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Abstract

We examine the extent to which differences in international tax rates may account for the small correlations of per capita consumption fluctuations across countries. Theory implies a close relationship between relative consumption growth, and consumption and capital income tax rate differentials. We find strong empirical evidence for this relationship. Idiosyncratic output fluctuations account for the majority of cross country consumption growth variability, but trends in tax differentials are informative about the dynamic evolution of international risk sharing. In particular, adjusting for capital taxes reveals an intuitive positive relationship between financial connectedness and risk sharing that is absent in baseline measures.

Keywords: International risk sharing; business cycle accounting; taxes.

JEL Codes: F41, F44, H29.

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1 Introduction

A central theoretical prediction of the benchmark international business cycle (IBC) model is that risk sharing between countries should be substantial. Furthermore, this international risk sharing should manifest itself through equalization of consumption growth rates across countries. Empirically, though, consumption growth rates across countries are generally far from being equal. Within the context of the frictionless, complete markets benchmark, this lack of equalization amounts to a failure of international risk sharing to hold as predicted by the theory. In this paper, we use panel data on taxes, output, and consumption for a set of 15 OECD countries to address the following question: Do cross-country differences and fluctuations in taxes matter, and if so in what way, for understanding international risk sharing, or its failure?

We show that introducing taxes into the standard IBC framework of Backus et al. (1992) implies that international risk sharing no longer implies the equalization of consumption growth rates across countries. This is replaced by a monotonic relationship between consumption growth rates, and the levels and growth rates of taxes both within and across countries. We test these and other model-implied relationships for a panel of 15 OECD countries for the period 1951-2008 using tax data from McDaniel (2009) and consumption and working-age population (ages 15-64) data from the OECD.

We obtain two main results. First, from the perspective of a business cycle accounting framework (see, for example, Chari et al., 2007), the inclusion of taxes provides a clearer evaluation of how international risk sharing has evolved over time compared to a baseline case when taxes are not taken into account. In particular, accounting for taxes suggests that risk sharing has increased over time broadly in line with increases in financial integration. Yet, absent taxes, when brought to the data the baseline risk-sharing prediction from IBC models tends to suggest, unintuitively, no notable relationship between risk sharing and financial integration. Our second main result obtains from relating the tax-inclusive model's implications to traditional regression-based tests of international risk-sharing. In the data, there is a statistically and economically significant relationship between consumption growth rates and taxes. However, we find that taxes alone cannot explain the extent to which consumption growth rates are not equalized across countries. Hence, while taxes alone cannot explain the lack of consumption growth-rate equalization across countries, accounting for the role of taxes in IBC models is key towards assessing the correct degree of international risk sharing or lack thereof across time.

The main empirical background for our paper is summarized through table 1 in the Appendix (section 8). As shown in table 1, at yearly frequency, cross-country correlations between growth rates of per capita consumption vary from -0.05 to 0.8, with a mean of

0.42.[1] Within the context of the benchmark IBC model, this correlation-based evidence points toward a general lack of risk sharing, which is also present at quarterly frequency (see Backus et al., 1992; Chari et al., 2002, among many others). The related prediction that the growth rate of the marginal utility of consumption should not be influenced by country-specific risks is also rejected by the data (Lewis, 1996).

To build intuition about why taxes might help resolve these two empirical anomalies, it is instructive to consider the following stylized example. Consider the case of a multinational corporation "A" that is fully owned by the residents of a reference home country, but owns claims to dividend streams from partly owned subsidiaries all around the world. Theory suggests that A's diversified income stream contributes to equating the marginal utility growth of its shareholders with those of foreigners who own the remaining shares in A's foreign subsidiaries. However if there are taxes on repatriating capital income in the home country in some states of nature, A might find it optimal not to do so. So, optimal risk sharing might involve some variation in international relative consumption growth across those states. Risk sharing, as measured by data on relative international consumption growth, would suggest that risk sharing is incomplete if these capital taxes were not taken into account. Thus a natural question to ask is whether the omission of taxes in tests of risk sharing based on an IBC framework is a significant one.

We make two main contributions to the literature. The first is to derive a simple relationship between the rate of marginal utility growth across countries and a wedge formed by taxes on consumption and capital income. This monotone relationship is shown to be quite general and not dependent on the details of the model, just as in Chari et al. (2007). Intuitively, differences in consumption taxes affect the implicit relative prices of consumption across countries even in simple environments where the real exchange rate would otherwise be unity, while differences in asset income taxes create incentives to deviate from perfect insurance. Our second contribution is to relate the international business cycle accounting literature to traditional regression-based tests of international risk-sharing through an examination of this tax wedge. Our regression-based tests show that taxes are unlikely to provide an answer to the consumption correlation anomaly. The relationship between consumption and taxes predicted by the model is found to be statistically significant. But taxes, owing to their low variability at the yearly frequency, account for only a small fraction of the variance of consumption growth over time and across countries. Thus, the inclusion of taxes does not influence conclusions regarding the degree of consumption risk-sharing because the coefficients on idiosyncratic country risk remain largely unchanged with or without taxes. However, our business cycle accounting approach suggests that accounting for taxes is considerably important for understanding the extent to which risk sharing fails at any given

[1] Yearly data, which are taken from the OECD, are detailed later in the paper and span 1960 through 2010.

point in time, and how this has evolved over longer horizons. Again, this last point owes to the fact that when taxes are accounted for, international risk sharing need not imply the equalization of consumption growth rates.

The estimates presented in our paper of the effect of cross-country differences in tax growth on consumption growth differentials also shed light on three additional important issues. First, our results suggest that country-specific risks pertaining to taxes on labor income and investment expenditure are not shared in international financial markets. Second, our estimates contribute to the recent debate about the effectiveness of fiscal devaluations as a policy tool (Farhi et al., 2011). Third, our methodology lets us arrive at independent estimates of the coefficient of relative risk aversion, a crucial parameter in the calibration of business cycle models. These points are elaborated further in later sections.

The rest of the paper is organized as follows. Section 2 integrates taxes into a standard decentralized IBC model and derives key testable predictions relating consumption growth rates and tax growth rates. Section 3 describes the data we use. Section 4 uses a business cycle accounting exercise to map the long-term evolution of risk sharing. Then, Section 5 describes our regression-based methodology, presents results, and also considers a number of extensions and robustness checks. Section 6 relates our results to existing work. Finally, Section 7 concludes.

2 Theory

2.1 Risk Sharing and Taxes

In this section we augment a standard IBC model (see Backus et al. (1992)) to incorporate taxes on consumption expenditures, asset income, and labor income. Alternatively, the development in the present section can be viewed as extending the closed-economy taxation framework studied, among others, in Prescott (2004), to an otherwise standard IBC framework. Following the literature on international risk sharing, we assume that risk sharing is complete within any one country.

There are I countries in the world (indexed by i) and all countries produce the same tradable good.[2] In each country there exists a representative household. Country i's household has idiosyncratic discount rate β_i.[3] A household obtains utility from consumption of the final tradable good and disutility from work hours (labor is immobile across countries). For the moment, we leave the precise form of the utility function unspecified. A household

[2]It is possible to include the real exchange rate in the theory. We do not do so because the data on international prices, and hence real exchange rates, include the value added tax component of our consumption tax figure. Thus, including the real exchange rate would not allow us differentiate between endogenous real exchange fluctuations and fluctuations caused by changes in relative average consumption taxes.

[3]The precise source of heterogeneity across countries will not matter for our results as long as it is time invariant. We adopt differences in discount factors to keep the exposition simple.

observes the history of states up to the period t, s^t, and forms expectations on the future state s_{t+1}.[4]

In each country there is also a representative firm that is owned by the domestic household. Ownership of the domestic capital stock utilized by this firm yields income in the form of profits that are distributed to the domestic household each period. We assume that these equity claims in each country are held entirely by the residents of that country and cannot be traded. Households also earn labor income from working for the domestic firm. Furthermore, households trade in contingent bonds that are described below. Agents take the wage earned at the domestic firm, profits from owning the domestic capital stock, and asset payoffs as given, and choose a sequence of consumption, labor supply and asset holdings to maximize lifetime utility. The world price of consumption is normalized to unity.

In each country there is also a national government that imposes taxes. Thus, in solving their maximization problem a household also faces time-varying taxes. The government redistributes taxation proceeds to consumers in the form of a lump-sum transfer each period (both taxes and transfers are taken as given by a household in solving its optimization problem).

Asset markets are complete. There is free trade in one-period state-contingent real bonds that pay out in units of the common world final consumption good. As in Chari et al. (2002), we let $B_i(s_{t+1}|s^t)$ denote the holdings of such a bond purchased in period t after history s^t (with payoffs contingent on some particular state s_{t+1} at $t+1$) by the consumer in country i. One unit of this bond pays one unit of world final consumption in period $t+1$ if the particular state s_{t+1} occurs and 0 otherwise. $Q_i(s_{t+1}|s^t)$ is the price of this bond in units of the final good in period t and after history s^t.

Formally, the maximization problem of the representative Home agent is

$$\max_{\{\mathrm{C_i(s^t),H_i(s^t),B_i(s_{t+1}|s^t)}\}} \sum_{t=0}^{\infty}\sum_{s^t} {\beta_i}^t \pi(s^t) U(C_i(s^t), H_i(s^t)),$$

where $C_i(s^t)$ is consumption, $H_i(s^t)$ is labor hours, $B_i(s^t)$ is the total payoff from contingent bonds (described below), and $\pi(s^t)$ is the period 0 probability of any particular history s^t, subject to the sequence of budget constraints

$$\begin{aligned}(1+\tau_i^c(s^t))C_i(s^t) + \sum_{s_{t+1}\in\mathbb{S}} Q(s_{t+1}|s^t)B_i(s_{t+1}|s^t) &= (1-\tau_i^h(s^t))W_i(s^t)H_i(s^t) \\ &+ (1-\tau_i^k(s^t))(B_i(s^t)+\Pi_i(s^t)) + T_i(s^t),\end{aligned} \tag{2.1}$$

where $\tau_i^c(s^t)$ is the tax on consumption expenditures, $\tau_i^h(s^t)$ is the tax on labor income,

[4] A reminder of standard notation: at each time t, the economy is in state $s_t \in \mathbb{S}$, where $\mathbb{S}$ is the set of possible states of the world. The sequence of events from the start of time till date t is denoted by the history s^t.

$W_i(s^t)H_i(s^t)$, and $\tau_i^k(s^t)$ is the tax on asset income (defined as the sum of the total payoff from contingent bonds and profits $\Pi_i(s^t)$ from owning the domestic capital stock), and $T_i(s^t)$ is a lump sum transfer made by the government.[5] Note from the budget constraint that profits from physical capital and the income from contingent bonds are taxed at the same capital income tax rate. This is meant as a realistic simplification (further details are given later, when we describe the tax data that we use to operationalize the model).

2.2 Implications

For our purposes it is sufficient to focus on the first-order conditions pertaining to bonds.[6] The Euler equation for the holdings of the contingent bond in country i is given by

$$Q(s_t|s^{t-1}) = \beta_i \pi(s_t|s^{t-1}) \frac{U_{Ci}(s^{t-1}, s_t)}{U_{Ci}(s^{t-1})} \frac{(1+\tau_i^c(s^{t-1}))}{(1+\tau_i^c(s^t))}(1-\tau_i^k(s^t)) \quad \forall s^t. \tag{2.2}$$

Equation 2.2 implies a risk-sharing condition across countries i and j that will hold for each time t and history s^t. Equating the right hand side of these for any country pair i and j gives us, $\forall s^t$ and $i \neq j$,

$$\beta_i \frac{U_{Ci}(s^{t-1}, s_t)}{U_{Ci}(s^{t-1})} \frac{(1+\tau_i^c(s^{t-1}))}{(1+\tau_i^c(s^t))}(1-\tau_i^k(s^t)) = \beta_j \frac{U_{Cj}(s^{t-1}, s_t)}{U_{Cj}(s^{t-1})} \frac{(1+\tau_j^c(s^{t-1}))}{(1+\tau_j^c(s^t))}(1-\tau_j^k(s^t)). \tag{2.3}$$

2.2.1 Business Cycle Accounting: The Risk Sharing Wedge

From a business cycle accounting perspective, equation 2.3 can be written for countries i and j as a "risk-sharing wedge" that captures the extent to which the tax-inclusive model's risk-sharing condition fails to hold empirically. This risk-sharing wedge approach is akin to the business cycle accounting framework (see Chari et al., 2007) used in recent papers, such as Prescott (2004), Gali et al. (2007), Ohanian et al. (2008), McDaniel (2011), and Karabarbounis (2014b,a), to study the labor wedge (the extent to which the marginal rate of substitution of consumption for leisure differs from the marginal product of labor) across time. Taking the ratio of the left and right hand sides of equation 2.3, we define the "all tax inclusive" risk-sharing wedge as follows.

