.053)	(0.037)			
Austria	-0.086	0.005	0.10	0.01	-0.172	0.015	0.20	0.13	24
	(0.043)	(0.008)			(0.069)	(0.009)			
Belgium	-0.064	0.010	0.05	-0.04	-0.159	0.067	0.11	0.03	25
	(0.046)	(0.019)			(0.089)	(0.031)			
Canada	-0.168	0.009	0.23	0.15	-0.327	0.054	0.25	0.17	22
	(0.067)	(0.031)			(0.115)	(0.058)			
Denmark		0.008	0.02	-0.03		-0.004	0.00	-0.04	25
		(0.014)				(0.015)			
France	-0.016	0.029	0.15	0.04	-0.069	0.058	0.17	0.06	18
	(0.034)	(0.018)			(0.067)	(0.028)			
Germany, W.	-0.063	-0.018	0.10	0.01	-0.168	-0.008	0.13	0.04	23
	(0.058)	(0.014)			(0.100)	(0.032)			
Italy	-0.037	0.006	0.10	0.02	-0.090	0.016	0.21	0.14	25
	(0.021)	(0.007)			(0.029)	(0.012)			
Japan	-0.055	0.026	0.10	0.02	-0.033	0.036	0.05	-0.04	25
	(0.072)	(0.015)			(0.133)	(0.023)			
Netherlands	-0.058	-0.017	0.19	0.11	-0.151	0.017	0.11	0.03	25
	(0.036)	(0.014)			(0.077)	(0.037)			

Norway		0.006	0.01	-0.03		0.043	0.06	0.02	25
		(0.008)				(0.026)			
Sweden		-0.022	0.05	0.01		-0.002	0.00	-0.05	24
		(0.020)				(0.044)			
UK	-0.023	0.015	0.03	-0.06	0.005	0.008	0.01	-0.09	24
	(0.024)	(0.017)			(0.042)	(0.023)			
US	-0.024	-0.006	0.02	-0.07	-0.115	-0.031	0.15	0.07	25
	(0.056)	(0.049)			(0.067)	(0.081)			

Note:

1. Each country's output and traded output regression is separately estimated by OLS.
2. Heteroscedasticity-corrected standard errors (in parentheses) are computed from the covariance matrix, $(X'X)^{-1}X'\Omega X(X'X)^{-1}$, where Ω is the diagonal of uu', and u is the vector of OLS residuals.
3. Data are not available over the entire sample period for all countries.

Table 7: Regressions of Log Output Innovations on Several Asset Returns, 1971-1995

Country	World Bond	World Equity	Commodity Price	Own Bond	Own Equity	Forward Payoff	R-Sq.	R-Sq. Adj.	Obs
Australia	-0.133	0.103	0.044	-0.006	-0.013	0.029	0.44	0.25	25
	(0.044)	(0.050)	(0.019)	(0.028)	(0.025)	(0.050)			
Austria	-0.047	0.015	0.049	-0.018	-0.002	0.093	0.46	0.27	24
	(0.069)	(0.023)	(0.027)	(0.086)	(0.009)	(0.042)			
Belgium	0.045	-0.026	0.074	-0.105	0.041	0.163	0.58	0.44	25
	(0.091)	(0.022)	(0.020)	(0.101)	(0.017)	(0.071)			
Canada	-0.060	0.103	0.096	-0.157	-0.082	0.069	0.38	0.13	22
	(0.101)	(0.090)	(0.038)	(0.081)	(0.058)	(0.139)			
Denmark	0.027	0.035	0.008		0.007	0.099	0.22	0.02	25
	(0.044)	(0.042)	(0.028)		(0.021)	(0.043)			
Finland	-0.220	0.072	0.071			0.001	0.40	0.28	25
	(0.074)	(0.032)	(0.040)			(0.064)			
France	-0.004	-0.039	0.019	-0.004	0.041	0.032	0.34	-0.03	18
	(0.090)	(0.039)	(0.028)	(0.081)	(0.022)	(0.039)			
Germany, W.	0.007	0.040	0.017	-0.084	-0.024	0.141	0.41	0.19	23
	(0.082)	(0.035)	(0.028)	(0.081)	(0.017)	(0.054)			
Greece	-0.004	0.031	0.083				0.17	0.05	25
	(0.068)	(0.062)	(0.043)						
Iceland	0.082	-0.027	-0.114				0.22	0.04	17
	(0.071)	(0.060)	(0.062)						
Italy	-0.028	-0.006	0.029	-0.019	0.005	0.063	0.29	0.05	25

