International diversification and labor income risk*

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Abstract

Can equity markets help diversifying away industry-related labor income risk? This paper reconsiders the hedging role of stock markets by focussing on international equity diversification, rather than domestic asset allocation, and on industry wage, rather than individual labor income. We test for differences in implied equilibrium equity portfolios across investors belonging to different industry-country pairs. We compare these industry-based portfolio holdings to the one that is optimal for an investor endowed with the average home-country labor income. Our analysis delivers insights concerning the role of occupational pension funds in designing optimal portfolios for their members.

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1 Introduction

Optimal portfolios ought to hedge labor income risk (Merton, 1971; Mayers, 1972). Such risk might *a priori* dictate considerable variation in equity portfolios across workers, since they face heterogeneous wage shocks in diverse industries. However, the correlation between domestic equity returns and occupation-related shocks to household income is usually close to zero (Campbell et al., 2001; Davis and Willen, 2000). This evidence casts doubts on the potential contribution of equity markets in diversifying away labor income risk.

Our paper reconsiders the hedging role of stock markets by shifting attention to international equity diversification, rather than domestic asset allocation, and to industry wage, rather than individual labor income. The benefits from international diversification of equity portfolios have indeed been documented long ago (Grubel, 1968; Levy and Sarnat, 1970) and persist despite increased stock market integration and systemic crises (Das and Uppal, 2004; De Santis and Gerard, 1997). Our second focus - the one on industry risk within each country - derives from the magnitude and stability of interindustry wage differentials in the US (Dickens and Katz, 1987; Krueger and Summers, 1987, 1988; Katz and Summers, 1989; Weinberg, 2001), which points to the importance of the industry factor in the labor income process. International comparisons confirm this pattern in many OECD countries (Gittleman and Wolff, 1993; Kahn 1998).

Against this background, this paper measures the differences in equity portfolios across investors belonging to different industry-country pairs in 1998-2004. In particular, we compute implied equilibrium holdings in the stock indices of ten destination countries held by US, Canadian and Italian investors working in seven different industries, from Financials to Manufacturing. We compare these industry based portfolios to the national restricted portfolio, i.e. the one that would be optimal for an investor endowed with the average home-country labor income. Should they turn out to be equal, then there would be no scope for hedging industry-specific risk through international equity markets - in line with previous evidence on individual wage profiles.

This comparison also provides insights on whether occupational pension funds may differentiate their investment strategies from those of open-end pension funds.[1] Members in any given occupational plan plausibly face the same industry shocks, since membership is based on their employment industry. On the contrary, participants in open-end pension fund belong to different industries. An occupational pension fund is therefore able to design portfolio composition so as to hedge shocks to its own industry, while open-end pension funds can only hedge national income shocks. Thus, if the correlation between shocks to French equity and shocks to wages in US manufacturing is higher than that of the average US worker, then US pension funds for manufacturing workers ought to demand less French stocks relative to the national restricted portfolio.

[1] We take the perspective of Defined Contribution (DC) plans, where contributions are fixed proportions of participants' salary and benefits depend on the plan's portfolio returns.

Clearly, this tailored allocation is valuable only if shocks differ across industries so that optimal allocations do as well.

Our results resurrect the role of equities in hedging wage risk by uncovering remarkable heterogeneity across industries within each investing country, pointing to a role for occupational pension funds in designing industry-based portfolios. A first indicator is the dispersion in implied equilibrium portfolios for workers belonging to different industries within a country. For instance, portfolio shares in UK equities range, depending on the industry, from -0.15 to 0.16 for US workers, from -0.04 to 0.29 for Canadians and from -0.19 to 0.30 for Italians. A second indicator is the distance between equilibrium weights for a worker in a given industry and the representative national worker. These distances range from a minimum of 0.04 to a maximum of 0.37 for a US investor, from 0.03 to 0.87 for a Canadian, and from 0.03 to 0.26 for an Italian. A third indicator is the difference in the labour income component of equilibrium portfolios between two industries, computed for all possible destination stock markets and all industry pairs. The percentage of statistically different labor income components across industry pairs is 48% for the US, 44% for Canada and 28% for Italy. These results complement existing evidence indicating that an investor benefits from diversification of equity portfolios both across countries and across industries (Griffin and Karolyi, 1998; Carrieri et al., 2004). This literature on the factor structure of stock returns does not however consider the non tradability of investors' human capital, that we take to the foreground.

Our paper builds on an equilibrium model of international equity allocation where investors hedge country-specific inflation risk (Adler and Dumas, 1983). Investors in different countries may choose different risky portfolio, because they hedge deviations from the world inflation rate. For instance, a Canadian investor attributes a lower weight, with respect to their market share, to Dutch stocks if the covariance of Dutch equity returns with Canadian inflation is lower than the world average inflation covariance. Here, we retain the assumption of country-specific inflation risk but also allow for heterogeneous labor income induced by being employed in different industries. Consequently, optimal stock portfolios may also hedge the deviation of an industry in a given country from world income growth. Thus, a Canadian investor working in the leisure industry attributes a lower weight to Dutch stocks if the covariance of Dutch equity returns with his industry wage exceeds the world average wage covariance. Our empirical results thus indicate the relative importance of wage and inflation risk in determining international equity diversification. Our data show that the labor hedging motive is stronger than the inflation hedging one in the three countries considered. Cross country comparison reveals that both hedging motives appear to be stronger in the US and in Canada than in Italy.

This type of analysis connects our paper to the literature on the so called "home bias puzzle", consisting in a disproportionate actual investment in domestic assets with respect to the weight of domestic assets in the market portfolio. The latter ought to be the equilibrium risky portfolio according to the International CAPM. Clearly, such large holdings of domestic assets by domestic investors could be rational if domestic equities are a better hedge of country-specific risks, such as deviations from the purchasing power parity or risks connected with non traded assets. Cooper and Kaplanis (1994) do not support the inflation hedging motive as an explanation of the *home bias*. Baxter and Jermann (1997) find a quasi-perfect positive correlation among domestic returns to human and physical capital, which should induce a short position in domestic assets - widening the *home bias*.[2] On the contrary, Bottazzi et al. (1996), while confirming that human capital and physical capital returns have positive correlation, argue that accounting for human capital reduces the bias towards domestic assets. Indeed, they find a negative correlation with financial returns, which reduces the *home bias* by about 30%. Palacios-Huerta (2001) observe that the *home bias* disappears when disaggregating human capital of stock-holders and non-stockholders.

Our disaggregation pursues instead the industry dimension. According to our results, hedging income risk at the industry level still cannot explain the *home bias* puzzle: the domestic equity holdings observed in actual portfolios are still higher than our implied equilibrium allocations. However, Baxter and Jermann (1997)'s prescription of going short in domestic assets holds only for Italy. In the US we find that accounting for both the labor and the inflation hedging effects leads to an optimal long position in domestic asset (0.36), albeit lower than its market share (0.42). For Canada and Italy, the optimal positions in domestic equities are 0.09 and -0.01, respectively.