[5]We assume that profits are taxed at the capital income tax rate at the firm level and firms take this into account when making their optimal plans. Note that the household takes the after-tax profit $(1-\tau_i^k(s^t))\Pi_i(s^t)$ as given in its budget constraint. Thus the capital tax enters the household's problem only through its decision regarding holdings of financial assets, $B_i(s^t)$.

[6]The optimality conditions for labor choice and the firm's problem are not directly relevant to the derivation of the cross-country risk-sharing conditions we are interested in. We use these conditions later to explore investment and labor income taxes as additional sources of non-diversifiable risk.

Definition 1 *The risk-sharing wedge between country i and j at time t is*

$$\Gamma_{A,t}^{ij} \equiv \frac{\beta_i \frac{U_{Ci}(s^t)}{U_{Ci}(s^{t-1})} \frac{(1+\tau_i^c(s^{t-1}))}{(1+\tau_i^c(s^t))}(1-\tau_i^k(s^t))}{\beta_j \frac{U_{Cj}(s^t)}{U_{Cj}(s^{t-1})} \frac{(1+\tau_j^c(s^{t-1}))}{(1+\tau_j^c(s^t))}(1-\tau_j^k(s^t))}, \tag{2.4}$$

where the "A" in $\Gamma_{A,t}^{ij}$ implies that "all relevant taxes" are included in the statement of the risk-sharing wedge. If the theoretical risk-sharing condition implied by the model holds exactly at every point in time between countries i and j, then $\Gamma_{A,t}^{ij} = 1 \; \forall t$.

2.2.2 Impact of Taxes on Consumption Growth Rates

Equations 2.2 and 2.3 also let us derive two counterparts of the seminal result in Backus and Smith (1993) that linked consumption ratios to real exchange rates. Our first proposition relates consumption growth within a country to a number of domestic and international factors.

Proposition 1 *Under separable, isoelastic utility there is a monotone relationship between consumption growth, consumption tax growth, and capital income taxes in country i along any equilibrium path with a given schedule of tax rates.*

Proof: With identical isoelastic preferences of the form $U(C_i) = \frac{C_i^{1-\gamma}}{1-\gamma}$, equation 2.2 implies the following relationship for any country i:

$$\Delta C_{it} = \frac{1}{\gamma}\ln[\beta_i] - \frac{1}{\gamma}\ln[\frac{Q(s^t)}{\pi(s^t)}] - \frac{1}{\gamma}\Delta(1+\tau_{it}^c) + \frac{1}{\gamma}\ln(1-\tau_{it}^k) \tag{2.5}$$

where $\Delta A_{it} = \ln(A_{i,t}) - \ln(A_{i,t-1})$, is the growth rate for any variable A_t pertaining to country i. ■

Equation 2.5 implies that consumption growth in a country depends on a number of factors. The first is a time-invariant component that depends on its time discount rate. Ceteris paribus, a more patient country (higher β_i) enjoys higher consumption growth. The second component summarizes aggregate, undiversifiable risk that does not vary across countries but may vary across periods. The last two terms are idiosyncratic consumption and capital income taxes. Consumption growth over the previous period is lower with higher consumption and capital income taxes in period t. The intuition for this relationship is as follows: Higher growth in consumption taxes between periods $t-1$ and t increases the intertemporal relative price of consumption at time t, lowering consumption growth. At the same time, a higher capital income tax rate at time t lowers consumption growth between periods $t-1$ and t by reducing income available at time t. Both effects are proportional to the elasticity of intertemporal substitution, $\frac{1}{\gamma}$.

Our second proposition relates relative consumption growth across country pairs to relative tax rates.

Proposition 2 *Under separable, isoelastic utility there is a monotone relationship between the differences of consumption growth, consumption tax growth, and capital income taxes in countries i and j along any equilibrium path with a given schedule of tax rates.*

Proof: With identical isoelastic preferences of the form $U(C_i) = \frac{C_i^{1-\gamma}}{1-\gamma}$ in both countries, equation 2.3 implies the following relationship between consumption growth for any pair of countries i and j:

$$\Delta C_{it} - \Delta C_{jt} = \frac{1}{\gamma}\beta_{ij} - \frac{1}{\gamma}[\Delta(1+\tau_{it}^c) - \Delta(1+\tau_{jt}^c)] + \frac{1}{\gamma}[\ln(1-\tau_{it}^k) - \ln(1-\tau_{jt}^k)] \tag{2.6}$$

where $\beta_{ij} = \ln[\beta_i] - \ln[\beta_j]$ and $\Delta A_{it} = \ln(A_{i,t}) - \ln(A_{i,t-1})$ is the growth rate for any variable A_t pertaining to country i. ■

Equation 2.6 says that the country with relatively low consumption tax growth or capital tax level enjoys higher consumption growth. Intuitively, differences in consumption tax growth affect the implicit relative prices of consumption across countries, while differences in asset income taxes create further incentives to deviate from perfect correlation of consumption growth. Proposition 2 formalizes the intuition behind the example provided in the introduction. As in Proposition 1, the effects of both taxes are proportional to the elasticity of intertemporal substitution, $\frac{1}{\gamma}$.

2.2.3 Discussion

It is well known that if there are unobserved factors influencing the measured stochastic discount factor, or if there are sources of exogenous or endogenous fluctuations that are omitted when evaluating risk-sharing, one can be led astray in drawing conclusions about the degree of risk-sharing. Several such possible omissions and alternative sources of fluctuations have been explored in the literature. Exogenous preference shocks (Stockman and Tesar, 1995), the presence of non-traded goods in the consumption bundle (Backus and Smith, 1993), non-additivity of leisure and consumption in the utility function (Lewis, 1996), sticky prices (Chari et al., 2002), inflation differentials (Hoffmann, 2008), and the role of expectations (Engel and Rogers, 2009) are some prominent examples. As such, taxes should be seen as a potential source of omitted variation confounding any attempt to observe risk-sharing in the data.

Once taxes are accounted for, perfect international risk sharing need not imply equalization of consumption growth rates. In the context of the canonical model, that is, absent taxes, equation 2.4 implies that if there is perfect risk sharing then

$$\Gamma_{B,t}^{ij} \equiv \frac{\beta_i \frac{U_{C_i}(s^t)}{U_{C_i}(s^{t-1})}}{\beta_j \frac{U_{C_j}(s^t)}{U_{C_j}(s^{t-1})}} = 1 \tag{2.7}$$

holds, where the "B" in $\Gamma_{B,t}^{ij}$ implies that we are dealing with a "baseline" model statement of the risk-sharing wedge. Therefore, assuming isoelastic utility, to the extent that the tax-inclusive model is correct, then $\Gamma_{A,t}^{ij} = 1 \neq \Gamma_{B,t}^{ij}$ implies that perfect risk sharing between countries ($\Gamma_{A,t}^{ij} = 1$) is not necessarily inconsistent with the growth rate of consumption between these two countries being different ($\Gamma_{B,t}^{ij} \neq 1$). In other words, in contrast to the canonical model, the tax-inclusive model suggests that perfect risk-sharing between countries does not necessarily imply equalization of consumption growth rates between those countries. Furthermore, that taxes may matter for understanding the correct degree of risk sharing between countries does not mean that taxes need be the reason that consumption growth rates are not equalized between countries.

Accordingly, our analysis proceeds in two steps. First, we consider the impact that taxes have on gauging the degree of international risk sharing by examining how they influence, or not, the dynamic behavior of the risk-sharing wedge as implied by equation 2.4. Second, using regression-based tests, we examine the extent to which taxes affect, or not, differences in consumption growth rates between countries.

3 Data

We limit our analysis to 15 OECD countries for which extensive time series data on taxes (discussed below) is available: Austria, Australia, Belgium, Canada, Finland, France, Germany, Italy, Japan, Netherlands, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Furthermore, because time series data on taxes are only available at yearly frequency, our analysis is at that frequency as well. In particular, given limitations on the availability of taxes time series data our analysis spans the years 1960 through 2010 for all countries except Australia and Japan. For these two countries the analysis spans 1960 through 2008 per the availability of tax data.

We use data from various sources in order to operationalize the model. Publicly available cross-country data on consumption, output, and the working-age population (ages 15-64) are taken from the OECD.[7] In particular, the data on consumption and output is from the OECD database VPVOBARSA (this is the OECD acronym for data in volume estimates, fixed purchasing power parities, OECD reference year (2005), annual levels, seasonally adjusted in millions of US dollars). In our benchmark analysis, we normalize consumption and output

[7]Available at **stats.oecd.org**.

by each country's respective working age population.

Our country-specific consumption, labor, capital, and investment tax data are derived in McDaniel (2009), and are publicly available on her website.[8] These average tax rates are calculated using national accounts data and a methodology analogous to that used Mendoza et al. (1994) and Carey and Rabesona (2002).[9]

In broad terms, the consumption tax rate is derived as the ratio of government revenue collected from consumption to total taxable consumption expenditures (household final consumption expenditure net of revenue collected from taxes levied on consumption expenditure).

Similarly, the labor tax rate is the ratio of government revenue owing to labor income (the sum of social security taxes and household income taxes paid on labor) to total taxable labor income (the labor-share weighted difference between gross domestic product and taxes on production and imports minus subsidies).

The capital tax rate is the ratio of government revenue from taxing capital (the sum of total capital tax revenue collected from households, direct taxes on corporations, and the share of taxes on production and imports that represents property taxes paid by entities other than households) to capital taxable income (the capital-share weighted difference between gross domestic product and taxes on production and imports minus subsidies, net of gross operating surplus earned by the government). Adding gross operating surplus earned by the government back into the measure of capital taxable income delivers a measure of the sum of operating surplus earned by corporations, the capital share of operating surplus earned by private unincorporated enterprises, and operating surplus earned by the government.

Finally, the investment tax rate is calculated as the ratio of tax revenues stemming from consumption and investment net of subsidies and net of consumption expenditure taxes to pre-tax private investment expenditures (total investment less this ratio's numerator).[10]

As detailed below, another portion of our analysis also uses data from the Bank for International Settlements (BIS). In particular, for all countries in our sample we use locational data on the external positions of reporting banks vis-à-vis individual countries and vis-à-vis all sectors. These data are in millions of US dollars, and reveal the amount of banking financial claims of one country over another. We use these data in conjunction with the publicly available cross-country data on nominal GDP from the OECD database CPCARSA (this is the OECD acronym for millions of US dollars, current prices, current purchasing power parities, annual levels, seasonally adjusted) to construct bilateral indexes of financial

[8] At **www.caramcdaniel.com**.

[9] In representative agent contexts, Mendoza et al. (1994) suggest that average tax rates derived from national accounts can be useful to represent the marginal tax rates faced by representative agent. Several papers by Enrique Mendoza and his coauthors have utilized tax data in calibrated dynamic models of international tax competition (Mendoza and Tesar, 1998, 2005; Mendoza et al., 2013). Recent papers such as Karabarbounis (2014b) and Ragan (2013) have used the data from McDaniel (2009).

[10] See McDaniel (2009) for a more detailed description on the calculation of each tax rate.

integration for all possible pairwise alternatives involving the countries in our sample.