	(0.054)	(0.036)	(0.027)	(0.032)	(0.011)	(0.031)			
Japan	0.021	-0.034	0.055	0.009	0.034	0.025	0.25	-0.00	25
	(0.060)	(0.051)	(0.022)	(0.089)	(0.014)	(0.030)			
Luxembourg	-0.050	-0.068	0.106				0.21	0.07	21
	(0.086)	(0.086)	(0.088)						
Netherlands	0.033	-0.033	0.030	-0.080	0.021	0.078	0.42	0.22	25
	(0.046)	(0.030)	(0.019)	(0.045)	(0.030)	(0.033)			
Norway	-0.085	0.004	0.018		-0.001	-0.012	0.20	-0.01	25
	(0.056)	(0.039)	(0.031)		(0.009)	(0.057)			
Sweden	-0.145	0.082	-0.007		-0.023	-0.007	0.37	0.20	24
	(0.047)	(0.033)	(0.033)		(0.024)	(0.060)			
UK	-0.046	0.072	0.075	-0.012	0.022	0.113	0.43	0.23	24
	(0.069)	(0.042)	(0.032)	(0.030)	(0.020)	(0.034)			
US	-0.073	0.123	0.029	0.035	-0.108		0.23	0.03	25
	(0.060)	(0.033)	(0.018)	(0.075)	(0.067)				

See notes to Table 6.

Table 8: Regressions of Innovations in Log Traded Output on Several Asset Returns, 1971-1995

Country	World Bond	World Equity	Commodity Price	Own Bond	Own Equity	Forward Payoff	R-Sq.	R-Sq. Adj.	Obs
Australia	-0.278	0.104	0.116	0.036	0.027	-0.150	0.47	0.29	25
	(0.091)	(0.078)	(0.037)	(0.064)	(0.049)	(0.111)			
Austria	-0.037	0.030	0.088	-0.119	0.004	0.117	0.48	0.29	24
	(0.070)	(0.038)	(0.037)	(0.077)	(0.009)	(0.048)			
Belgium	0.305	-0.179	0.144	-0.408	0.176	0.322	0.74	0.65	25
	(0.172)	(0.043)	(0.027)	(0.166)	(0.026)	(0.090)			
Canada	-0.148	0.094	0.199	-0.209	-0.048	-0.161	0.50	0.30	22
	(0.159)	(0.136)	(0.061)	(0.155)	(0.093)	(0.266)			
Denmark	0.030	0.024	0.080		-0.030	-0.004	0.23	0.03	25
	(0.062)	(0.038)	(0.028)		(0.024)	(0.054)			
Finland	-0.230	0.010	0.199			0.058	0.47	0.37	25
	(0.108)	(0.068)	(0.042)			(0.060)			
France	0.010	-0.098	0.055	-0.047	0.086	0.059	0.45	0.15	18
	(0.147)	(0.063)	(0.044)	(0.124)	(0.030)	(0.068)			
Germany, W.	-0.094	0.006	-0.030	-0.138	0.014	0.061	0.33	0.08	23
	(0.144)	(0.051)	(0.053)	(0.130)	(0.025)	(0.102)			
Greece	-0.130	0.098	0.121				0.21	0.10	25
	(0.083)	(0.076)	(0.070)						
Iceland	0.053	-0.004	-0.122				0.14	-0.06	17
	(0.137)	(0.121)	(0.075)						
Italy	0.005	0.013	0.093	-0.077	0.009	0.134	0.39	0.18	25