The effect of labor income on optimal portfolio composition has been investigated in life-cycle models (Campbell et al., 2001; Davis and Willen, 2000; Cocco et al, 2005; Koijen et al, 2007). There are two other important differences between these papers and our study, aside from our focus on industry-based (rather than individual) portfolio choice and labor income. They calibrate optimal portfolio composition in partial equilibrium, whereas we calibrate equilibrium equity allocations.[3] Portfolio choice rests on the correlation structure of financial asset returns and labor income in both cases. However, what matters in our model is the relative magnitude of correlations. Thus, a *small* negative correlation between US manufacturing wages and French equity returns would dictate a *small* optimal portfolio share in French stocks for a US manufacturing worker in partial equilibrium. On the contrary, it may translate in *large* holdings of French stocks in our model, if other wages have positive correlations with French returns.

Second, life cycle models usually account for predictable individual wage profiles, conditional on observed

[2] Consideration of non traded consumption goods and/or factors of production does not help reducing the *home bias* (Baxter et al., 1998).

[3] Other models compare implied portfolio shares to actual holdings, trying to explain the cross sectional dispersion of household portfolios (Heaton and Lucas, 2000; Guiso et al., 1996; Angerer and Lam, 2008) or observed life-cycle patterns (Benzoni et al., 2007). On the contrary, we do not observe the industry based portfolios – but test for differences between implied industry portfolios.

characteristics such as age and education. On the contrary, our portfolio choice rule is myopic - as in similar portfolio decisions with constant investment opportunities. Thus we simply use the rate of growth in per capita labor income to measure returns to human capital and its realized volatility to proxy for risk, following - for instance - Jagannathan and Wang (1996).

This paper is structured as follows. In section 2 we describe the theoretical setting. Section 3 reports details on data and econometric methods. In section 4 we discuss our empirical results. Section 5 concludes.

2 The model

2.1 The setup

We now derive optimal equity portfolios extending Cooper and Kaplanis (1994) and Coën (2001) to industry-specific human capital. We consider a representative investor living in home country l ($l = 1, ..., L$) and working in industry s ($s = 1, ..., S$), who chooses among N country stock indexes and 1 risk-free asset. She maximizes a time-additive, constant relative risk aversion utility function over life-time consumption expenditures. The objective function for the investor sl is:

$$\underset{C^{sl};w^{sl}}{Max}\ E\int_t^T V(C^{sl}, P^l, \tau)d\tau \tag{1}$$

where C^{sl} is her nominal rate of consumption expenditures, w^{sl} denotes the $N \times 1$ vector containing investor's portfolio weights on the available equity indexes, P^l is the price index and $V(.)$ is the instantaneous rate of utility[4], which is homogeneous of degree zero in C^{sl} and P^l.

The instantaneous rate of return on the equity index of country j ($j = 1, ..., N$), expressed in the measurement currency, follows the stationary Ito process

$$dY_j/Y_j = \mu_j dt + \sigma_j dz_j \tag{2}$$

where Y_j denotes the market value of equity index j, μ_j and σ_j represent the instantaneous expectation and standard deviation of the nominal rate of return on the equity index j, z_j is a standard Wiener process and dz_j is the associated white noise process.

The price index P_l follows the stationary Ito process

[4] Adler and Dumas (1983) provide details on the maximization problem in presence of a price index instead of a set of commodity prices.

$$dP^l/P^l = \pi^l dt + \sigma_\pi^l dz_\pi^l \tag{3}$$

where π^l and σ_π^l are the instantaneous expectation and standard deviation of the inflation rate faced by investor in country l, z_π^l is a standard Wiener process and dz_π^l is the associated white noise process.

The return on human capital for the investor working in industry s in country l, expressed in the measurement currency, follows the stationary Ito process

$$dH^{sl}/H^{sl} = h^{sl} dt + \sigma_h^{sl} dz_h^{sl} \tag{4}$$

where H^{sl} is human capital in terms of the measurement currency, h^{sl} and σ_h^{sl} are the instantaneous expectation and standard deviation of the nominal rate of change of wage, z_h^{sl} and dz_h^{sl} are a standard Wiener process and the associated white noise process, respectively.

Each investor is assumed to receive $(1-\eta)$ of his total income from financial income and η from income related to human capital.[5] Then the wealth dynamics are:

$$dW^{sl} = (1-\eta)\left\{\left[\sum_{j=1}^{N} w_j^{sl}(\mu_j - r) + r\right] W^{sl}dt + \sum_{j=1}^{N} w_j^{sl}\sigma_j W^{sl} dz_j\right\} + \eta\left\{h^{sl}W^{sl}dt + \sigma_h^{sl}W^{sl}dz_h^{sl}\right\} - C^{sl}dt \tag{5}$$

where W^{sl} denotes the investor's nominal wealth and w_j^{sl} is the portfolio share invested in country j equities. The reader can recognize in the first curly bracket the portfolio return, and in the second bracket the return on human capital.

We denote by $J(W, P, t)$ the maximum value of the instantaneous expected utility subject to the wealth accumulation constraint, obtained by solving the problem with the Bellman principle. We also denote by λ

$$\lambda = -\frac{J_{WW}}{J_W}W$$

the common investor's relative risk aversion coefficient where J_W and J_{WW} are, respectively, the first and second partial derivative of $J(.)$ with respect to W.

2.2 Optimal portfolio choice

From the solution of the problem[6], the nominal risk premium on equity index j is:

[5] Campbell (1996) - among others - imposes this assumption, ensuring that income distribution between factor of production is constant.

[6] See Appendix A for details on the derivation.

$$\mu_j - r = \left[\sigma_{j\pi}^l (1-\lambda)\right] + \lambda \left[(1-\eta) \sum_{k=1}^{N} w_k^{sl} \sigma_{jk} + \eta \sigma_{jh}^{sl} \right] \tag{6}$$

where $\sigma_{j\pi}^l$ is the covariance between returns on stock index j and the inflation rate in country l, σ_{jk} is the covariance between returns on assets j and k, and σ_{jh}^{sl} is the covariance between returns on asset j and the labor income growth in sector s in country l.

The equity portfolio of investor sl is, therefore:

$$\mathbf{w}^{sl} = \mathbf{\Omega}^{-1} \left\{ \frac{\frac{1}{\lambda}}{(1-\eta)} \left[\boldsymbol{\mu} - r\mathbf{i}\right] + \frac{(1-\frac{1}{\lambda})}{(1-\eta)} \boldsymbol{\varpi}^l - \frac{\eta}{(1-\eta)} \boldsymbol{\kappa}^{sl} \right\} \tag{7}$$

where $\mathbf{i}$ is a $N-$vector of ones, $\mathbf{\Omega}$ is a (NxN) matrix of instantaneous variances-covariances σ_{jk} of nominal rates of return on equity indexes, $\boldsymbol{\varpi}^l$ is a $N-$vector of covariances $\sigma_{j\pi}^l$ between nominal equity return in country j and country l's rate of inflation and $\boldsymbol{\kappa}^{sl}$ is a $N-$vector of covariances σ_{jh}^{sl} between nominal equity return j and investor sl's labor income growth.