The BIS data is available publicly on their website, but only for a relatively short time horizon.[11] However, we are able to access confidential data from the BIS that allows us to create yearly indices of financial integration for a majority of each of the years 1978 through 2010 for all possible pairwise country combinations. A precise motivation for our index of bilateral financial integration is provided in a later section.

4 Evolution of Risk Sharing

As noted earlier, the risk-sharing wedge (defined in equation 2.4) captures the extent to which the tax-inclusive model's risk-sharing condition fails to hold. If this risk-sharing condition holds perfectly in all periods of time, then $\Gamma^{ij}_{A,t} = 1 \ \forall t$. We operationalize the wedge using isoelastic preferences of the form $U(C_i) = \frac{C_i^{1-\gamma}}{1-\gamma}$, the OECD consumption and output data VPVOBARSA normalized by the appropriate OECD measures of working-age population, and the simplifying assumption that $\beta_i = \beta_j \ \forall i, j$ pairs. We show results for $\gamma = 2$, which is the value that Backus et al. (1992), among many others, use in their benchmark calibration. In all cases, we take the United States as country j per the notation in equation 2.4. The choice of the United States as country j is in the spirit of standard IBC analysis, for instance Backus et al. (1992). In such analyses results are presented with the United States as the benchmark country that interacts with "the rest of the world" instead of results being presented for all possible pairwise interactions of countries in a data sample.

The dashed black line in Figure 1 plots the risk-sharing wedge for all countries assuming away all taxes. This is the baseline risk-sharing wedge, $\Gamma^{ij}_{B,t}$, that is analyzed by the current literature on international risk sharing. In all cases, this risk-sharing wedge generally oscillates about 1. This suggests that in level terms the baseline wedge derived from the canonical model's risk-sharing condition has been trendless while being subject to relatively short lived deviations (in some cases, though, of considerable magnitude) around unity. The solid blue line in Figure 1 plots the risk-sharing wedge with "consumption taxes only", $\Gamma^{ij}_{\mathrm{C},t}$, defined as:

$$\Gamma^{ij}_{\mathrm{C},t} \equiv \frac{\left(\frac{C_i(s^t)}{C_i(s^{t-1})}\right)^{-\gamma} \frac{(1+\tau^c_i(s^{t-1}))}{(1+\tau^c_i(s^t))}}{\left(\frac{C_j(s^t)}{C_j(s^{t-1})}\right)^{-\gamma} \frac{(1+\tau^c_j(s^{t-1}))}{(1+\tau^c_j(s^t))}}. \tag{4.1}$$

A similar conclusion is obtained once consumption taxes are included.

Figure 2 again plots the risk-sharing wedge (the solid black line), but now accounting for both capital and consumption taxes as implied by the complete theory leading to condition 2.4. As in Figure 1, we continue using $\gamma = 2$ and the United States as country j (per the notation in equation 2.4). The difference compared to the no-tax and consumption-tax-only

[11] At http://www.bis.org/statistics/bankstats.htm.

cases depicted in Figure 1 is stark. Indeed, inspection of Figure 2 shows that in all cases except Germany and Japan the tax-inclusive risk-sharing wedge broadly exhibits a trend decline across countries. In particular, over time risk-sharing wedges generally approach unity from above. This decline is consistent with the tax-inclusive risk-sharing condition implied by the theory generally starting to hold only in relatively recent years. More specifically, the results in Figure 2 suggest that risk sharing between the United States and other countries has slowly improved from 1960 through the late 2000s.

4.1 The Risk-Sharing Wedge and Overall Financial Openness

It is intuitive that greater financial liberalization might be associated with greater risk sharing, especially as the inclusion of capital taxes (Figure 2) is what makes the difference for observing trends in risk sharing. To address this intuition, Figure 2 also plots for each country its Chinn-Ito financial openness index (see Chinn and Ito, 2006, 2008) relative to that of the United States (the dashed green line). While this index is not available for all countries over our entire sample period, it is still illuminating to compare the behavior of the risk-sharing wedge with that of the financial openness index.

In line with intuition, inspection of Figure 2 suggests that the full tax-inclusive risk-sharing wedge is generally negatively correlated with the financial liberalization index over the long run. In contrast, absent taxes and, in particular, absent capital taxes (Figure 1) the risk-sharing condition would suggest that financial liberalization is largely irrelevant for the long-term evolution of risk sharing. It is important to note that the Chinn-Ito index is a de jure measure of restrictions on cross-border financial transactions compiled from the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER), and is not correlated with our tax series purely by construction.

The Chinn-Ito index is a measure of overall financial openness, but not of pairwise financial connectedness. In essence, then, what can be concluded from visual inspection Figure 2 is that at the same time that countries' overall financial openness has risen, risk sharing of all other countries in our sample with the United States has risen as implied by the behavior of the full risk-sharing wedge. In fact, although not shown for expositional simplicity, operationalizing the full risk-sharing wedge using other countries in our sample as country j (per the notation in equation 2.4) does not suggest, at least visually, nearly as much of a negative correlation between risk-sharing wedges and overall financial openness as does Figure 2. Thus, an important complementary question is whether, as seems intuitive, greater pairwise financial connectedness (as opposed to overall financial openness measure by the Chinn-Ito index) across countries is associated with a pairwise risk-sharing wedge that is closer to 1. In the following section, we address this question using a measure of bilateral financial integration between countries.

4.2 The Risk-Sharing Wedge and Pairwise Financial Integration

We use data from the BIS, described earlier, to construct our measure of bilateral *de-facto* financial connectedness. This measure, which we henceforth refer to as $\mathbb{F}_{ij,t}$, is equal to the sum of financial claims of banks resident in country i over country j ($f_{i\to j,t}$), and financial claims of banks resident in country j over country i ($f_{j\to i,t}$), divided by the sum of these countries' nominal GDP ($Y_{i,t}$ and $Y_{j,t}$):

$$\mathbb{F}_{ij,t} = \frac{f_{i\to j,t} + f_{j\to i,t}}{Y_{i,t} + Y_{j,t}}. \tag{4.2}$$

In line with the rest of the data used in our paper, this ratio is at yearly frequency. Furthermore, the fact that in currency terms this ratio is unitless allows us to use it within analysis involving real variables.

Two points about this financial connectedness measure are worth noting. First, the BIS data used in its construction utilizes the residence principle, which will tend to overstate the financial connectedness to other economies of financial centers such as Switzerland. Ideally, one would like to use consolidated data on the nationality (as opposed to residence) of the owning entity of these claims to assess questions of risk sharing. Unfortunately, the BIS consolidated data is very limited in its time span. The second caveat has to do with looking only at banking claims while excluding portfolio investment. Again, our choice is motivated by data availability. The Consolidated Portfolio Investment Survey conducted by the International Monetary Fund provides information on bilateral portfolio holdings, but only since 2001. Given these data limitations, $\mathbb{F}_{ij,t}$ provides a bird's eye view of bilateral financial linkages between the economies in our sample over the period 1978-2010.

We define three counterparts of the extent to which the risk sharing wedge deviates from the perfect risk sharing value of unity, all in absolute values: the baseline deviation without any taxes ($\mathbb{G}^{ij}_{\mathrm{B},t}$, that is, the counterpart of the baseline statement of the wedge from earlier expressed as an absolute deviation from unity), the deviation after accounting for consumption taxes ($\mathbb{G}^{ij}_{\mathrm{C},t}$, that is, the consumption tax inclusive statement of the wedge form earlier expressed as an absolute deviation from unity), and the all tax inclusive deviation ($\mathbb{G}^{ij}_{\mathrm{A},t}$, that is, the all tax inclusive statement of the wedge form earlier expressed as an absolute deviation from unity). As before, these are operationalized using $U(C_i) = \frac{C_i^{1-\gamma}}{1-\gamma}$, with $\gamma = 2$. These absolute deviations are, respectively,

$$\mathbb{G}^{ij}_{\mathrm{B},t} \equiv |\, \Gamma^{ij}_{\mathrm{B},t} - 1 \,| \tag{4.3}$$
$$\mathbb{G}^{ij}_{\mathrm{A},t} \equiv |\, \Gamma^{ij}_{\mathrm{C},t} - 1 \,| \tag{4.4}$$
$$\mathbb{G}^{ij}_{\mathrm{A},t} \equiv |\, \Gamma^{ij}_{\mathrm{A},t} - 1 \,|. \tag{4.5}$$

To test the association of these bilateral deviations with bilateral financial connectedness, we estimate a dynamic panel regression of the following form

$$\mathbb{G}_{\mathrm{k},t}^{ij} = \rho \mathbb{G}_{\mathrm{k},t-1}^{ij} + \varphi \mathbb{F}_{ij,t} + \epsilon_{ij,t}, \tag{4.6}$$

for each deviation $k = B, C, A$. The error term $\epsilon_{ij,t}$ is assumed to have the following structure

$$\epsilon_{ij,t} = \alpha_t + \alpha_{ij} + \varepsilon_{ij,t}, \tag{4.7}$$

where α_t and α_{ij} are time and country-pair fixed effects respectively, and $\varepsilon_{ij,t}$ is an idiosyncratic shock with zero mean. We estimate the regression 4.6 for our panel of 105 unique country pairs over the period 1978-2010 (subject to some gaps in the data) using Ordinary Least Squares (without the fixed effects), with country pair and time fixed effects (Least Square Dummy Variables, LSDV), and difference GMM (Arellano and Bond, 1991) as a robustness check. Note that since the time dimension of our data is large ($T = 33$ years), we expect our LSDV estimation to perform reasonably well.[12]

Our hypothesis, motivated by Figures 1 and 2, is that higher values of the financial connectedness index should be associated with smaller absolute deviations from unity of all the wedges (that is, the point estimates of φ should be negative). However, to the extent that taxes matter for assessing the correct degree of risk sharing, the strength of this relationship should be strongest for $\mathbb{G}_{\mathrm{A},t}^{ij}$, and weakest for $\mathbb{G}_{\mathrm{B},t}^{ij}$, with $\mathbb{G}_{\mathrm{C},t}^{ij}$ lying in between (in between, of course, to the extent that consumption taxes do matter at least somewhat for the correct assessment of bilateral risk sharing, which was not entirely obvious from visual inspection of Figure 1). Thus we expect the coefficient φ for the baseline and consumption tax adjusted wedges to be less statistically significant than that on the all-tax adjusted wedge.

Our estimation results are reported in Table 2 in three panels. Panels I, II and III show the results for the baseline wedge ($\mathbb{G}_{\mathrm{B},t}^{ij}$), the consumption tax adjusted wedge ($\mathbb{G}_{\mathrm{C},t}^{ij}$), and the all tax adjusted wedge ($\mathbb{G}_{\mathrm{A},t}^{ij}$). The results are consistent with our hypotheses. In all three cases – naive OLS, LSDV with country pair and time fixed effects, and difference GMM – the coefficient on $\mathbb{F}_{ij,t}$ is numerically the largest for Panel III, and smallest for Panel I. Likewise, the coefficient on $\mathbb{F}_{ij,t}$ is most significant statistically in Panel III, and insignificant in Panel I. Thus, adjusting for capital taxes (as in $\mathbb{G}_{\mathrm{A},t}^{ij}$) reveals an intuitive positive relationship between financial connectedness and risk sharing that is smaller (in the case of $\mathbb{G}_{\mathrm{C},t}^{ij}$) or statistically absent (in the case of $\mathbb{G}_{\mathrm{B},t}^{ij}$) for measures of risk sharing that do not make this adjustment.

Of note, the link between financial openness and risk sharing has been explored by papers such as Kose et al. (2003, 2009) and Bengui et al. (2013). As such, understanding the precise

[12] Judson and Owen (1999) find using Monte Carlo methods that LSDV performs well for unbalanced panels with $T \geq 30$.

mechanism that links financial openness and risk sharing is beyond the scope of the present paper. Instead, our focus is on the risk-sharing implications of taxes themselves. Having established the relevance of taxes for revealing the trend behavior of the risk-sharing wedge, the next relevant issue is understanding the extent to which taxes themselves affect risk sharing. We turn to this issue the next section.