	(0.088)	(0.063)	(0.036)	(0.056)	(0.016)	(0.069)			
Japan	0.015	-0.037	0.119	0.113	0.035	0.016	0.25	0.00	25
	(0.097)	(0.090)	(0.054)	(0.167)	(0.027)	(0.067)			
Luxembourg	-0.032	-0.214	0.309				0.32	0.20	21
	(0.257)	(0.196)	(0.177)						
Netherlands	-0.017	-0.104	0.023	-0.098	0.074	-0.087	0.26	0.01	25
	(0.109)	(0.065)	(0.049)	(0.100)	(0.069)	(0.078)			
Norway	-0.282	-0.013	0.073		0.023	-0.274	0.31	0.13	25
	(0.154)	(0.108)	(0.107)		(0.025)	(0.168)			
Sweden	-0.099	-0.102	0.065		0.099	0.124	0.27	0.07	24
	(0.088)	(0.122)	(0.065)		(0.076)	(0.135)			
UK	-0.178	0.046	0.143	0.084	0.031	0.008	0.41	0.20	24
	(0.095)	(0.062)	(0.053)	(0.049)	(0.032)	(0.082)			
US	-0.223	0.179	0.006	0.037	-0.184		0.25	0.05	25
	(0.132)	(0.084)	(0.043)	(0.125)	(0.135)				

See notes to Table 6.

Table 9: **Optimal Domestic Equity Holdings for the Average Investor, Perfect Substitution between Traded and Nontraded Goods**

		Using Estimated Covariances			*Assuming Perfect Correlation*		
	Observed Sharpe Ratio	Autarky Sharpe Ratio	Optimal Equity Position	Hedge Portion	Autarky Sharpe Ratio	Optimal Equity Position	Hedge Portion
Australia	0.19	0.01	135.84	-8.83	0.08	87.02	-57.65
Austria	0.12	0.00	94.36	-3.44	0.06	51.42	-46.38
Belgium	0.34	-0.00	330.47	1.77	0.07	260.83	-67.87
Canada	0.22	0.00	316.07	-6.61	0.10	182.25	-140.44
France	0.22	0.02	187.09	-18.30	0.06	150.88	-54.51
Germany, W.	0.25	-0.02	283.72	20.89	0.08	178.72	-84.11
Italy	0.08	-0.00	46.83	0.69	0.07	6.81	-39.34
Japan	0.28	0.01	228.42	-11.72	0.08	174.03	-66.11
Netherlands	0.38	-0.02	408.98	16.89	0.05	336.46	-55.63
UK	0.27	0.01	156.03	-3.79	0.08	113.13	-46.68
US	0.29	-0.01	458.13	10.67	0.07	340.69	-106.77

Notes:

1. The Observed Sharpe Ratio is calculated as the average real return on domestic equity (Table 4) minus a riskless real return of 2.5 percent, divided by the standard deviation of returns on domestic equity (Table 4).

2. The Autarky Sharpe Ratio is calculated according to Proposition 2. It equals the product of the slope coefficient in a regression of output innovations on own-country equity returns and the standard deviation of own-country equity returns.

3. The Optimal Equity Position and the Hedge Portion are calculated according to Proposition 1. The calculations treat domestic equity as the only risky asset traded by the investor. The expected returns on equity and their standard deviations are set equal to sample values.

4. Results based on the "Estimated Covariances" rely on sample covariances between national output innovations on own-country equity returns. Results based on "Perfect Correlation" set the covariance so that national output innovations and domestic equity returns are perfectly correlated.

5. All investors are assumed to have a relative risk aversion level of 3. See the text for a description of how absolute risk aversion coefficients are calibrated.