The optimal portfolio can be decomposed into three parts. The first is the usual myopic portfolio which is common to all investors since it only depends upon the joint distribution of equity returns. The share demanded in the j-th stock index increases in j-th excess return, and falls in its contribution to overall risk. The second term is the country specific hedge portfolio of Adler and Dumas (1983). When relative risk aversion exceeds 1, the portfolio share of j-th stock index increases if the correlation between country l inflation and j-th nominal returns is positive. This ensures that the j-th stock index is a good hedge against increases in the price of country l consumption goods. The third is the industry-country specific hedge portfolio built to hedge labor income risk. We maintain that investors who work in the same industry and country face common labor income risk. Consequently they share the same hedging portfolio against this type of risk. The portfolio share of j-th stock index increases if the correlation between wage risk in industry s in country l has negative correlation with the j-th nominal return. If the correlation between each industry wage of country l and the j-th nominal return is equal, then we obtain the optimal portfolio composition of Coën (2001). Clearly, the optimal portfolio coincides with the myopic portfolio for all investors when investors' specific background risks are neglected.

More precisely, in the particular case of $\eta = 0$ there is no labor income and the optimal portfolio reduces to the Adler and Dumas (1983) formulation in which there is only the inflation-hedging component in addition to the logarithmic one. Furthermore, if the investor's risk aversion is equal to one ($\lambda = 1$), then the inflation-hedging component is null and the optimal portfolio reduces to the logarithmic one common to all investors.

It should now become clear why the choice of which labor income to hedge is extremely relevant. Wages may be acyclical at industry level, while they tend to be cyclical at the country level (Barsky and Solon, 1989). Thus considering the correlations between aggregate wages - as opposed to industry wages - and stock returns is likely to imply very different portfolio strategies.

2.3 Equilibrium

We impose the market clearing condition, requiring that the vector of equity supply in the N countries equals the vector of equity demand.[7] When both vectors are expressed as shares, we have:

$$\mathbf{MS} = \sum_{sl} \psi^{sl} \mathbf{w}^{sl} \tag{8}$$

where $\mathbf{MS}$ is the market portfolio, i.e. the vector of shares of each equity market over total world capitalization, and ψ^{sl} represents the wealth of industry s in country l as a fraction of total world wealth (accordingly, ψ^{l} represents the wealth of country l as a fraction of total world wealth). Substituting (7) into (8) we obtain the following equilibrium condition:

$$\mathbf{MS} = \ \mathbf{\Omega}^{-1}\left[\frac{\frac{1}{\lambda}}{(1-\eta)}(\boldsymbol{\mu} - r\mathbf{i}) + \frac{(1-\frac{1}{\lambda})}{(1-\eta)}\sum_{l}\psi^{l}\varpi^{l} - \frac{\eta}{(1-\eta)}\sum_{sl}\psi^{sl}\kappa^{sl}\right] \tag{9}$$

Substituting the market clearing condition back into the equity portfolio we can rewrite the final equilibrium portfolio as:

$$\mathbf{w}^{sl} = \mathbf{MS} + \frac{(1-\frac{1}{\lambda})}{(1-\eta)}\mathbf{\Omega}^{-1}\left[\left(\varpi^{l} - \sum_{l}\psi^{l}\varpi^{l}\right)\right] - \frac{\eta}{(1-\eta)}\mathbf{\Omega}^{-1}\left[\left(\boldsymbol{\kappa}^{sl} - \sum_{sl}\psi^{sl}\kappa^{sl}\right)\right] \tag{10}$$

where $\sum_{l}\psi^{l}\varpi^{l}$ captures the average world covariance between country inflation rates and equity returns, while $\sum_{sl}\psi^{sl}\kappa^{sl}$ measures the average world covariance between industry labor income and equity returns. In equilibrium investor sl's optimal portfolio is made of the market portfolio, which is universally efficient if background risks are neglected, and two hedging components.

The first hedging component indicates that investor sl's allocation to equity j is higher than the j-th market share when the covariance of the j-th return with country l inflation is higher than the world average inflation covariance. The second hedging component indicates that investor sl's allocation to equity j is higher the lower is the covariance between the j-th return and wage growth in industry sl with respect to the world average wage covariance.

Equation (9) can also be used in order to derive equilibrium risk premia. The inflation and labor income

[7] The following condition says that the net supply of bonds is zero and of equities is the capitalization of the relevant equity market.

hedging demands affect the equilibrium equity premia, leading to a reformulation of the International CAPM (Adler and Dumas,1983) with industry specific human capital. In a recent work, Eiling (2006) finds evidence of the ability of human capital returns at the industry level to account for a large portion of observed returns.[8] While this evidence is in line with our approach, we do not pursue asset pricing issues and focus on portfolio implications.

2.4 Implications

The first implication of the model concerns the role of international equity markets in diversifying industry wage risk. Assume that wage growth rates in all the industries in country l exhibit the same comovement with the index return j, i.e.:

$$cov(h^{sl}, R_j) = cov(h^l, R_j) \qquad \forall s \tag{11}$$

where h^{sl} is the wage growth rate prevailing in industry s country l, h^l is the average wage growth in country l and R_j is the nominal return on equity index j. Then we would obtain that the portfolio composition $\mathbf{w}^l$ is optimal for all industries in country l[9]:

$$\mathbf{w}^{sl} = \mathbf{w}^l \quad \forall s \tag{12}$$

When (11) or, indifferently, (12) holds, the portfolio suitable to hedge risks associated with the average national labor income in country l (that we call the "national restricted portfolio") is also optimal for hedging labor income risks at industry level sl. This result would indicate no role for hedging industry risk in international equity markets. It would thus extend, to an equilibrium setting with international diversification, partial equilibrium results referring to domestic asset allocation (Campbell et al., 2001; Davis and Willen, 2000). Furthermore, result (12) would suggest no difference in the equity portfolio of occupational pension funds and open-end pension funds.[10]

If (12) does not hold, then there is scope for delineating optimal investment strategies suitable to hedge labor income risk at the industry level - a specific role for occupational pension funds.

A second implication concerns the *home bias* puzzle, defined in the literature as the difference between

[8] The performance of the static CAPM improves the adjusted R^2 of estimated equations by 6% when aggregate human capital is included and by 36% when industry specific human capital is considered.

[9] In this case, our model replicates Coën (2001) where all risks are country specific.

[10] We cannot test for equality of actual pension funds holdings, because of data availability. Indeed the industry classification common to the three investing countries does not in general coincide with that of occupational pension funds.

the actual and the smaller implied equilibrium position of country l in its own domestic equity market. When restriction (12) is implicitly imposed, the quasi perfect correlation between human capital and assets returns at the national level leads to an implied equilibrium short position in domestic assets. This widens the *home bias* (Baxter and Jermann, 1997). Bottazzi et al. (1996), using a different sample period and a different econometric model, find an optimal long position in domestic assets which reduces the *home bias*. Palacios-Huerta (2001) solves the puzzle by considering stockholders' rather than aggregate human capital, as well as by relaxing assumptions maintained in the static ICAPM.

In our framework, the equilibrium position in domestic equity, and hence the *home bias*, is the result of the aggregation of industry specific portfolios, which in turn depends on the covariance between industry specific wage growth rates and the returns on equity. We juxtapose the aggregate industry specific portfolios, which we call the "national unrestricted portfolio", defined as $\sum_s \nu^{sl}\mathbf{w}^{sl}$[11], to the national restricted one obtained by imposing (12).