5 Taxes and Consumption Growth

Propositions 1 and 2 (Section 2) imply a monotonic relationship between consumption growth rates and taxes. Specifically, consumption growth both within a country and relative to another country is predicted to be proportional to the growth in consumption taxes and the logarithm of the level of capital taxes (both within a country and in relative terms). In this section, we investigate whether this structural relationship exists in the data, and if it affects regression-based tests of risk sharing.[13] Henceforth, all consumption and output data used in the analysis corresponds to the VPVOBARSA series unless noted otherwise.

5.1 Testing Propositions 1 and 2

We use the expressions in Propositions 1 and 2 (equations 2.5 and 2.6) that relate consumption growth to taxes to derive two alternative regression-based tests following Lewis (1996). Both of these regression tests exploit the idea that the asset Euler equations as well as the risk-sharing conditions between country pairs place restrictions on the estimated coefficients in a regression of country i's consumption growth, or their difference, on idiosyncratic country variables.[14] Thus, changes in the volatility of output or the precise decomposition of output risk into permanent and transitory components (see Imbs, 2006; Artis and Hoffmann, 2008) are not critical for our main result.

Replacing the state notation with a subscripted t and allowing for an unobserved preference shock b_i in country i, so that utility for consumption in country i is $U(C_i) = b_i \frac{C_i^{1-\gamma}}{1-\gamma}$,

[13] The approach of most papers in this literature can be thought of in the following empirical framework. Consider the canonical regression based test of risk sharing, which takes the form $\Delta C_{it} = \alpha + \psi X_{it} + \epsilon_{it}$. ΔC_{it} denotes the growth rate of consumption in country i and X_{it} is a country-specific idiosyncratic variable, usually the difference between country i and a measure of world GDP growth. Theory suggests that estimates of ψ should be close to zero since idiosyncratic risks should not influence consumption when risk sharing is perfect. Unobservable shocks to preferences or omitted variables arising from model misspecification will enter into the error term ϵ_{it}. If these factors are correlated with our choice of idiosyncratic variable X_{it}, then biased and inconsistent estimates of ψ will obtain. This happens when, for example, when both output and consumption are influenced by labor inputs due to non-additive preferences, the growth in the real exchange rate is correlated with GDP growth, or when the measurement errors in consumption and GDP are correlated.

[14] See Flood et al. (2012) for a discussion on necessary versus necessary and sufficient conditions for risk-sharing.

equation 2.5 can be rewritten as

$$\Delta C_{it} = \alpha_i + \alpha_t + \theta_1 \Delta(1+\tau^c_{it}) + \theta_2 \ln(1-\tau^k_{it}) + \psi X_{it} + \epsilon_{it} \tag{5.1}$$

where $\epsilon_{it} = \frac{1}{\gamma}\Delta b_{it} + \epsilon'_{it}$ is a composite error term (as before let $\Delta A_{it} = \ln(A_{i,t}) - \ln(A_{i,t-1})$ denote the growth rate for any variable A_t pertaining to country i). The term α_i, which corresponds to the time discount rate of country i, subsumes all time-invariant country characteristics. The term α_t, which depends on the asset price $Q(s^t)$ and hence aggregate world consumption at time t, can be interpreted as a time fixed effect in a country-year panel regression. X_{it} is a country i specific idiosyncratic variable. The economic interpretation of regression 5.1 is that the consumption of an individual country depends on aggregate world consumption (which is equal to aggregate world output) but not on idiosyncratic country variables. The implication is that $\psi = 0$ for any time varying idiosyncratic country i variable X_{it} not appearing directly in the Euler equation.[15]

Similarly, equation 2.6 can be rewritten as:

$$\begin{aligned}\Delta C_{it} - \Delta C_{jt} = \alpha_{ij} + \theta'_1[\Delta(1+\tau^c_{it}) - \Delta(1+\tau^c_{jt})] + \theta'_2[\ln(1-\tau^k_{it}) \\ -\ln(1-\tau^k_{jt})] + \psi[X_{it} - X_{jt}] + \epsilon_{ij,t},\end{aligned} \tag{5.2}$$

where α_{ij} is a country pair fixed effect, and $\epsilon_{ij,t} = \frac{1}{\gamma}[\Delta b_{it} - \Delta b_{jt}] + \epsilon'_{ij,t}$ is a composite error term. Perfect risk-sharing then implies $\psi = 0$.[16]

We take logarithms of the yearly series for consumption and gross consumption tax rates and time-difference to construct the data for estimating regression 5.1 and 5.2. The capital tax rate is used in its logarithms without taking its time difference, corresponding to the derived structural equations.[17] The idiosyncratic country variable X_{it} in our benchmark regressions is per capita GDP growth in country i between periods $t-1$ and t. Note that the coefficient estimates on our variables of interest in both our regressions are identical if we use deviation of national per capita GDP growth from world per capita GDP growth. This is due to the time fixed effect in regression 5.1 (which absorbs world GDP growth in period t) and the country differencing of contemporaneous variables in regression 5.2 (where world GDP growth cancels out).

[15]Under the null of our model, $\alpha_i = \frac{1}{\gamma}\ln[\beta_i]$, $\alpha_t = -\frac{1}{\gamma}\ln[\frac{Q(s^t)}{\pi(s^t)}]$, $\theta_1 = -\frac{1}{\gamma}$, and $\theta_2 = \frac{1}{\gamma}$.

[16]Under the null of our model $\alpha_{ij} = \frac{1}{\gamma}\beta_{ij} = \ln[\beta_i] - \ln[\beta_j]$, $\theta'_1 = -\frac{1}{\gamma}$, and $\theta'_2 = \frac{1}{\gamma}$.

[17]We perform panel unit root tests for all the series, which are found to be stationary with the exception of the capital tax rate which enters 5.1 in its logarithms without differencing. Thus the estimated coefficient on capital taxes should be interpreted with caution in the estimation of regression 5.1. However the difference of capital taxes across a country pair, which enters regression 5.2 is stationary.

5.2 Benchmark Regression Results

The first three columns (labelled "No Tax", "With τ^{c}" and "With τ^{c}, τ^{k}") of tables 3 and 4 in the Appendix (section 8) summarize the results of the benchmark regressions derived from Propositions 1 and 2. The result in column 4 (labelled "With $\tau^{c}, \tau^{k}, \tau^{x}, \tau^{h}$" are discussed in a later section. In the following sentences "relative" refers to the average country i relative to the United States.[18]

Both Propositions 1 and 2 are supported by the data. First, the coefficient on consumption growth and relative consumption growth have the sign predicted by the expressions in Propositions 1 and 2: an increase in domestic consumption tax growth is associated with lower consumption growth in table 1; the same is true for relative quantities in table 4. While the log-level of capital taxes has the wrong sign in table 3, it is not statistically significant. It has the correct sign in table 4: an increase in relative capital income tax growth reduces relative consumption growth.

The magnitude of the estimated coefficients in the benchmark regressions are also consistent with the theory. Note that a 10 percentage point increase in the growth rate of gross consumption taxes in country i is roughly associated with a 1.6 percentage point decline in the consumption growth rate of country i (table 3 columns 2 and 3). The value of the coefficient of relative risk aversion (γ) implied by these estimates (recall that the coefficient on consumption tax growth is $-\frac{1}{\gamma}$ under the null of the model) is approximately 6.3. The estimates of the effect of relative changes in consumption taxes in table 4 implies a value of γ of 3.9. Both these values are at the upper end of the range of γ used in the IBC literature. For example Backus et al. (1992) use a value of γ equals 2 in their benchmark calibration whereas Chari et al. (2002) use a value of γ equal to 6 in order to generate volatile real exchange rates. At the same time these are lower than existing macro estimates based on asset prices (Mehra and Prescott, 1985). The inclusion of other taxes in the regression, which we explore in a later section, leads to an estimated γ between 1.9 and 2.8.

Our estimates of γ fall well within the range of measures for the coefficient of relative risk aversion that are derived from responses to changes in tax rates. Gruber (2006), using data from the Consumer Expenditure Survey on non-durable consumption, estimates the impact of changes in the after-tax interest rate that are driven by exogenous changes in the tax rate and finds the intertemporal elasticity of substitution to be around 2. Under certain assumptions for utility, this implies a coefficient of relative risk aversion of around 0.5. By the author's own admission, however, this value is small and at odds with much of previous literature. A more recent study by Cashin (2013), estimates an elasticity of intertemporal substitution of around 0.13 in response to pre-announced changes to the value-added tax in Japan. This would imply a much larger coefficient of relative risk aversion under particular

[18] Since $\mathrm{E}[\Delta C_{it} - \Delta C_{jt}] = \mathrm{E}[\Delta C_{it} - \Delta C_{kt}] + \mathrm{E}[\Delta C_{kt} - \Delta C_{jt}]$ we do not lose any information by using only the United States as country j.

function forms for utility. In particular, for our specification of utility, the tax-based estimates in Cashin (2013) imply a γ of around 7.7.

Compared to the effects of per capita GDP growth, the effects of tax growth rate changes are small in terms of magnitude. For example, table 1 shows that a one standard deviation increase in per capita GDP growth is associated with a 0.7 standard deviation increase in per capita consumption growth. In comparison, a one standard deviation increase in $\Delta(1+\tau^c)$ is associated with a 0.06 standard deviation decline in per capita consumption growth. A one standard deviation increase in relative per capita GDP growth is roughly consistent with a 0.75 standard deviation increase in relative per capita consumption growth. In comparison, one standard deviation increase in relative $\Delta(1+\tau^c)$ is associated with a 0.09 standard deviation decline in per capita consumption growth. These effects are roughly twice as large in the specification with investment and labor taxes included, which we motivate and discuss in section 5.3.1. These results are not surprising in light of the low variance of the yearly tax rate growth series compared to that of per capita consumption and GDP growth.

The overall picture that emerges from these two tables (especially column 4, which we discuss shortly) is that the relationship between taxes and consumption predicted by the theory holds in the data. However, owing to the low sample variability of the tax series, taxes do not explain much of the variance in consumption both within and across countries. In addition, due to their low covariance with GDP, the inclusion of taxes in regressions does not have a large influence on the coefficient on GDP growth. Thus, in econometric terms, taxes are unlikely to be an important source of omitted variable bias in regression-based tests that use GDP growth as a measure of idiosyncratic country risk.

As a final note, our results in this section can also be seen in the context of the puzzles that emerge from the application of the consumption capital asset pricing model (CCAPM) to macroeconomic data (see Mehra and Prescott, 1985; Brandt et al., 2006, for example). Taking variances of both sides of equation 2.6, we have

$$\mathrm{Var}\Big(\Delta C_{it} - \Delta C_{jt}\Big) = \frac{1}{\gamma^2}\mathrm{Var}\Big([\Delta(1+\tau^c_{it}) - \Delta(1+\tau^c_{jt})] - \frac{1}{\gamma}[\ln(1-\tau^k_{it}) - \ln(1-\tau^k_{jt})]\Big). \quad (5.3)$$

We can back out the value of γ that lets us match the volatility of the left and right hand sides of equation . The cross sectional average (over our 105 country pairs) of the ratio of the sample time series variances (over 1978-2010) gives a value of $\gamma = 0.1528$. Thus an alternative way to frame our findings is that given the volatility of taxes, the volatility of consumption in the data is too high. In other words, we need an unreasonably low value of the coefficient of relative risk aversion, or equivalently, an unreasonably high degree of intertemporal substitutability of consumption, to reconcile the joint empirical series on consumption and taxes in a CCAPM framework.

5.3 Extensions and Robustness

In this section, we extend our regression tests to include taxes on investment expenditures and labor income. We also consider non-separable preferences, higher moments of consumption and tax growth, and alternative sources of data. Finally, we discuss the effects of an alternative asset market structure.