Table 10: **Optimal Domestic Equity Holdings for the Average Investor, Additive Separability between Traded and Nontraded Goods**

		Using Estimated Covariances			*Assuming Perfect Correlation*		
	Observed Sharpe Ratio	Autarky Sharpe Ratio	Optimal Equity Position	Hedge Portion	Autarky Sharpe Ratio	Optimal Equity Position	Hedge Portion
Australia	0.20	0.01	150.33	-5.25	0.04	123.92	-31.66
Austria	0.16	0.00	118.75	-3.40	0.03	101.26	-20.89
Belgium	0.37	0.01	361.90	-5.76	0.04	332.21	-35.46
Canada	0.22	0.01	315.79	-9.71	0.05	249.24	-76.26
France	0.24	0.01	210.79	-8.73	0.03	194.65	-24.86
Germany, W.	0.27	-0.01	285.73	6.18	0.04	234.71	-44.85
Italy	0.09	-0.00	55.49	0.40	0.03	36.76	-18.33
Japan	0.28	0.01	230.66	-7.94	0.05	197.73	-40.87
Netherlands	0.41	-0.00	421.75	0.83	0.03	387.77	-33.16
UK	0.29	0.00	169.00	-1.37	0.04	149.11	-21.26
US	0.32	-0.01	504.02	14.96	0.03	437.64	-51.42

See notes to Table 10.

Table 11: **The Gains from Trade in Risky Financial Assets under Perfect Substitution between Traded and Nontraded Goods**

	Domestic assets only				*Marg. benefit of world assets*				*Total benefit of assets*			
	HB	HC	RP	Total	HB	HC	RP	Total	HB	HC	RP	Total
Australia	0.6	1.8	24.4	23.2	0.6	3.2	27.6	25.1	1.3	5.0	52.0	48.3
Austria	0.2	-5.9	69.0	75.0	0.4	9.6	91.5	82.4	0.6	3.7	160.5	157.5
Belgium	0.1	-2.3	80.4	82.8	0.9	10.8	66.6	56.7	1.1	8.5	147.0	139.5
Canada	1.5	-11.1	58.1	70.7	0.0	-0.9	48.8	49.7	1.5	-12.0	106.9	120.4
Denmark	0.0	0.0	0.0	0.0	0.2	3.3	29.5	26.4	0.2	3.3	29.5	26.4
Finland	0.0	0.0	0.0	0.0	4.4	4.0	32.6	33.0	4.4	4.0	32.6	33.0
France	0.3	6.0	33.4	27.8	0.4	-0.7	10.8	12.0	0.7	5.3	44.3	39.7
Germany, W.	0.4	-13.1	99.0	112.6	0.1	5.7	146.2	140.6	0.6	-7.4	245.2	253.2
Greece	0.0	0.0	0.0	0.0	0.2	5.9	38.7	33.0	0.2	5.9	38.7	33.0
Iceland	0.0	0.0	0.0	0.0	0.8	-18.0	132.2	150.9	0.8	-18.0	132.2	150.9
Italy	0.2	-0.9	4.7	5.8	0.4	-5.3	40.9	46.5	0.6	-6.2	45.6	52.4
Japan	0.2	4.3	52.1	48.0	0.2	-3.0	18.7	21.9	0.4	1.3	70.8	69.8
Luxembourg	0.0	0.0	0.0	0.0	1.9	-6.9	48.8	57.6	1.9	-6.9	48.8	57.6
Netherlands	0.3	-10.0	101.6	111.9	0.2	9.6	275.1	265.6	0.5	-0.4	376.7	377.5
Norway	0.0	0.0	0.0	0.0	0.5	-1.9	33.5	35.9	0.5	-1.9	33.5	35.9
Sweden	0.0	0.0	0.0	0.0	1.8	5.5	43.4	39.7	1.8	5.5	43.4	39.7
UK	0.1	2.5	48.5	46.1	0.7	5.7	11.1	6.1	0.8	8.2	59.6	52.2
US	0.1	-3.0	57.0	60.1	0.5	3.2	13.3	10.6	0.5	0.2	70.3	70.7