3 Empirical Analysis: Data and Methodology

3.1 Data

We consider three investing countries -US, Canada and Italy- for which monthly data on wages at industry level are available. Data are drawn for the US from the *Current Employment Statistics*, for Canada from the *Survey of Employment, Payrolls and Hours* and for Italy from *Retribuzioni e Lavoro, ISTAT*. The coarser industry level disaggregation for the Italian labor markets forces us to consider only seven industries within each country: Financials, Leisure, Manufacturing, Trade, Transports and Communications, Utilities, Other Services.

In Canada these labor statistics are available since 1997, only. Thus we use data over 1997:01 - 2004:12, for a total of 96 observations. We then derive 84 overlapping annual observations on the corresponding growth rates prevailing over 1998:01 to 2004:12. We thus have enough information to consistently estimate the relationship of wage growth and inflation rates with financial returns.

Annual stock market capitalization and total returns -in local currencies- are drawn from Datastream Equity Indexes for ten destination countries: Canada, France, Germany, Italy, Japan, Netherlands, Sweden, United Kingdom, United States, Rest of the World. In the empirical implementation we assume that investors completely hedge exchange rate risk, i.e. we keep all variables expressed in local currencies.[12]

[11] The national unrestricted portfolios are obtained by aggregating across industries the industry-based portfolios within each country. In the aggregation, the relative weight ν^{sl} of industry s in country l is measured by the total labor compensation paid by industry sl with respect the total labor compensation paid in country l .

[12] Baxter and Jermann (1997) adopt the same approach.

Finally, inflation rates are based on CPI indices from the *IMF International Financial Statistics.*

In Table 1 we report the mean and standard deviations of nominal industry wage growths in the three investing countries from which it can be evidenced that they are comparable across the three countries. Importantly, heterogeneity across industries emerges when considering correlations of industry nominal wages with the respective national wage growth in Table 2.[13] Over the whole sample period, US correlations range from -0.33 to 0.80, from -0.42 to 0.73 for Canada and from 0.01 to 0.73 for Italy, evidencing a lower degree of heterogeneity in Italy.

Table 3 displays the mean and standard deviation of stock returns for the ten destination countries so as to complete the overview of the relevant variables.

3.2 Methodology

In order to compute the equilibrium allocations in (10), we directly observe in the data the vector of market shares MS while we obtain the hedging components from regression analysis, following Cooper and Kaplanis (1994). The term $\mathbf{\Omega}^{-1}\left[\left(\varpi^l - \sum_l \psi^l \varpi^l\right)\right]$ is the vector $\mathbf{b}^l$ of coefficients of the multiple regression of $(\mathbf{p}^l - \sum_l \psi^l \mathbf{p}^l)$ -where $\mathbf{p}^l$ is the inflation rate of country l- on the vector of realized nominal returns $\mathbf{R}$.

$$\mathbf{\Omega}^{-1}\left(\varpi^l - \sum_l \psi^l \varpi^l\right) = \mathbf{b}^l \equiv \begin{pmatrix} b_1^l \\ \vdots \\ b_j^l \\ \vdots \\ b_N^l \end{pmatrix} \tag{13}$$

Similarly, the labor income component, $\mathbf{\Omega}^{-1}\left(\boldsymbol{\kappa}^{sl} - \sum_{sl} \psi^{sl} \boldsymbol{\kappa}^{sl}\right)$ coincides with the vector $\mathbf{q}^{sl}$ of coefficients of the multiple regression of $(\mathbf{x}^{sl} - \sum_{sl}^{S,L} \psi^{sl}\mathbf{x}^{sl})$ onto the vector of realized nominal returns $\mathbf{R}$, where $\mathbf{x}^{sl}$ is the rate of change of labor income in industry s-country l:

$$\mathbf{\Omega}^{-1}\left(\boldsymbol{\kappa}^{sl} - \sum_{sl} \psi^{sl} \boldsymbol{\kappa}^{sl}\right) = \mathbf{q}^{sl} \equiv \begin{pmatrix} q_1^{sl} \\ \vdots \\ q_j^{sl} \\ \vdots \\ q_N^{sl} \end{pmatrix} \tag{14}$$

[13] Persistent heterogeneity is a common finding. On the one hand, wage growth displays a different cyclical pattern at the industry and at the aggregate level (Barsky and Solon, 1989). On the other hand, the labor contribution to total factor productivity varies considerably across industries and persists over time (Jorgenson et al., 2005; Corrado et al. 2007).

For each industry sl, we obtain the $\mathbf{q}^{sl}$ hedging coefficients to compute the industry portfolios. The weighted aggregation across industries, where weights are taken from the relative labor compensation in each industry sl, is what we call the "national unrestricted portfolio", i.e. the country l portfolio obtained by aggregating the S industry-based portfolios of that country.

For each country l, we also obtain the national restricted portfolio suitable to hedge risks attached to the average labor income process by estimating the $\mathbf{q}^l$ hedging coefficients: thus, we also run a regression where the dependent variable is the deviation of the average national wage rate from the average world wage rate.

In the above regressions we proxy the wealth shares (ψ) with the market shares (MS) as in Cooper and Kaplanis (1994) and Adler and Dumas (1983). Contemporaneous returns are instrumented with lagged returns, and estimation is performed through GMM.[14] We thus run one regression for each country l to obtain the inflation hedging coefficients $\mathbf{b}^l$ (13):

$$(p^l - \sum_l MS^l p^l)_t = b_0^l + \sum_{j=1}^{J} b_j^l R_{j,t} + \varepsilon_t^l \tag{15}$$

and one regression for each industry sl to obtain the industry specific labor income hedging coefficients $\mathbf{q}^{sl}$ (14):

$$(x^{sl} - \sum_{sl} MS^{sl} x^{sl})_t = q_0^{sl} + \sum_{j=1}^{J} q_j^{sl} R_{j,t} + \upsilon_t^{sl} \tag{16}$$

In our analysis, we investigate the ability of financial returns to hedge inflation and labor income risks at annual frequency. We use monthly observations on overlapping annual equity returns, wage growth and inflation rates so to have enough information to consistently estimate parameters. We correct for the induced serial correlations in the errors with the Newey-West method to obtain consistent standard errors.[15]

Under the new notation, the j-th element of the vector of equilibrium allocations in (10) is equal to:

$$w_j^{sl} = MS_j + \frac{(1-\frac{1}{\lambda})}{(1-\eta)} b_j^l - \frac{\eta}{(1-\eta)} q_j^{sl} \tag{17}$$

The coefficients λ and η are exogenous parameters. The risk aversion parameter λ is set equal to 5.[16]

[14] We have also conducted a Three-Stages-Least-Squares estimation to account for correlation between wage growth rate and inflation rate. We estimated within a system all equations for the inflation hedging coefficient and for labor hedging coefficients in all industries. The estimated coefficients are unaffected and the standard errors do not significantly alter results with respect to the case of applying directly the GMM method to the system. We therefore opt for the latter as it provides robust standard errors of estimates.

[15] Boudoukh and Richardson (1993), among others, apply the same correction when looking at the inflation-stock returns regression with overlapping returns.