5.3.1 Investment and Labor Income Taxes

Intuitively, fluctuations in labor income and investment expenditure taxes may present additional sources of undiversifiable risk when asset markets are incomplete. Thus, they might affect consumption growth both within and across countries. In this subsection, we log-linearize the investment and labor supply optimality conditions of the model to show the effect of these two taxes on consumption growth.

Consider the problem of the representative firm. Profits or dividends, $\Pi_i(s^t)$ are defined by

$$\Pi_i(s^t) = Y_i(s^t) - W_i(s^t)H_i(s^t) - (1+\tau_i^x(s^t))\{K_i(s^t) - (1-\delta)K_i(s^{t-1})\}$$

where $\tau_i^x(s^t)$ is a possibly time- and state- varying tax on capital investment expenditures by the firm in country i. The firm's profits are taxed at the capital income tax rate $\tau_i^k(s^t)$, which can also be vary over time and states of nature. The firm in country i enters period t with capital stock $K_i(s^{t-1})$, which is used in production at time t (and is hence K_t when the state-dependent notation is dropped below), and chooses $\{X_i(s^t), \Pi_i(s^t), H_i(s^t)\}_0^\infty$ – investment, dividend payments, and labor demand – to maximize discounted after-tax profits. The objective function of the firm is

$$\max_{\{\mathrm{X_i(s^t),\Pi_i(s^t),H_i(s^t)}\}} \sum_{t=0}^{\infty}\sum_{s^t} \beta_i(s^t)(1-\tau_i^k(s^t))\Pi_i(s^t)$$

where $\beta_i(s^t)$ is the stochastic discount factor used to price dividends. $\beta_i(s^t)$ is assumed to be equal to

$$\beta_i(s^t) \equiv \pi(s^t)\beta_i^t \frac{U'(C_i(s^t))}{U'(C_i(s^0))}. \tag{5.4}$$

because we make the simplifying assumption that domestic capital is only owned by domestic residents. The domestic firm observes the history of states up to the period t, s^t, and forms expectations on the future state s_{t+1}. Suppressing the state dependent notation and country subscript, the first order necessary condition for maximization with respect to investment is

$$\mathbb{E}_t\left[\frac{\beta_{t+1}}{\beta_t}\frac{1}{(1-\tau_t^k)(1+\tau_t^x)}\Big\{(1-\tau_{t+1}^k)\Big(\frac{\theta Y_{t+1}}{K_{t+1}} + (1-\delta)(1+\tau_{t+1}^x)\Big)\Big\}\right] = 1, \tag{5.5}$$

where $\mathbb{E}_t$ denotes expectation conditional on information at time t. Log-linearizing the above condition with iso-elastic utility while ignoring the expectations operator we get

$$-\gamma(\hat{C}_{t+1}-\hat{C}_t)-(\widehat{1+\tau_t^x})-(\widehat{1-\tau_t^k})+\hat{R}_{t+1}\approx 0, \tag{5.6}$$

where $R_{t+1}=(1-\tau_{t+1}^k)[\frac{\theta Y_{t+1}}{K_{t+1}}+(1-\delta)(1+\tau_{t+1}^x)]=(1-\tau_{t+1}^k)[\mathrm{MPK_{t+1}}+(1-\delta)(1+\tau_{t+1}^x)]$ is the gross rate of after-tax return paid on physical capital (inclusive of the capital income and investment expenditure taxes) between periods t and $t+1$ (MPK stands for the marginal product of capital).[19] From equation 5.6, consumption growth at time t can be written as

$$\hat{C}_t\approx\frac{1}{\gamma}(\widehat{1+\tau_t^x})+\frac{1}{\gamma}(\widehat{1-\tau_t^k})+\hat{C}_{t+1}-\frac{1}{\gamma}\hat{R}_{t+1}. \tag{5.7}$$

Thus, higher growth in the investment tax rate leads to higher consumption growth at time t. Ceteris paribus, a higher investment tax rate makes physical investment today relatively unattractive. Firms respond by cutting investment and increasing dividends. This leads to higher consumption growth between periods $t-1$ and t. Conversely, a lower capital income tax rate at time t (translating into higher $(\widehat{1-\tau_t^k})$) encourages disbursement of dividends, and increases consumption growth at time t.

Now consider the condition for hours worked by households,

$$\begin{aligned}\frac{(1-\tau_i^h(s^t))}{(1+\tau_i^c(s^t))}U_{Ci}(s^t)W_i(s^t)+U_{Hi}(s^t)&\geq 0\\ &=0 \quad \text{if } H_i(s^t)>0.\end{aligned} \tag{5.8}$$

Utility in the benchmark case is assumed to be $U(C,H)=\frac{C^{1-\gamma}}{1-\gamma}+\frac{\mu H^{1+\psi}}{1+\psi}$, where γ is the coefficient of relative risk aversion, $\frac{1}{\psi}$ is the Frisch labor supply elasticity, and $\mu<0$. Log-linearizing the first order condition for the case when $H_i(s^t)>0$ while suppressing the state-dependent notation and the country subscript i, we get

$$\hat{C}_t\approx\frac{1}{\gamma}(\widehat{1-\tau_t^h})-\frac{1}{\gamma}(\widehat{1+\tau_t^c})+\frac{1}{\gamma}\hat{W}_t-\frac{\psi}{\gamma}\hat{H}_t. \tag{5.9}$$

Ceteris paribus, higher $(\widehat{1-\tau_t^h})$ caused by lower growth of the labor income tax increases consumption growth between periods $t-1$ and t.

Following equations 5.7 and 5.9, we include the growth rates of $(1+\tau^x)$, $(1-\tau^k)$, and $(1-\tau^h)$ as additional regressors in our benchmark specifications, regressions 5.1 and 5.2. The results are reported in column 4 of tables 3 and 4. In both tables the coefficients have the

[19] Defining R_{t+1} in terms of returns after deduction of the capital income tax simplifies our log-linearized expressions. Defining R_{t+1} as pre-tax adds an additional $(\widehat{1-\tau_{t+1}^k})$ to our regressors and does not change our results substantively.

expected sign. The variables of interest in column 4 of table 3 are $\Delta(1+\tau^x)$ and $\Delta(1-\tau^h)$. An increase in the growth rate of the domestic investment tax is associated with an increase in the domestic consumption growth rate. An increase in the growth rate of $(1-\tau^h)$ caused by lower domestic labor income taxes is associated with an increase in domestic consumption growth. The quantitative effects of tax growth rate changes are small compared to the effects of per capita GDP growth: A one standard deviation increase in per capita GDP growth is associated with a 0.83 standard deviation increase in per capita consumption growth. In comparison, one standard deviation increases in $\Delta(1+\tau^x)$ and $\Delta(1-\tau^h)$ are associated with 0.08 and 0.06 standard deviation increases in per capita consumption growth, respectively.

Table 4 is estimated in country differences. As shown by the table, an increase in the growth rate of the investment tax of country i relative to country j is associated with an increase in the relative consumption growth rate. An increase in the relative growth rate of $(1-\tau^h)$ caused by lower relative labor income taxes is associated with an increase in relative consumption growth. The quantitative effects of tax growth rate changes are somewhat larger than in table 3: A one standard deviation increase in relative per capita GDP growth is associated with a 0.7 standard deviation increase in relative per capita consumption growth. In comparison, one standard deviation increases in relative $\Delta(1+\tau^x)$ and $\Delta(1-\tau^h)$ are associated with 0.12 and 0.08 standard deviation increases in relative consumption growth, respectively.

The last notable point about column 4 of tables 3 and 4 is that the coefficient on consumption tax growth in both tables is roughly twice as large as in columns 1 and 2. In table 4 for example, a one standard deviation increase in relative per capita GDP growth is associated with a 0.75 standard deviation increase in relative per capita consumption growth. In comparison, a one standard deviation increase in relative $\Delta(1+\tau^c)$ is associated with a 0.19 standard deviation decline in relative consumption growth.

These results shed light on the extent to which risks arising from taxes are shared in international financial markets. Propositions 1 and 2 suggest that while taxes on consumption expenditure and capital income should have predictive power regarding consumption growth, taxes on labor income and investment expenditure should not. Yet we find that the growth rates of the latter two taxes are significantly correlated with consumption growth in the data. This finding suggests that risks to disposable income caused by fluctuations of these two taxes are not hedged effectively in international financial markets.

The estimates in table 4 also let us understand the response of consumption growth differentials to simultaneous changes in the growth rate of valued added taxes and labor taxes across two countries. A 10 percentage point decline in the growth rate differential of labor taxes coupled with a 10 percentage point increase in the growth rate differential of consumption taxes, controlling for per capita GDP growth differences and other taxes, is associated with a roughly 4 percentage point decline in the consumption growth rate differential between countries i and j. This simple example is in the spirit of recent proposals for internal (fiscal) devaluations for countries in the Eurozone (see Farhi et al., 2011; De Mooij and Keen, 2012). The central idea behind these proposals is that a decline in the labor tax engineered through a reduction in social contributions paid by employers together with an increase in destination-based VATs should mimic the effects of an external devaluation through fiscal means. In theory this should lead to improvements in external competitiveness and net exports. Our simple example shows that such a policy could potentially lead to substantial improvements in the external balance through reductions in relative domestic consumption growth.[20]

5.3.2 Non-Separability of Leisure

We also experiment with counterparts of regressions 5.1 and 5.2 above for the case of non-separable utility of the kind suggested by King et al. (1988). With utility in country i given by $U(C_i) = b_i \frac{C_i^{1-\gamma}}{1-\gamma} L_i^{\phi}$, where L_i is the fraction of time devoted to leisure, we get:

$$\Delta C_{it} = \alpha_i + \alpha_t + \theta_1 \Delta(1+\tau_{it}^c) + \theta_2 \ln(1-\tau_{it}^k) + \eta \Delta L_{it} + \psi X_{it} + \epsilon_{it} \tag{5.10}$$

and

$$\begin{aligned} \Delta C_{it} - \Delta C_{jt} = \alpha_{ij} + \theta_1^{'}[\Delta(1+\tau_{it}^c) - \Delta(1+\tau_{jt}^c)] + \theta_2^{'}[\ln(1-\tau_{it}^k) \\ -\ln(1-\tau_{jt}^k)] + \eta^{'}[\Delta L_{it} - \Delta L_{jt}] + \psi[X_{it} - X_{jt}] + \epsilon_{ij,t} \end{aligned} \tag{5.11}$$

The empirical counterpart of the fraction of time devoted to leisure is constructed as $L_{it} = \frac{T-H_{it}}{T}$, using a measure of annual hours worked H_{it}, and setting $T = 5200$ (52 weeks times 100 productive hours per week) as the time endowment.[21] The results from estimating regressions 5.10 and 5.11 are shown in tables 5 and 6. The non-additive labor specification is significant in only two cases (columns 3 and 4 of table 6). Even for these two cases the estimated coefficients on the tax terms change very little due to the low sample correlation between labor hours and taxes. Thus, non-separability related to leisure does not influence our empirical results both in the benchmark case and the extension considered in section 5.3.1.[22]

[20] Two caveats are in order. Fiscal devaluations should ideally be revenue neutral. Since we do not control for budget deficits, our example should be interpreted with caution. Also, our sample contains countries in different exchange rate regimes with respect to each other. Thus the magnitudes in our example might be biased downwards since they incorporate endogenous changes in the real exchange rate in response to tax rate changes.

[21] Under the null of the model $\eta = \eta^{'} = \frac{\phi}{\gamma}$. The rest of the coefficients are as before.