Notes: (1) HB is the benefits provided by the hedge portfolio. HC is the cost of the hedge portfolio. RP is the return to taking on market risk under the optimal portfolio. "Total" refers to the total welfare benefits of the optimal equity postion implied by the theory. (2) "Domestic Assets" refers to own-country equity and bond indexes. "Foreign Assets" refers to world equity and bond indexes, the commodity price index and the foreign exchange postion. (3) Assumptions: relative risk aversion of 3, riskless interest rate of 2.5 percent per year, mean and covariance matrix of asset returns set to sample values and the covariance between national output innovations and domestic equity returns set to sample values.

Table 12: **The Gains from Trade in Risky Financial Assets under Additive Separability between Traded and Nontraded Goods**

	Domestic assets only				*Marg. benefit of world assets*				*Total benefit of assets*			
	HB	HC	RP	Total	HB	HC	RP	Total	HB	HC	RP	Total
Australia	0.2	0.8	28.4	27.7	0.1	-0.8	28.4	29.4	0.3	0.0	56.8	57.1
Austria	0.1	-5.6	130.8	136.5	0.0	3.4	89.9	86.5	0.1	-2.2	220.7	223.0
Belgium	0.1	0.7	108.1	107.5	0.3	1.4	79.2	78.2	0.4	2.1	187.3	185.6
Canada	0.4	-4.4	55.6	60.4	0.1	-5.0	49.2	54.3	0.6	-9.4	104.7	114.7
Denmark	0.0	0.0	0.0	0.0	0.0	-0.0	32.3	32.3	0.0	-0.0	32.3	32.3
Finland	0.0	0.0	0.0	0.0	0.6	-4.4	38.0	43.0	0.6	-4.4	38.0	43.0
France	0.1	2.7	38.1	35.5	0.1	-0.7	11.9	12.6	0.2	2.0	49.9	48.1
Germany, W.	0.2	-9.2	132.6	142.0	0.2	5.7	152.9	147.4	0.3	-3.5	285.5	289.3
Greece	0.0	0.0	0.0	0.0	0.2	3.3	36.9	33.7	0.2	3.3	36.9	33.7
Iceland	0.0	0.0	0.0	0.0	0.0	-4.7	141.4	146.1	0.0	-4.7	141.4	146.1
Italy	0.1	-1.2	7.9	9.2	0.0	-1.5	45.7	47.2	0.2	-2.7	53.6	56.4
Japan	0.1	3.2	53.3	50.1	0.1	-2.0	18.2	20.3	0.1	1.2	71.5	70.4
Luxembourg	0.0	0.0	0.0	0.0	2.2	-12.2	46.8	61.1	2.2	-12.2	46.8	61.1
Netherlands	0.1	-2.7	128.3	131.0	0.0	0.8	284.5	283.7	0.1	-1.9	412.8	414.8
Norway	0.0	0.0	0.0	0.0	0.4	-1.1	33.0	34.5	0.4	-1.1	33.0	34.5
Sweden	0.0	0.0	0.0	0.0	0.2	-3.9	55.7	59.8	0.2	-3.9	55.7	59.8
UK	0.0	0.9	55.5	54.6	0.1	1.6	10.0	8.5	0.1	2.5	65.5	63.1
US	0.1	-5.1	73.7	78.9	0.0	-0.3	18.2	18.5	0.2	-5.4	91.8	97.4

See notes to Table 11.