[16] In our simulations we consider alternative values for the coefficient of relative risk aversion λ in the range $\{2, 10\}$, as commonly proposed by the literature. Our findings on portfolio compositions are similar under different degrees of risk aversion. So we report results only for the case of risk aversion equal to five.

The parameter η is set equal to the world average labor share (0.63).[17]

4 Empirical Analysis: Results

In this section we present the equilibrium allocations implied by equation (10), after estimating the hedging coefficients $\mathbf{b}^l$ and $\mathbf{q}^{sl}$ in regressions (13) and (14).

The resulting portfolio shares at industry level, w^{sl}, are reported in Tables from 4 to 6, columns 1 to 7. These are obtained considering only the statistically significant (at ten percent confidence level) hedging coefficients b_j^l and q_j^{sl}. We set to zero the non significant ones, therefore imposing that the corresponding labor (or inflation) hedging portfolio weight is null. [18] Column 8 reports the national unrestricted portfolio obtained as the weighted sum of all optimal industry portfolios. Column 9 displays the national restricted portfolios obtained when restriction (12) is imposed and the equilibrium allocation hedges the country-level background risk. Column 10 reports, for reference, the vector of market shares MS of the destination countries: if neither the inflation hedging nor the labor income hedging are important then the optimal portfolio will be equal to the market share of destination countries.

Columns 1 to 7 in Table 4 show that, in the US, industry specific allocations are quite different from each other. US workers in Manufacturing invest 0.50 of their portfolio in US equity (above the US market share, MS_{US}), shorting German shares (-0.12). On the contrary, a US worker in the Leisure industry holds in US equity a share lower than MS_{US} (0.28) and higher than MS_{GE} (0.09) in German equity. These patterns can be traced back to $q_{US}^{man,US}$ relative to $q_{US}^{leis,US}$. Indeed, it is the case that the correlation of wage growth in US Leisure (Manufacturing) with US equity is higher (lower) than the world average wage correlation. The opposite holds for correlations with German equity returns.

Industry-based portfolios are diverse in Canada and Italy as well. The range of domestic investment is {0.00 - 0.24} for Canadian industries (see Table 5) and {–0.18, 0.02} for Italian industries (Table 6). In Canada, workers in Trade are long in Dutch shares (0.20) but should short UK shares (-0.04) while those in Transport would short Dutch shares (-0.20) and long UK equity (0.24). In Italy, heterogeneity of portfolio shares in foreign stock indexes across industries is smaller, and similarities do not seem to be confined to Euro-area stock indexes. Industry portfolios differ also in the fraction each industry optimally invests in the risk free asset, ranging from -0.15 to 0.17 for US, from -0.47 to -0.19 for Canada and from -0.10 to 0.22 for Italy.

[17] Campbell (1996) suggests that the ratio of human wealth to total wealth is about two-thirds, since 2/3 of the national GDP goes to labor. The choice of a specific level of η, should not affect our conclusions about the heterogeneity of optimal portfolios across industries.

[18] The resulting portfolio allocations are - if anything - biased against our conjecture that hedging labor income risk at industry level is relevant. Portfolio shares including all coefficients are available upon request.

In the following sections we subject these preliminary observations to robustness checks. We first scrutinize the relative size of inflation and labor income hedging components (4.1). We then test for heterogeneity of the optimal portfolio compositions across different industries, which provides insight on the role of equity markets in hedging industry wage risk (4.2).

4.1 Hedging motives: labor income and inflation risk

Tables 4-6 say nothing about the relevance of different hedging components. The distance between the market shares, **MS**, and the implied equilibrium industry holdings could be associated with either small labor hedging components and large inflation ones, or *vice versa*. In this section we focus on the relative importance of the two.

We report the weight of the labor hedging component across industries in each country in Tables 7a-9a, while in Tables 7b-9b we display the weight of the labor income hedging portfolio relative to the market share. These tables reveal relevant labor-hedging motives even when considering only statistically significant coefficients. Previous research on the correlation between aggregate equity returns and occupation-related shocks to individual wage profiles suggested instead a small or negligible labor hedging component. [19] However, the observed response of actual asset holdings to permanent income risk also suggests a non-zero correlation between household labor income and risky returns (Angerer and Lam, 2008). Looking at domestic positions, the relative weight of the labor hedging component ranges from -0.24 to 0.28 in the US, from -3.28 to 4.54 in Canada and from -8.29 to -7.87 in Italy. In some industries, such as US Manufacturing, labor income hedging requires workers to be long in domestic equities, while these should be shorted by four other US industries and disregarded by two (Table 7b). A similar pattern emerges for foreign equities. For instance, the relative labor hedging component in German equities ranges from -6.43 for a US Transportation worker to 9.72 for a US Utilities worker.[20] Table 8b shows that higher heterogeneity characterizes implied industry portfolios in Canada, although fewer hedging coefficients differ significantly from zero.

The extent of heterogeneity among Italian industry portfolios is rather low, compared with US and Canada, considering that very few stock indices should be held for labor hedging purposes by a small number of investing industries. Only two investing industries (ITA Financials and ITA Transport) should hedge labor income risk through international equity diversification - i.e. by investing in at least four out of ten stock markets. Moreover, three equity indices would be totally disregarded for labor hedging purposes by all industries.

[19] Campbell et al. (2001) find that the sensitivity of income innovations to aggregate domestic equities is insignificant for many occupations. Davis and Willen (2000) confirm such result, but uncover correlation between the occupational component of individual income shocks and returns to size and industry based portfolios.

[20] The corresponding range in terms of the labor hedging component, i.e. not rescaled by the market share (see Table 7a), is {-0.23, 0.34}.

Column 9 of each table reports the inflation hedging component, which is common to all industries in a country. Our findings point to a modest role of several international equity markets in hedging inflation risk. Five out of ten destination stock indices turn out to have no significant hedging role for US inflation risk. Moreover, US equities are shorted by US investors. On the contrary, six equity indices are significantly useful to hedge inflation risk for Canadians, who also have an implied long position in domestic equities. Finally, equity markets play a little role in hedging Italian inflation risk: eight stock indices, including the domestic one, are not significantly correlated with domestic inflation.

For comparison, Column 8 of Tables 7-9 displays the labor hedging component in the national unrestricted portfolio, obtained by aggregating the labor hedging components at industry level weighted by labor income compensation. Summing up values in Columns 8 and 9 we obtain the total hedging component in the national unrestricted portfolio (Column 10). Such component can be interpreted as the equilibrium portfolio share, due to the hedging motives of all industries in a country. For all the three countries considered, labor hedging motives seem to prevail on inflation hedging ones in determining departure of the optimal aggregate demand from the **MS**.