[22] This is consistent with the findings of Lewis (1996) and Backus et al. (1992). Lewis (1996) includes a non-separable labor specification similar to ours in her country panel regressions and finds the labor term to be insignificant. Backus et al. (1992) in their seminal theoretical investigation find that correlation between consumption and labor inputs caused by non-separable leisure and technology-shock-driven business cycles

5.3.3 Higher Moments

Our regression analysis deals only with the sample means of consumption and tax growth rates. We also explore if higher moments of consumption growth and taxes are correlated. Under our market completeness assumption, equation 2.6 holds for each state of nature. Thus, it holds for the mean or any higher moment of the left and right sides of equation 2.6 (Backus and Smith, 1993; Canova and Ravn, 1996). Figure 3 provides a scatter plot of the sample standard deviation, skewness, kurtosis, and first-order autocorrelation of the expressions $\Delta C_{it} - \Delta C_{jt}$ and $[\ln(1-\tau_{it}^{k}) - \ln(1-\tau_{jt}^{k})] - [\Delta(1+\tau_{it}^{c}) - \Delta(1+\tau_{jt}^{c})]$ for all country pairs i and j. The theory, under the strong assumption of market completeness, predicts that there should be a positive relationship between all four plotted moments. The estimated OLS regression coefficients are significantly positive for two of the four moments plotted: the skewness (p-value=0.000) and kurtosis (p-value=0.093).[23]

5.3.4 Alternative Data

Our benchmark results use per capita consumption and GDP data from the OECD. We carry out robustness checks with aggregate consumption and output data not normalized by population, as well as alternative data on consumption and output from the Penn World Tables (Heston et al., 2012, publicly available at **http://www.ggdc.net/pwt**) and also from the OECD data set VOBARSA (this is the OECD acronym for millions of national currency, volume estimates, OECD reference year, annual levels, seasonally adjusted (publicly available at **stats.oecd.org**)). Our conclusions regarding the relative importance of taxes remain unchanged.

5.3.5 Alternative Asset Market Structure

Our Euler equation and risk-sharing condition, equations 2.2 and 2.3, were derived under the assumption of the availability of a complete set of contingent assets. In sharp contrast to that case, we consider here an extreme form of financial markets incompleteness where there is only one internationally traded asset, a non-contingent real bond denominated in terms of the world final good.

One unit of the bond pays one unit of the final good in period $t+1$ in all states of nature s_{t+1}. Let $\bar{B}_i(s^t)$ be the holdings of such a bond purchased in period t after history s^t with payoffs *not* contingent on any particular state s_{t+1} at $t+1$, by the consumer in country i. Let $\bar{Q}_i(s^t)$ denote the price of this bond in units of the home good in period t and after history s^t. Consumers in country i now face the sequence of budget constraints

are not quantitatively large.

[23]A caveat for these p-values is that the standard errors used to calculate them do not take into account that the regressions use estimated moments as inputs. Thus they are likely to be underestimated.

$$
\begin{aligned}
(1+\tau_i^c(s^t))C_i(s^t)+\bar{Q}(s^t)\bar{B}_i(s^t) = {} & (1-\tau_i^h(s^t))W_i(s^t)H_i(s^t) \\
& + (1-\tau_i^k(s^t))(\bar{B}_i(s^{t-1})+\Pi_i(s^t))+T_i(s^t)
\end{aligned}
\tag{5.12}
$$

The bond Euler equation for the agent in country i now holds only in expectation instead of holding in each state of nature as in the previous section.

$$
\bar{Q}(s_t)=\beta_i\sum_{s_{t+1}\in\mathbb{S}}\pi(s_{t+1}|s^t)\frac{U_{Ci}(s^t,s_{t+1})}{U_{Ci}(s^t)}\frac{(1+\tau_i^c(s^t))}{(1+\tau_i^c(s^{t+1}))}(1-\tau_i^k(s^{t+1}))
\tag{5.13}
$$

Equating 5.13 for countries and i and j gives us

$$
\begin{aligned}
& \mathbb{E}_t\Big[\beta_i\frac{U_{Ci}(s^t,s_{t+1})}{U_{Ci}(s^t)}\frac{(1+\tau_i^c(s^t))}{(1+\tau_i^c(s^{t+1}))}(1-\tau_i^k(s^{t+1}))\Big] \\
= {} & \mathbb{E}_t\Big[\beta_j\frac{U_{Cj}(s^t,s_{t+1})}{U_{Cj}(s^t)}\frac{(1+\tau_j^c(s^t))}{(1+\tau_j^c(s^{t+1}))}(1-\tau_j^k(s^{t+1}))\Big],
\end{aligned}
\tag{5.14}
$$

where $\mathbb{E}_t$ denotes expectation conditional on information at time t. Comparing equations 5.13 and 5.14 to equations 2.2 and 2.3, it is clear that a monotonic relationship between the marginal utility growth wedge and the tax wedge will hold in this case in expected values. Thus the complete markets assumption does not affect the general form of our regression based tests.

6 Related Literature

Our paper brings together two broad strands of literature in international macroeconomics, the first pertaining to consumption risk sharing and the second related to taxes in international business cycles. The first strand of literature is exemplified by papers such as Backus et al. (1992, 1994), Backus and Smith (1993), Baxter and Crucini (1995), Stockman and Tesar (1995), Chari et al. (2002), Kehoe and Perri (2002), and Corsetti et al. (2008), among many others, that has sought theoretical explanations for the risk-sharing puzzle.[24] The main conclusion of this literature is that the consumption correlation anomaly is notoriously difficult to solve in the absence of enforcement frictions in international financial markets or strong wealth effects of domestic shocks. Since the framework from which our risk-sharing tests are derived abstracts from both of these complications, it is not surprising that we reject the null of perfect risk sharing. Instead our results should be interpreted as evidence that theoretical models that rely on fluctuations in average tax rates, or fiscal factors in general, are unlikely to provide a resolution to the consumption risk-sharing puzzle. But,

[24] Artis and Hoffmann (2008) provide an excellent survey.

accounting for taxes does suggest time series changes in the degree of risk sharing. It follows that accounting for taxes is indeed important for arriving at a correct metric against which the relative success or failure of any one explanation for the risk-sharing puzzle should be compared.

In a separate strand of literature, taxes are considered as a possible reason for which the marginal product of labor differs from the marginal rate of substitution of consumption for leisure at any given point in time (for instance, Prescott (2004), Ohanian et al. (2008), and McDaniel (2011)). Karabarbounis (2014b) uses the same time series on taxes as our paper to adjust for the level of labor wedges across countries and explores the relevance of non-separable preferences with home production for international business cycles.[25] Karabarbounis (2014b) notes that time variation in taxes is not relevant for explaining the cyclical properties of the labor wedge. He shows that, conditional on the noted level adjustment, when parameters of the home sector are estimated to generate a labor wedge that mimics its empirical counterpart the standard international business cycle model with complete asset markets can match some key stylized facts of the data, including that output is more correlated than consumption across countries. Our analysis of the role of taxes in consumption risk-sharing, which uses a business cycle accounting approach and regression-based tests of risk sharing, is complementary to the labor-wedge approach followed by Karabarbounis (2014b).

Methodologically, we are closest to the large literature that examines empirical measures and tests of risk sharing. Since the seminal work of Cochrane (1991), Mace (1991) and Townsend (1994), a vast literature testing risk sharing at the state and country level has developed, as exemplified by Lewis (1996), Asdrubali et al. (1996), Imbs (2006), Artis and Hoffmann (2008), Flood et al. (2012), among many others. Recent papers in this literature have documented how the degree of risk sharing, as captured by regression-based tests, has evolved over time. The thrust of these papers has been to reconcile the surge in financial globalization in the last two decades with the surprising lack of evidence in favor of improved risk sharing. Explanations have centered around still existent financial frictions and the statistical properties of underlying risks. In contrast, our paper is about a hitherto unexplored source of country specific risk, namely taxes.

7 Conclusion

This paper develops an understanding of how, and the extent to which, cross-country differences and fluctuations in taxes matter for understanding international risk sharing. To the best of our knowledge, this is the first paper in the literature to do so. It well known

[25] Because these taxes are only available at yearly frequency, he assumes that the same average tax rate holds throughout a year, but his overall analysis is at quarterly frequency.

that, empirically, a lack of international risk sharing is substantially prevalent in the data as measured by a lack of equalization of consumption growth rates across countries. The degree to which such robust international risk sharing fails to manifest itself empirically is puzzling from the point of view of a standard international business cycle model. Indeed, this model predicts that consumption, or its growth rates, should be highly correlated across countries when risk sharing between countries is substantial.

We examine the impact of taxes from two broad vantage points: business cycle accounting and regression based tests. Our analysis makes use of panel data on output and consumption. We extend an otherwise standard international business cycle model to account for taxes, making use of cross-country data on average tax rates on consumption and investment expenditures, as well as cross-country data on average taxes on capital and labor income.

Our business cycle accounting perspective allows us to derive the notion of a risk-sharing wedge. This wedge captures the extent to which an international real business cycle model's risk-sharing condition fails to hold at any point in time, and therefore allows for a dynamic vantage point of risk sharing. The inclusion of taxes in the operationalized model reveals substantial improvements in the degree of international risk sharing over time, especially since the 1980s. We show that this improvement in international risk sharing generally coincides with improvements in financial liberalization. Yet, we also show that this intuitive result is virtually absent when taxes are not incorporated in the analysis. We conclude that accounting for taxes is critical for assessing the correct degree of international risk sharing over time.

Having established the notable implications of taxes for the dynamic behavior of the risk-sharing wedge, we turn to examining the extent to which taxes themselves can explain the lack of risk sharing across countries. We investigate this matter by implementing regression-based tests of international risk sharing. We find that consumption growth differentials are significantly correlated to fluctuations in the level of capital taxes and the growth rate of consumption taxes, as predicted by our theory. However, in spite of this relationship, our analysis leads us to conclude that taxes alone cannot explain the lack of consumption growth-rate equalization across countries since tax growth within and across countries does not display much volatility. Our theory also implies that taxes on labor income and investment expenditure should not have predictive power with respect to consumption growth. However, we find that these two taxes are significantly correlated with consumption growth in the data. We interpret this finding as evidence that international asset markets are incomplete with respect to the risks related to fluctuations in these two taxes.

It follows that while cross-country differences and fluctuations in taxes are not in themselves a significant factor limiting risk sharing across countries, accounting for taxes matters for establishing a correct metric for the evolution of risk sharing across time.

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8 Appendices

Table 1: Correlation of Per capita Consumption Growth Rates Across Countries

	Aus	Aut	Bel	Can	Fin	Fra	Ger	Ita	Jap	Nld	Spa	Swe	Swi	UK	USA
Aus	1.00														
Aut	0.05	1.00													
Bel	0.24	0.65	1.00												
Can	0.28	0.16	0.26	1.00											
Fin	0.28	0.29	0.32	0.34	1.00										
Fra	0.23	0.69	0.69	0.26	0.50	1.00									
Ger	-0.09	0.64	0.58	0.25	0.31	0.71	1.00								
Ita	0.19	0.58	0.70	0.14	0.38	0.72	0.56	1.00							
Jap	0.04	0.61	0.60	0.08	0.40	0.77	0.63	0.64	1.00						
Nld	0.40	0.46	0.54	0.36	0.20	0.57	0.61	0.47	0.34	1.00					
Spa	0.32	0.71	0.66	0.41	0.44	0.80	0.59	0.77	0.61	0.57	1.00				
Swe	0.34	0.33	0.41	0.46	0.56	0.54	0.39	0.44	0.29	0.35	0.64	1.00			
Swi	0.03	0.59	0.61	0.29	0.44	0.72	0.72	0.66	0.61	0.51	0.66	0.36	1.00		
UK	0.23	0.15	0.31	0.46	0.40	0.33	0.15	0.26	0.32	0.19	0.39	0.32	0.31	1.00	
USA	0.19	0.22	0.22	0.57	0.25	0.37	0.36	0.16	0.30	0.38	0.37	0.28	0.36	0.64	1.00

Notes: Pairwise correlations are calculated for yearly per capita country consumption growth.
Data Source: OECD.