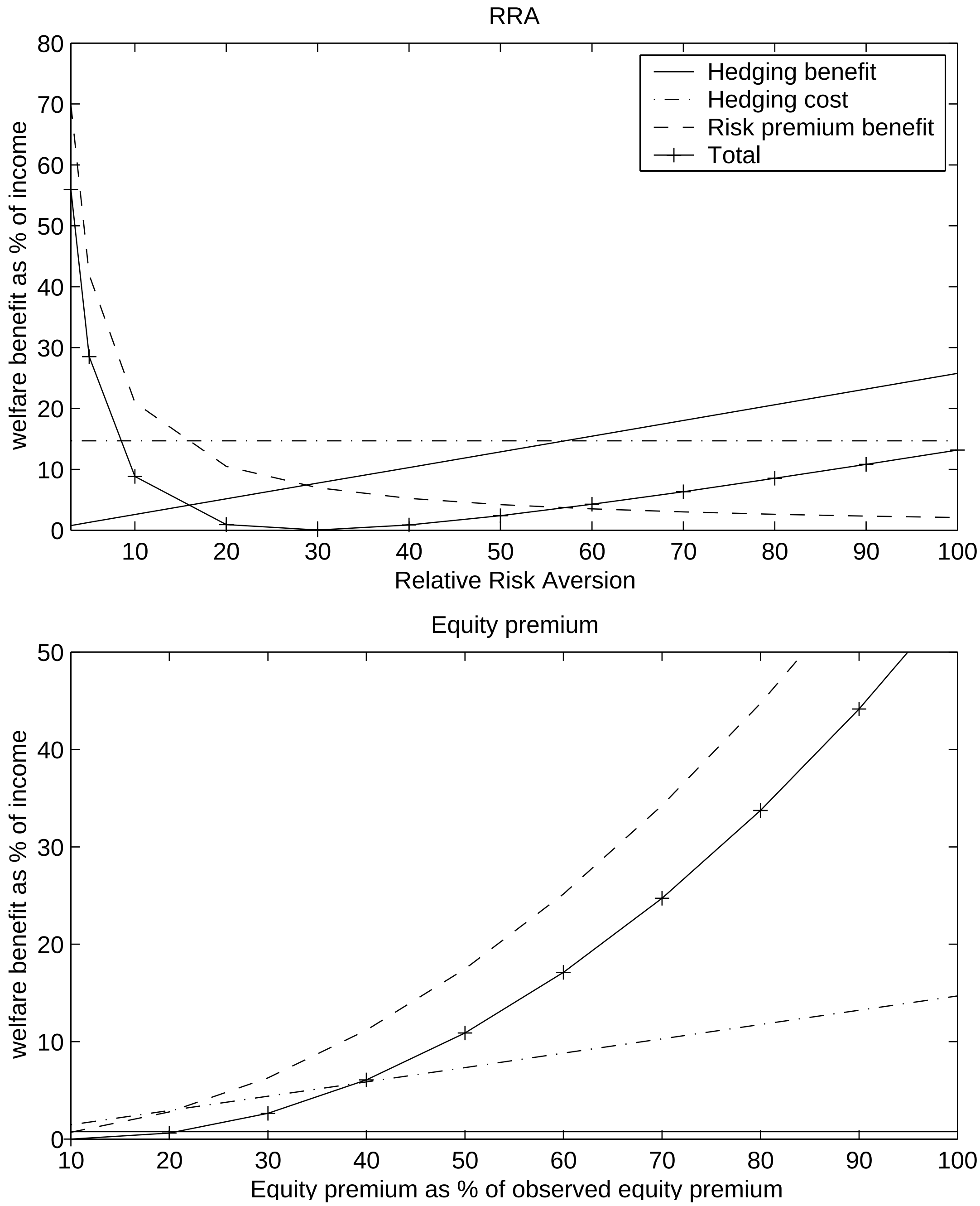

Figure 1: **How do the gains from trade vary with risk aversion and equity premia? Perfect Substitution between Traded and NonTraded Goods.** `int plot rra eprem trad.eps`