Yet, this perspective even underestimates the size of the aggregate labor hedging motive, as positive and negative positions in industry-specific portfolios offset each other in the aggregation procedure. Table 10 provides an alternative measure of the size of the labor hedging motive, that is the weighted average - across industries- of the *absolute* values of labor hedging components, by destination countries (Columns 3 and 4). Columns 1 and 2 display, by destination stock indices, the absolute size of the inflation hedging components. The last row in each panel reports the sum of the hedging components for all destination countries. This is the sum of the (absolute) portfolio positions specifically designed to hedge inflation (Columns 1 and 2) or industry risk (Columns 3 and 4). Comparison between Column 2 and 4, which account for statistically significant coefficients only, evidences that the labor hedging motive is stronger than the inflation hedging one in all investing countries. A cross country comparison reveals that both hedging motives appear to be stronger in US and Canada than in Italy.[21]

Column 5 and 6 of Table 10 report the absolute value of the labor hedging component in the national restricted portfolio. Ignoring heterogeneity across industries leads to underestimate the labor hedging motive, as the weighted average of labor hedging component across industries (Column 4) exceeds the size of the labor hedging in the national restricted portfolio (Column 6). This result suggests that both the size and the heterogeneity of labor hedging components across industry matter. In the following section we subject heterogeneity to a statistical test.

[21] The small size of the labor hedging component for Italy supports the conjecture that centralized wage setting smoothes wage shocks, possibly weakening the link with financial shocks.

4.2 Hedging industry-specific labor income risk

So far we maintained the assumption that restriction (12) does not hold. We now test the equality of labor income hedging coefficients across investing industries (q_j^{sl}) by estimating the regressions (16) for the seven industries within the same country in a system. The result of this test reveals whether hedging wage risk requires industry-specific portfolios. The null hypothesis of the Wald test we perform is the following

$$Ho: \underset{i \in S}{q_j^{il}} = \underset{s \in S, s \neq i}{q_j^{sl}} \tag{18}$$

where S is the set of investing industries. Under the null, the equilibrium portfolio share held in stock index l by industry i is equal to that held by industry s.

We provide a graphical representation of the result of this test, hence of the statistical difference among the industry-based portfolios. For each and every pair of industries within a country, we count the number of significantly different coefficients. Since we have seven industries, we consider 21 possible pairs for each investing country. For each pair we count the number of significantly different labor hedging portfolio components. For instance, we check whether US workers in the trade and in the leisure industry invested the same portfolio share in Japanese stocks. We repeat this test for the other nine destination countries.

Figure 1-3 associate the number of statistically different coefficients on the horizontal axis to the number of industry-pairs on the vertical axis. Thus there are eight industry-pairs out of 21 that differ in five portfolio shares out of ten in the US. In Canada five industry-pairs out of 21 differ by seven portfolio weights out of ten. In Italy six industry-pairs differ by two portfolio weights.[22] The subtitle to each graph reports the number of statistically different coefficients as a percentage of 210 (21 pairs times 10 coefficients, one for each destination country). This is 48% for the US, 44% for Canada and 28% for Italy. Thus, it appears that an industry- tailored portfolio designed by occupational pension funds would be most valuable in the US and in Canada.

Last but not least, we perform a Wald test on the difference between the industry specific labor hedging coefficient, q_j^{il}, and the national restricted one, q_j^l.

$$Ho: \underset{s \in S}{q_j^{sl}} = q_j^l \tag{19}$$

Table 11 reports the statistically significant absolute distances between industry ($\mathbf{w}^{sl}$) and national restricted portfolio weights ($\mathbf{w}^l$). We find that such distances are large. The widest range, from 0.03 to 0.87, is observed for Canada, being 0.04-0.37 for US and 0.03-0.26 for Italy. Moreover, the number of statistically

[22] This type of test could be used in order to endogenize the optimal industry perimeter of pension funds, when there is a cost to specialized portfolio management.

significant distances is highest for US and lowest for Italy, confirming that industry-tailored portfolios are most useful to the US and Canada.

Finally, Table 12 reports portfolio dispersion measures derived over industry portfolios shown in Tables 4, 5 and 6. Table 12.I and 12.II report the measures of dispersion of optimal equity portfolios across investing industries for fully hedged and unhedged[23] positions, respectively. Panel (a) displays the standard deviation of differences between industry portfolios from the national restricted portfolio in the corresponding country.[24] These are computed weighting each difference either with the industry labor compensation (weighted) or with equal weights (unweighted). In table 12.I this is equal to 32 percentage points (pp) in the US, 42 pp for Canada and 22 pp for Italy, when we account for statistically significant weighted differences. The dispersion measures increase to 36 pp for the US, 56 pp for Canada and 25 pp for Italy when industries are equally weighted. Thus, it appears that industries with a smaller relative labor income compensation should command portfolio shares that are more distant from the national restricted one.

Panel (b) displays the standard deviation of industry portfolio weights assigned to each destination country (w_j^{sl}) evaluated with respect to the corresponding weight in the national restricted portfolio (w_j^l).[25] The standard weighted deviation is 10 pp for US, 13 pp for Canada and 7 pp for Italy. Table 12.II reports these measures of dispersion computed under the assumption that exchange rate risk is unhedged. Though the unhedged optimal portfolio compositions[26] differ substantially from the fully-hedged ones, results about heterogeneity across industry portfolios are qualitatively similar.

The extent of heterogeneity in labor income across industries, and hence the role of occupational pension funds appear to be robust independently of the metric used. They consistently appear more marked in the US and Canada than in Italy. Lower industry heterogeneity in Italy might be ascribed to stronger centralized wage setting[27], which in turn might cause lower correlation between domestic stock returns and wage growth.

4.3 Home bias and industry risk

We now assess whether hedging wage risk at the industry level resolves the *home bias* puzzle. We accomplish this by re-examining the risky portfolio composition in column 8 of Tables 4, 5 and 6. To allow for comparison with previous literature we normalize the equity portfolio shares to sum up to one. The resulting portfolio compositions are not displayed.

Hedging industry wage-risk cannot explain the puzzle. In no case we find that the aggregation of industry

[23] For each investing industry, unhedged positions are computed on series expressed in the home-currency.

[24] The measures of dispersion are derived computing standard measures of variability around the national restricted portfolio rather than around the mean. Reported measures are derived, alternatively, on all distances and on only significant distances.

[25] The measures of dispersion are explained in detail in Table 12.

[26] Not reported here, but available upon request.

[27] Indeed, Kahn (1998) and Flanagan (1999) find that wage dispersion across industries is related to centralized wage setting in a cross-country study. Italy, contrary to the US and Canada, has centralized wage setting.

equity portfolios, which sum up to the unrestricted national portfolios, match the high domestic equity holdings observed in actual portfolios and widely documented by previous literature (see Lewis, 1999). At the end of year 2003, US investors held 0.86 of their wealth in domestic equities. The corresponding figures for Canada and Italy were 0.70 and 0.58. The equilibrium weights, implied by our model, are 0.36, 0.09, and -0.01, respectively[28].

We now benchmark in more detail our results with those in previous literature. Table 13 displays the *home bias*, which is the difference between actual and optimal position in domestic assets for each investing country. Column 3, 4 and 5 report results by Baxter and Jermann (1997), Bottazzi et al. (1996)[29] and Coën (2001) respectively, while columns 6-9 report our results. Columns 6 and 7 (8 and 9) report, respectively, the *home bias* measures for the restricted national portfolio and the unrestricted one in the case exchange rate risk is fully hedged (unhedged).