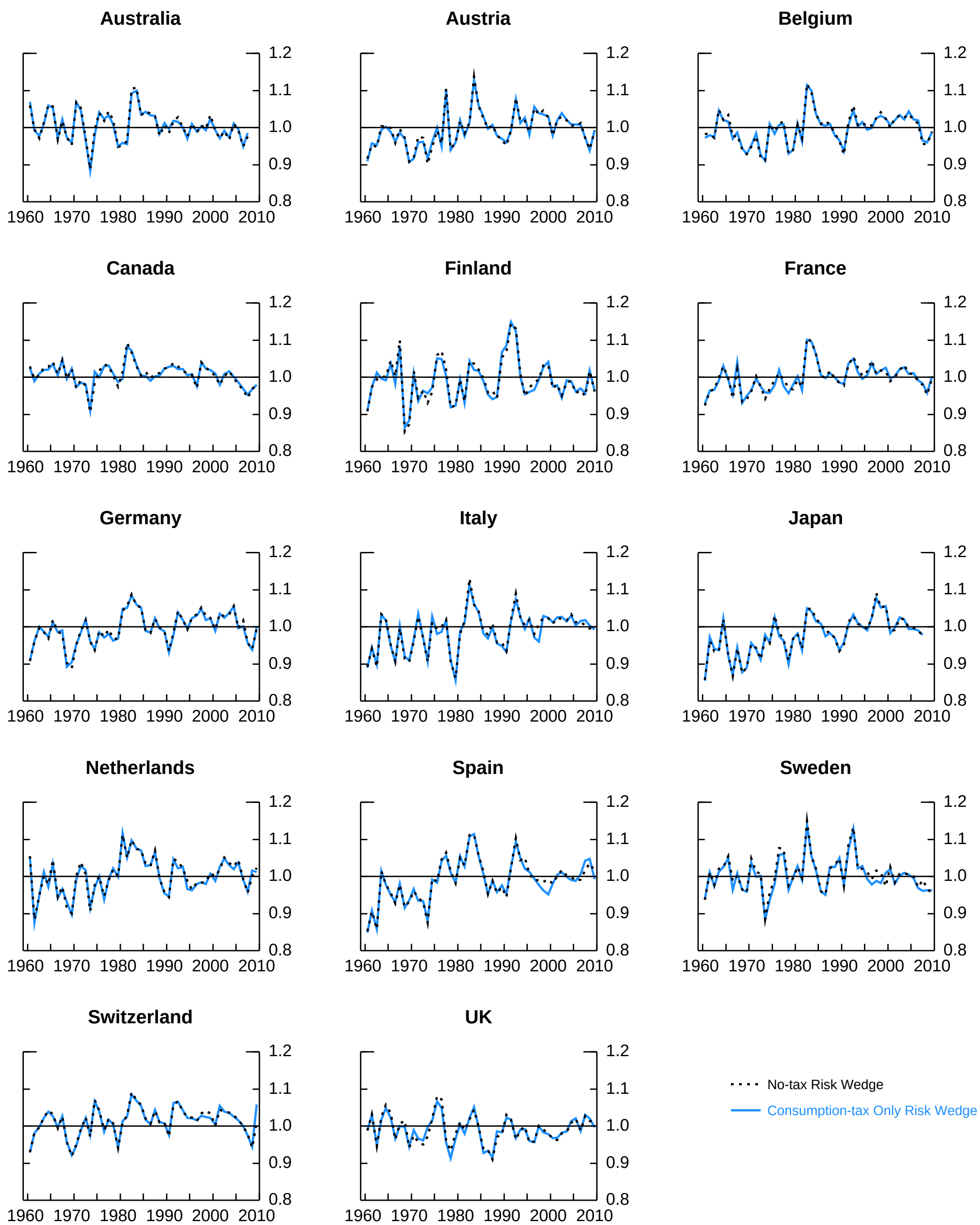


Figure 1: Baseline and Consumption Tax Adjusted Wedges. Data sources: OECD and McDaniel (2009).

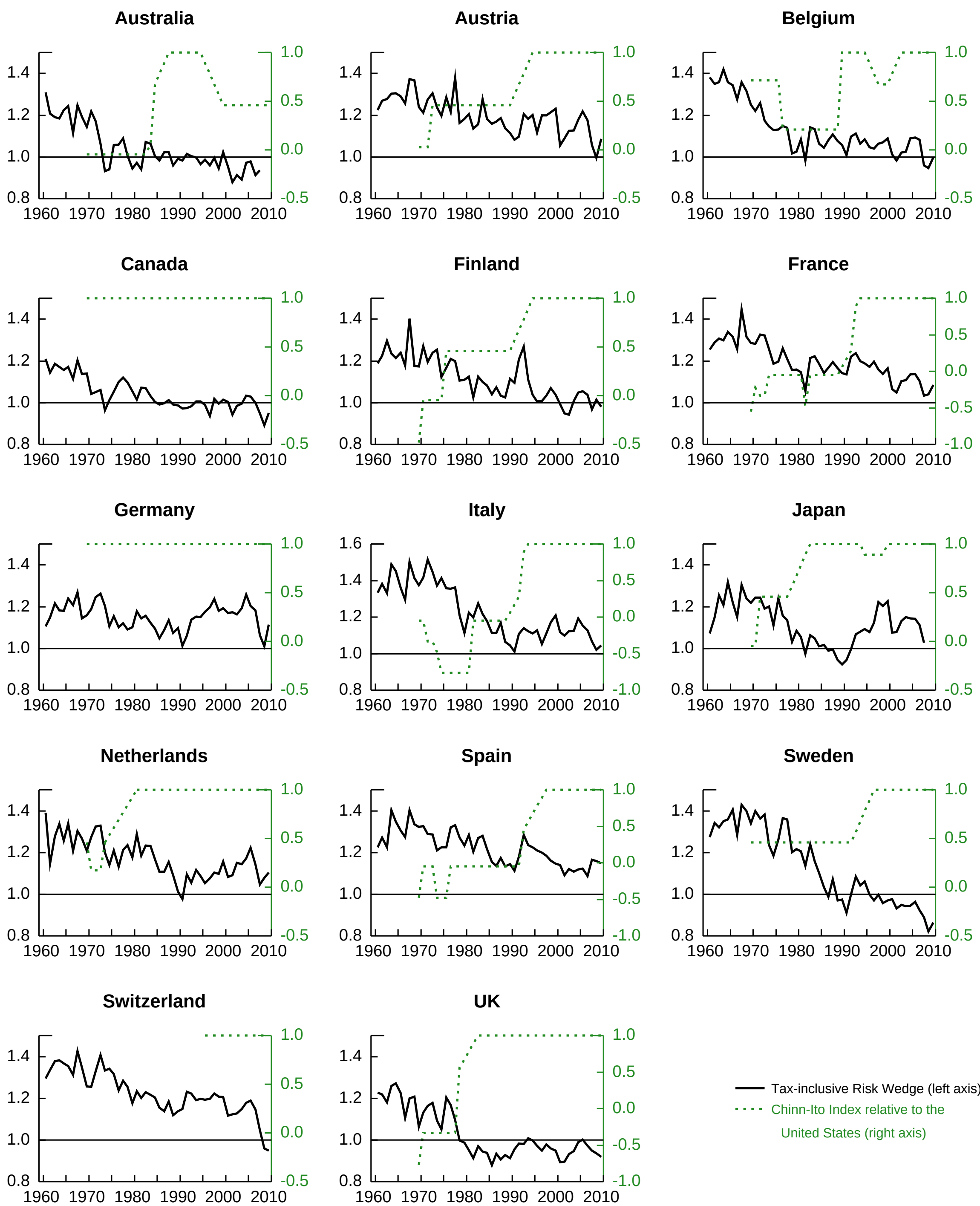


Figure 2: Wedge Adjusted for All Taxes and Financial Openness. Data sources: OECD, McDaniel (2009), and Chinn and Ito (2006)

Table 2: Absolute Deviation of Wedges and Bilateral Financial Connectedness

	Panel I: Dependent Variable $\mathbb{G}^{ij}_{\mathrm{B},t}$		
Variable Name	OLS	LSDV	GMM
$\mathbb{G}^{ij}_{\mathrm{B},t-1}$	0.273***	0.144***	0.157***
	(0.023)	(0.021)	(0.024)
$\mathbb{F}_{ij,t}$	-0.018	-0.030	-0.046
	(0.011)	(0.020)	(0.045)
R^2	0.079	0.171	-
No. Obs.	2908	2908	2799
	Panel II: Dependent Variable $\mathbb{G}^{ij}_{\mathrm{C},t}$		
Variable Name	OLS	LSDV	GMM
$\mathbb{G}^{ij}_{\mathrm{C},t-1}$	0.283***	0.161***	0.179***
	(0.024)	(0.024)	(0.026)
$\mathbb{F}_{ij,t}$	-0.020*	-0.039	-0.040
	(0.012)	(0.026)	(0.049)
R^2	0.083	0.179	-
No. Obs.	2845	2845	2736
	Panel III: Dependent Variable $\mathbb{G}^{ij}_{\mathrm{A},t}$		
Variable Name	OLS	LSDV	GMM
$\mathbb{G}^{ij}_{\mathrm{A},t-1}$	0.798***	0.622***	0.561***
	(0.012)	(0.022)	(0.026)
$\mathbb{F}_{ij,t}$	-0.042**	-0.087*	-0.339**
	(0.0121)	(0.047)	(0.412)
R^2	0.648	0.671	-
No. Obs.	2845	2845	2736
Country Fixed Effects	No	Yes	Yes
Year Fixed Effects	No	Yes	Yes

Notes: Coefficient estimates of Regression 4.6 using OLS, LSDV and Arellano-Bond difference GMM. Dependent variables in Panels I, II and III are absolute deviations from unity of the baseline wedge, the consumption tax inclusive wedge, and the all tax inclusive wedge, respectively. Regressors are the lagged dependent variable and a measure of bilateral financial connectedness. See text for details. Robust standard errors, clustered at the country level, in parentheses. Coefficients marked $***$, $**$ and $*$ are significant at 1%, 5% and 10%, respectively. Data Source: BIS, OECD and McDaniel (2009).

Table 3: The Sensitivity of Domestic Consumption to Domestic Tax Rates: Benchmark

Variable Name	No Tax	With τ^c	With τ^c, τ^k	With $\tau^c, \tau^k, \tau^x, \tau^h$
X_{it}	0.768***	0.766***	0.770***	0.769***
	(0.04)	(0.04)	(0.04)	(0.04)
$\Delta(1+\tau^c_{it})$		-0.161*	-0.160**	-0.360***
		(0.08)	(0.07)	(0.09)
$\ln(1-\tau^k_{it})$			-0.013	-0.009
			(0.01)	(0.01)
$\Delta(1-\tau^k_{it})$				-0.036
				(0.02)
$\Delta(1+\tau^x_{it})$				0.413***
				(0.13)
$\Delta(1-\tau^h_{it})$				0.062*
				(0.03)
R^2	0.7476	0.7503	0.751	0.7541
No. Obs.	745	745	745	745
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Coefficient estimates of Regression 5.1. Dependent variable is country consumption growth between periods t and $t-1$. Independent variables are the growth rates of (1) per capita GDP (X), (2) the gross consumption tax rate $(1+\tau^c)$, (3) the investment tax rate (τ^x), and (4) the labor income tax rate (τ^h); the natural logarithm of (5) $(1-\tau^k)$, where τ^k is the capital income tax rate. Robust standard errors, clustered at the country level, in parentheses. Coefficients marked $***$, $**$ and $*$ are significant at 1%, 5% and 10%, respectively. Data Source: OECD and McDaniel (2009).