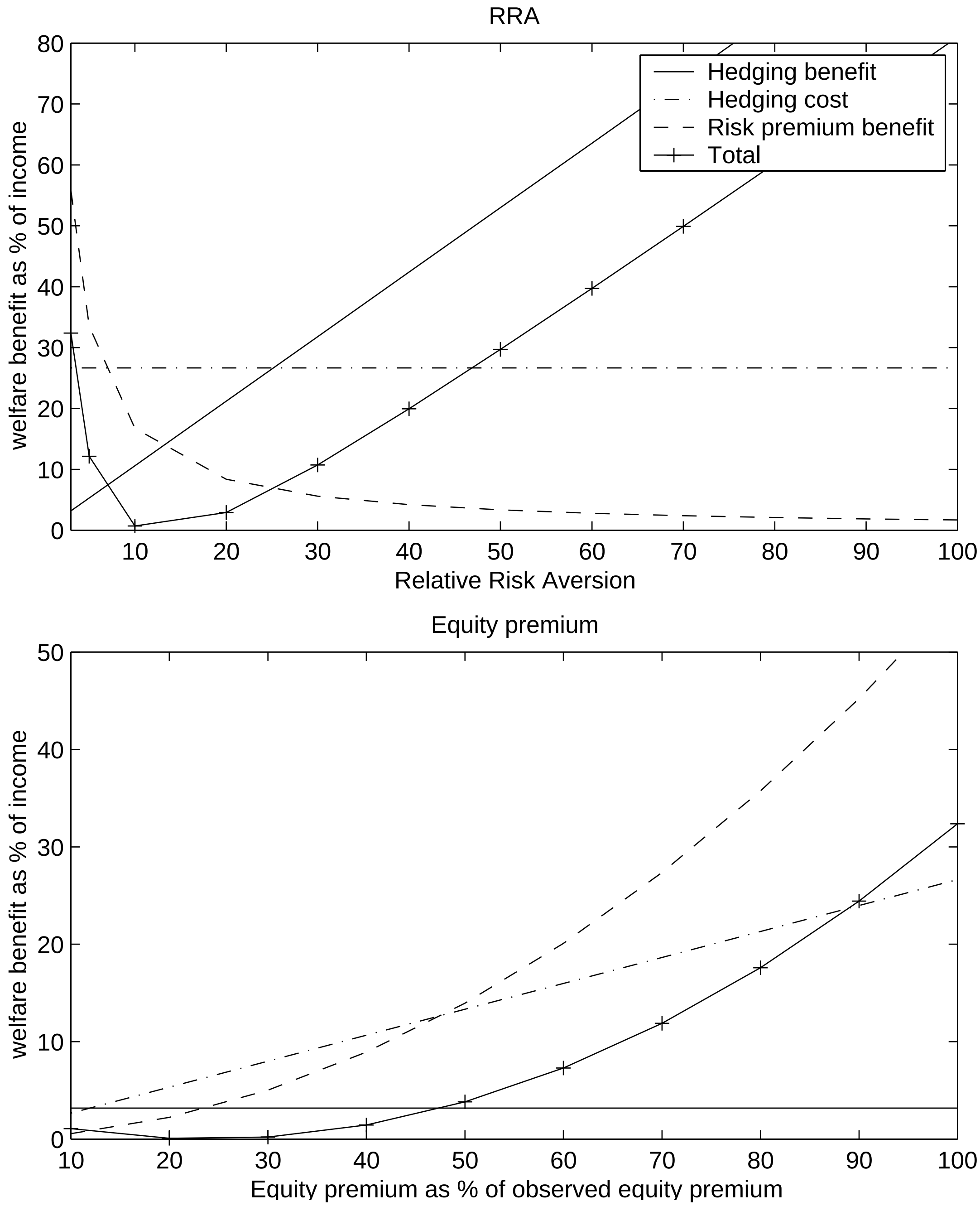

Figure 2: **How do the gains from trade vary with risk aversion and equity premia? Additive Separability between Traded and NonTraded Goods.**