According to our results, Baxter and Jermann (1997)'s prescription of going short in domestic assets does not necessarily hold. The correlation of US stock returns with wages and inflation induces an equilibrium domestic share (0.36) just below the market share (0.42). The Canadian market share and Canadian optimal domestic position are respectively equal to 0.03 and 0.09, while the corresponding digits for Italy are 0.02 and -0.01.

In order to make the comparison with Baxter and Jermann (1997) more precise we should ignore the inflation hedging component when deriving equity portfolios. Even in this case, Baxter and Jermann (1997) prescription does not necessarily hold, as going short in domestic equities is not universally optimal. For example, at the aggregate level, the Canadian labor income hedging component is positive, as four out of seven industries in Canada should be long in domestic assets.

Our results on the equilibrium portfolio suitable to hedge both inflation and labor income at the national level are directly comparable with those in Coën (2001). He finds that domestic assets do not have a role in hedging both types of risks, so the optimal portfolio weight on domestic equity does not significantly depart from its market share. He evaluates the *home bias* as the difference between the actual position in domestic equity and the market share (both at the end of 1994) finding values equal to 0.51 for US, 0.70 for Canada and 0.83 for Italy, that we report in Table 13 column 5. We report in column 6 the *home bias* corresponding to the optimal national restricted portfolio implied by our estimation analysis: it is equal to 0.56 for the US, to 0.62 for Canada and 0.56 for Italy.

Finally, comparing columns 6 and 7 in Table 13 we find that accounting for industry-based risk does not affect substantially the *home bias*. It is slightly reduced for US (0.50) and Canada (0.61), while it turns out

[28] Our results confirm Pesenti and van Wincoop (2002) findings on the limited ability of nontradables in explaining the home bias puzzle.

[29] In Table 13 we report *our* computations of the home bias according to results in Bottazzi et al. (1996).

to increase for Italy (0.59).[30]

5 Conclusions

Households often fail to attain their objectives in financial decision planning (Campbell, 2006) and institutional investors may help cope with these failures (Bodie, 2003). As pension funds' assets represent a large fraction of households' wealth in most countries [31], tracing connections between their investment strategies and households' risk exposure is relevant. The size and heterogeneity of labor income hedging components in equilibrium portfolios, implied by our estimates, suggests that pension funds may help workers smooth labour income by tailoring their international equity portfolios to industry wage risk. Our results resurrect a role for equity markets in diversifying occupational risk.

This role is especially pronounced for Canada and the US, while it appears to be weaker in Italy. This pattern could be ascribed to stronger centralized wage setting in Italy. If this conjecture is correct, the role of occupational pension funds would be reduced in countries where wage setting institutions already dampen industry wage shocks. In order to provide further evidence on this, the cross-sectional dimension of our data set should be widened. Unfortunately these data are unavailable in other countries to our knowledge.

We did not test for differences of actual portfolio holdings across pension funds, because of missing comparable cross-country data. Thus the question whether occupational pension funds do hedge industry shocks is open, but can be addressed in future research focussing on a single country. Last but not least, a one-country focus would also allow to investigate portfolio allocations with predictable (returns and) labor income growth, thanks to longer data series.

[30] Columns 8 and 9 of Table 13 report the home bias assuming that exchange rate positions are unhedged. Since unhedged portoflios differ substantially from fully-hedged ones, the home bias measures differ as well. When exchange rate risk is unhedged, the home bias is reduced and unchanged for the US and Canada respectively, while it increases for Italy.

[31] Pension funds' assets over GDP are equal to 95% for US and 52% for Canada. In Italy they are expected to grow, from the current 3%, as a consequence of social security reform (*OECD, 2004*).

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A Appendix: Optimal Portfolios

$$\underset{C^{sl},w^{sl}}{Max} \quad E\int_t^T V(C^{sl},P^l,\tau)d\tau \tag{20}$$

$$dW^{sl} = (1-\eta)\left[\sum_{j=1}^{N} w_j^{sl}(\mu_j - r) + r\right] Wdt + \eta h^{sl} Wdt - C^{sl}dt + (1-\eta)\sum_{j=1}^{N} w_j^{sl}\sigma_j W dz_j + \eta\sigma_h^{sl} W dz_h^{sl} \tag{21}$$

We provide details on the derivation of the optimal portfolio rule. The covariance between asset k and asset j is denoted by σ_{jk}, the covariance between the labor income process and the stock return j is indicated as σ_{jh}^{sl}, the covariance between the labor income process and the inflation rate is indicated as $\sigma_{\pi h}^{sl}$ and the covariance between stock return j and the inflation rate is denoted as $\sigma_{j\pi}^{l}$. The variance of the labor income process is denoted by $\left(\sigma_h^{sl}\right)^2$ while the variance of inflation rate is indicated by $\left(\sigma_\pi^l\right)^2$.

Denoting by $J(W^{sl}, P^l, t)$ the maximum value of (4) subject to (5) the Bellman principle states that its total expected rate of increase must be equal to zero:

$$\begin{aligned}
0 = \underset{C^{sl},w^{sl}}{Max} \Big[& V(C^{sl},P^l,\tau) + J_t + J_W \left\{ \left[(1-\eta)\left[\textstyle\sum_{j=1}^N w_j^{sl}(\mu_j - r) + r\right] + \eta h^{sl}\right] W^{sl} - C^{sl}\right\} + \\
& + J_P P^l \pi^l + \tfrac{1}{2} J_{W,W} \left\{ (1-\eta)^2 \textstyle\sum_{j=1}^N \sum_{k=1}^N w_j^{sl} w_k^{sl} \sigma_{jk} + \eta^2 \left(\sigma_h^{sl}\right)^2 + 2\eta(1-\eta)\sum_{j=1}^N w_j^{sl}\sigma_{jh}^{sl} \right\} \left(W^{sl}\right)^2 + \\
& + \tfrac{1}{2} J_{PP} \left(\sigma_\pi^l\right)^2 \left(P^l\right)^2 + J_{W,P} \left\{ (1-\eta)\textstyle\sum_{j=1}^N w_j^{sl}\sigma_{j\pi}^l + \eta\sigma_{\pi h}^{sl} \right\} W^{sl} P^l \Big]
\end{aligned} \tag{22}$$

The homogeneity of degree 0 of the function $V(C, P, \tau)$ implies that $J(W^{sl}, P^l, t)$ satisfying 22 be homogeneous of degree zero in W^{sl} and P^l and therefore by Euler's theorem

$$\begin{aligned}
J_P &\equiv -(W^{sl}/P^l) J_W \\
J_{P,W} &\equiv -(1/P^l) J_W - (W^{sl}/P^l) J_{W,W} \\
J_{P,P} &\equiv 2(W^{sl}/\left(P^l\right)^2) J_W + (W^{sl}/P^l)^2 J_{W,W}
\end{aligned} \tag{23}$$