Table 4: The Sensitivity of International Consumption Differentials to International Tax Rate Differentials: Benchmark

Variable Name	No Tax	With τ^c	With τ^c, τ^k	With $\tau^c, \tau^k, \tau^x, \tau^h$
$X_{it} - X_{jt}$	0.764***	0.750***	0.726***	0.716***
	(0.03)	(0.03)	(0.02)	(0.02)
$\Delta(1+\tau^c_{it}) - \Delta(1+\tau^c_{jt})$		-0.248***	-0.255***	-0.517***
		(0.06)	(0.06)	(0.11)
$\ln(1-\tau^k_{it}) - \ln(1-\tau^k_{jt})$			0.018**	0.022***
			(0.01)	(0.01)
$\Delta(1-\tau^k_{it}) - \Delta(1-\tau^k_{jt})$				-0.063***
				(0.01)
$\Delta(1+\tau^x_{it}) - \Delta(1+\tau^x_{jt})$				0.550***
				(0.16)
$\Delta(1-\tau^h_{it}) - \Delta(1-\tau^h_{jt})$				0.103**
				(0.04)
R^2	0.6315	0.6388	0.644	0.6535
No. Obs.	695	695	695	695
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No

Notes: Coefficient estimates of Regression 5.2. Dependent variable is the difference between country i and j of consumption growth between periods t and $t-1$. Country j is always the United States. Independent variables are the difference between country i and j of the growth rates of (1) per capita GDP (X), (2) the gross consumption tax rate $(1+\tau^c)$, (3) the investment tax rate (τ^x), and (4) the labor income tax rate (τ^h); the difference between country i and j of the natural logarithm of (5) $(1-\tau^k)$, where τ^k is the capital income tax rate. Robust standard errors, clustered at the country level, in parentheses. Coefficients marked $***$, $**$ and $*$ are significant at 1%, 5% and 10%, respectively. Data Source: OECD and McDaniel (2009).

Table 5: The Sensitivity of Domestic Consumption to Domestic Tax Rates: Non-Additive Labor in Utility Function

Variable Name	No Tax	With τ^c	With τ^c, τ^k	With $\tau^c, \tau^k, \tau^x, \tau^h$
ΔPer capita GDP_{it}	0.758***	0.756***	0.761***	0.760***
	(0.04)	(0.04)	(0.04)	(0.04)
ΔL_{it}	-0.081	-0.081	-0.076	-0.075
	(0.14)	(0.14)	(0.14)	(0.14)
$\Delta(1+\tau_{it}^c)$		-0.161**	-0.160**	-0.361***
		(0.07)	(0.07)	(0.09)
$\ln(1-\tau_{it}^k)$			-0.012	-0.009
			(0.01)	(0.01)
$\Delta(1-\tau_{it}^k)$				-0.034
				(0.02)
$\Delta(1+\tau_{it}^x)$				0.417***
				(0.13)
$\Delta(1-\tau_{it}^h)$				0.062*
				(0.03)
R^2	0.7479	0.7506	0.7512	0.7543
No. Obs.	745	745	745	745
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Notes: Coefficient estimates of Regression 5.10. Dependent variable is country consumption growth between periods t and $t-1$. Independent variables are the growth rates of (1) per capita GDP (X), (2) per capita labor hours (L), (3) the gross consumption tax rate ($1+\tau^c$), (4) the investment tax rate (τ^x), and (5) the labor income tax rate (τ^h); the natural logarithm of (6) $(1-\tau^k)$, where τ^k is the capital income tax rate. Robust standard errors, clustered at the country level, in parentheses. Coefficients marked $***$, $**$ and $*$ are significant at 1%, 5% and 10%, respectively. Data Source: OECD and McDaniel (2009).

Table 6: The Sensitivity of International Consumption Differentials to International Tax Rate Differentials: Non-Additive Labor in Utility Function

Variable Name	No Tax	With τ^c	With τ^c, τ^k	With $\tau^c, \tau^k, \tau^x, \tau^h$
$X_{it} - X_{jt}$	0.748***	0.737***	0.682***	0.676***
	(0.04)	(0.04)	(0.03	(0.03)
$\Delta L_{it} - \Delta L_{jt}$	-0.139	-0.116	-0.288**	-0.272**
	(0.12)	(0.11)	(0.11)	(0.10)
$\Delta(1+\tau^c_{it}) - \Delta(1+\tau^c_{jt})$		-0.242***	-0.243***	-0.514***
		(0.06)	(0.05)	(0.11)
$\ln(1-\tau^k_{it}) - \ln(1-\tau^k_{jt})$			0.025***	0.028***
			(0.01)	(0.01)
$\Delta(1-\tau^k_{it}) - \Delta(1-\tau^k_{jt})$				-0.057***
				(0.01)
$\Delta(1+\tau^x_{it}) - \Delta(1+\tau^x_{jt})$				0.563***
				(0.17)
$\Delta(1-\tau^h_{it}) - \Delta(1-\tau^h_{jt})$				0.106**
				(0.05)
R^2	0.6327	0.6396	0.6483	0.6571
No. Obs.	695	695	695	695
Country Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No

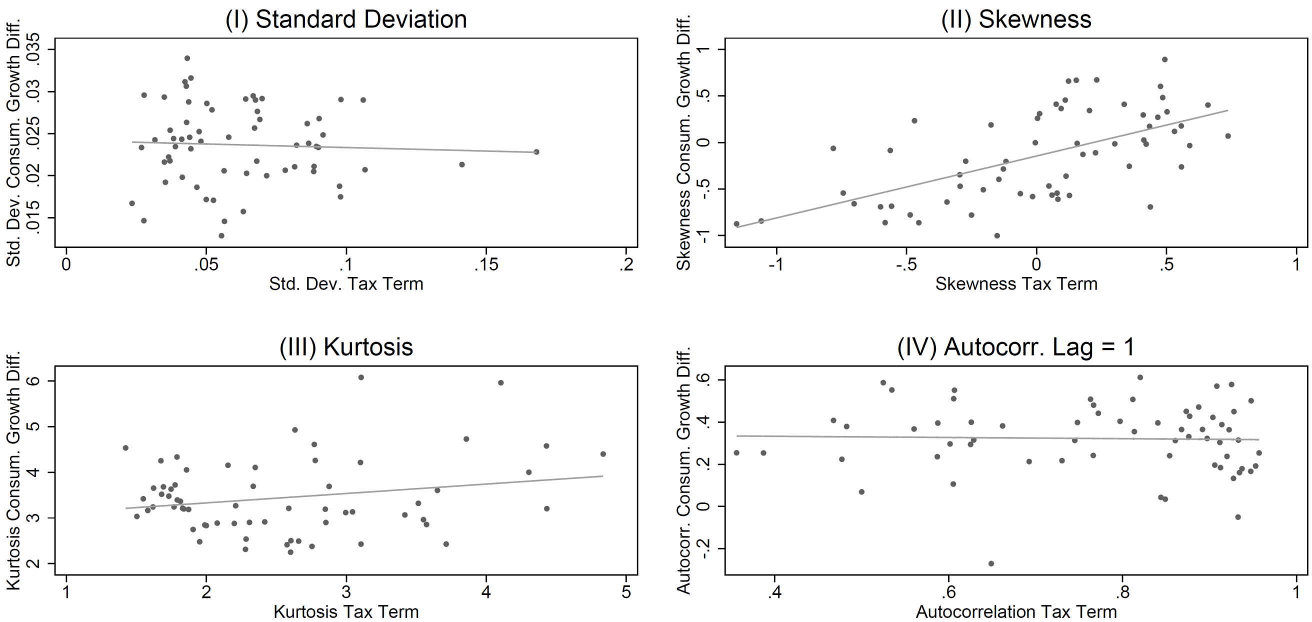
Notes: Coefficient estimates of Regression 5.11. Dependent variable is the difference between country i and j of consumption growth between periods t and $t-1$. Country j is always the United States. Independent variables are the difference between country i and j of the growth rates of (1) per capita GDP (X), (2) per capita labor hours (L), (3) the gross consumption tax rate $(1+\tau^c)$, (4) the investment tax rate (τ^x), and (5) the labor income tax rate (τ^h); the difference between country i and j of the natural logarithm of (6) $(1-\tau^k)$, where τ^k is the capital income tax rate. Robust standard errors, clustered at the country level, in parentheses. Coefficients marked $***$, $**$ and $*$ are significant at 1%, 5% and 10%, respectively. Data Source: OECD and McDaniel (2009).

Table 7: Summary Statistics of Variables Used in Regressions

Variable Name	No. Obs.	Mean	Std. Dev.	Min.	Max.
$\mathbb{G}^{ij}_{\mathrm{B},t}$	3465	0.0329935	0.0274149	0.000024	0.1752859
$\mathbb{G}^{ij}_{\mathrm{C},t}$	3399	0.0337833	0.0281799	0.0000031	0.1735971
$\mathbb{G}^{ij}_{\mathrm{A},t}$	3399	0.099514	0.0714455	0.0000633	0.409421
$\mathbb{F}_{ij,t}$	2974	0.0182584	0.0329996	0.000028	0.315706
ΔP.C. C_{it}	745	0.0220872	0.0218668	-0.0507903	0.100527
ΔP.C. GDP_{it}	745	0.0220793	0.0236309	-0.0923579	0.1008265
ΔL_{it}	745	0.0013056	0.0054942	-0.0256427	0.022381
$\Delta(1+\tau^c_{it})$	745	0.0008837	0.0074406	-0.0375679	0.0463924
$\ln(1-\tau^k_{it})$	745	-0.2647971	0.0872759	-0.512929	-0.0705729
$\Delta(1-\tau^k_{it})$	745	-0.0013337	0.0213322	-0.1206634	0.1118835
$\Delta(1+\tau^x_{it})$	745	0.0004252	0.0046853	-0.034612	0.0449434
$\Delta(1-\tau^h_{it})$	745	-0.0039873	0.0153218	-0.1184155	0.0876947
ΔP.C. $\mathrm{C}_{it} - \Delta$P.C. C_{jt}	695	0.0017606	0.0232926	-0.0697918	0.0800581
ΔP.C. $\mathrm{GDP}_{it} - \Delta$P.C. GDP_{jt}	695	0.0040932	0.0242457	-0.0666292	0.1050301
$\Delta L_{it} - \Delta L_{jt}$	695	0.0014546	0.0063995	-0.0337849	0.0228134
$\Delta(1+\tau^c_{it}) - \Delta(1+\tau^c_{jt})$	695	0.0013748	0.0080512	-0.0360524	0.0479861
$\ln(1-\tau^k_{it}) - \ln(1-\tau^k_{jt})$	695	0.1325793	0.1157324	-0.1580179	0.4289718
$\Delta(1-\tau^k_{it}) - \Delta(1-\tau^k_{jt})$	695	-0.0052271	0.0305789	-0.1272543	0.1212688
$\Delta(1+\tau^x_{it}) - \Delta(1+\tau^x_{jt})$	695	0.0005836	0.004919	-0.0343993	0.0433238
$\Delta(1-\tau^h_{it}) - \Delta(1-\tau^h_{jt})$	695	-0.0029162	0.0175909	-0.1217293	0.0887701

Notes: Δ refers to the growth rate of variables, and P.C. to Per Capita variables (for consumption: C, and Gross Domestic Product: GDP). Other variables are: bilateral financial connectedness ($\mathbb{F}_{ij,t}$) ; absolute deviations from unity of the baseline wedge ($\mathbb{G}^{ij}_{\mathrm{B},t}$), the consumption tax inclusive wedge ($\mathbb{G}^{ij}_{\mathrm{C},t}$), and the all tax inclusive wedge ($\mathbb{G}^{ij}_{\mathrm{B},t}$); consumption tax rate (τ^c_{it}); capital income tax rate (τ^k_{it}); investment expenditure tax rate (τ^x_{it}); and labor income tax rate (τ^h_{it}). Other details are provided in the text. Data Source: BIS, OECD and McDaniel (2009).

Figure 3: Scatter Plots of Higher Moments of the Left- and Right-Hand Sides of 2.6.



Notes: The standard deviation, skewness, kurtosis, and autocorrelation of $\Delta C_{it} - \Delta C_{jt}$ and $[\ln(1-\tau_{it}^{k}) - \ln(1-\tau_{jt}^{k})] - [\Delta(1+\tau_{it}^{c}) - \Delta(1+\tau_{jt}^{c})]$ on the vertical and horizontal axes respectively. Each dot represents a country pair.