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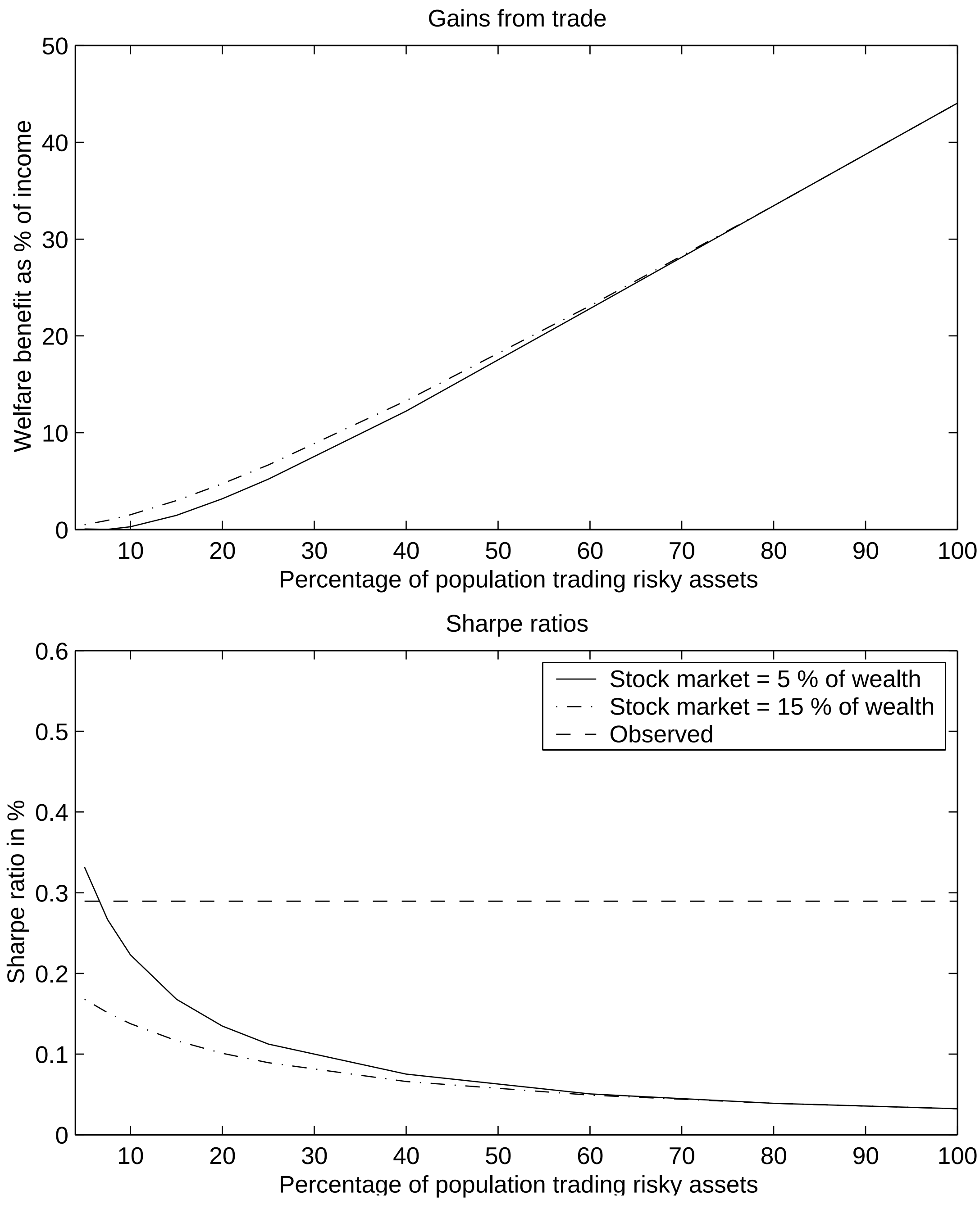

Figure 3: **Gains from Trade and the Sharpe Ratio with Limited Participation**