Substituting into the previous expression

$$\begin{aligned}
0 = \underset{C^{sl},w^{sl}}{Max} \Big[& V(C^{sl},P^l,\tau) + J_t + J_W \left\{ \left[(1-\eta)\left[\textstyle\sum_{j=1}^N w_j^{sl}(\mu_j - r) + r\right] + \eta h^{sl}\right] W^{sl} - C^{sl}\right\} + \\
& - \tfrac{W^{sl}}{P^l} J_W P^l \pi^l + \tfrac{1}{2} J_{W,W} \, (1-\eta)^2 \textstyle\sum_{j=1}^N \sum_{k=1}^N w_j^{sl} w_k^{sl} \sigma_{jk} + \eta^2 \left(\sigma_h^{sl}\right)^2 + 2\eta(1-\eta)\sum_{j=1}^N w_j^{sl}\sigma_{jh}^{sl} \Big\} \left(W^{sl}\right)^2 + \\
& + \tfrac{1}{2} \left[2(W^{sl}/\left(P^l\right)^2) J_W + (W^{sl}/\left(P^l\right)^2) J_{W,W} \right] \left(\sigma_\pi^l\right)^2 \left(P^l\right)^2 + \\
& \left[-(1/P^l) J_W - (W^{sl}/P^l) J_{W,W} \right] \left\{ (1-\eta)\textstyle\sum_{j=1}^N w_j^{sl}\sigma_{j\pi}^l + \eta\sigma_{\pi h}^{sl} \right\} W^{sl} P^l \Big]
\end{aligned} \tag{24}$$

$$\begin{aligned}
0 = \underset{C^{sl},w^{sl}}{Max} \Big[& V(C^{sl},P^l,\tau) + J_t + J_W \left\{ \left[(1-\eta)\left[\textstyle\sum_{j=1}^N w_j^{sl}(\mu_j - r) + r\right] + \eta h^{sl}\right] W^{sl} - C^{sl}\right\} + \\
& - J_W \pi^l W^{sl} + \tfrac{1}{2} J_{W,W} \left\{ (1-\eta)^2 \textstyle\sum_{j=1}^N \sum_{k=1}^N w_j^{sl} w_k^{sl} \sigma_{jk} + \eta^2 \left(\sigma_h^{sl}\right)^2 + 2\eta(1-\eta)\sum_{j=1}^N w_j^{sl}\sigma_{jh}^{sl} \right\} \left(W^{sl}\right)^2 + \\
& + J_W \left(\sigma_\pi^l\right)^2 W^{sl} + \tfrac{1}{2} J_{W,W} \left(\sigma_\pi^l\right)^2 \left(W^{sl}\right)^2 - J_W (1-\eta) \textstyle\sum_{j=1}^N w_j^{sl}\sigma_{j\pi}^l W^{sl} - J_W \eta \sigma_{\pi h}^{sl} W^{sl} + \\
& - J_{W,W} (1-\eta) \textstyle\sum_{j=1}^N w_j^{sl}\sigma_{j\pi}^l \left(W^{sl}\right)^2 - J_{W,W} \eta \sigma_{\pi h}^{sl} \left(W^{sl}\right)^2 \Big]
\end{aligned} \tag{25}$$

$$
\begin{aligned}
0 = \underset{C^{sl},w^{sl}}{Max} \Big[& V(C^{sl},P^l,\tau) + J_t + J_W \,\{\, [\, (1-\eta)\left[\textstyle\sum_{j=1}^{N} w_j^{sl}(\mu_j - r) + r\right] + \eta h^{sl} - \pi^l + \left(\sigma_\pi^l\right)^2 + \\
& -(1-\eta)\textstyle\sum_{j=1}^{N} w_j^{sl}\sigma_{j\pi}^l - \eta\sigma_{\pi h}^{sl} \,]\, W^{sl} - C^{sl} \,\} + \tfrac{1}{2} J_{W,W} \,\{\, (1-\eta)^2 \textstyle\sum_{j=1}^{N}\sum_{k=1}^{N} w_j^{sl} w_k^{sl}\sigma_{jk} + \\
& +\eta^2\left(\sigma_h^{sl}\right)^2 + 2\eta(1-\eta)\textstyle\sum_{j=1}^{N} w_j^{sl}\sigma_{jh}^{sl} + \left(\sigma_\pi^l\right)^2 - 2(1-\eta)\textstyle\sum_{j=1}^{N} w_j^{sl}\sigma_{j\pi}^l - 2\eta\sigma_{\pi h}^{sl} \,\}\left(W^{sl}\right)^2 \,\Big]
\end{aligned} \tag{26}
$$

The derivatives with respect to $C^{sl}$and w_j^{sl} are set equal to zero to obtain FOC with respect to consumption: $V_C = J_W$ and FOC with respect to portfolio weights w_j :

$$
\begin{aligned}
& 0 = J_W \left[(1-\eta)(\mu_j - r) - (1-\eta)\sigma_{j\pi}^{sl}\right] W^{sl} + \tfrac{1}{2} J_{W,W} \left[\, 2(1-\eta)^2 \textstyle\sum_{k=1}^{N} w_k^{sl}\sigma_{jk} + \right. \\
& \left. +2\eta(1-\eta)\textstyle\sum_{k=1}^{N}\sigma_{jh}^{sl} - 2(1-\eta)\textstyle\sum_{j=1}^{N}\sigma_{j\pi}^l \,\right]\left(W^{sl}\right)^2 \\
& 0 = J_W\left[(\mu_j - r) - \sigma_{j\pi}^l\right] + J_{W,W}\left[(1-\eta)\textstyle\sum_{k=1}^{N} w_k^{sl}\sigma_{jk} + \eta\textstyle\sum_{j=1}^{N}\sigma_{jh}^{sl} - \textstyle\sum_{j=1}^{N}\sigma_{j\pi}^l\right] W^{sl}
\end{aligned} \tag{27}
$$

Defining as $-\dfrac{J_{W,W}}{J_W}W^{sl} = \lambda$ the investor relative risk aversion, we derive the nominal risk premium (6) on security j

$$
\begin{aligned}
(\mu_j - r) &= \lambda\left[(1-\eta)\textstyle\sum_{k=1}^{N} w_k^{sl}\sigma_{jk} + \eta\sigma_{jh}^{sl} - \sigma_{j\pi}^l\right] + \sigma_{j\pi}^l = \\
&= \lambda\left[(1-\eta)\textstyle\sum_{k=1}^{N} w_k^{sl}\sigma_{jk} + \eta\sigma_{jh}^{sl}\right] + (1-\lambda)\sigma_{j\pi}^l
\end{aligned} \tag{28}
$$

or, in vector notation for all securities,

$$
(\boldsymbol{\mu} - r\mathbf{i}) = \lambda\left[(1-\eta)\,\boldsymbol{\Omega}\mathbf{w}^{sl} + \eta\boldsymbol{\kappa}^{sl}\right] + (1-\lambda)\,\boldsymbol{\varpi}^l \tag{29}
$$

where $\mathbf{i}$ is a $Nx1$ vector of ones, $\boldsymbol{\mu}$ is the vector of nominal expected returns μ_j, $\boldsymbol{\Omega}$ is the NxN matrix of instantaneous covariances σ_{jk} of the nominal rates, $\boldsymbol{\varpi}^l$ is the $Nx1$ vector of covariances $\sigma_{j\pi}^l$ of the N risky securities returns with the investor's rate of inflation, $\boldsymbol{\kappa}^{sl}$ is the $Nx1$ vector of covariances σ_{jh}^{sl} of the N risky securities returns with the investor's rate of wage growth.

Consistent with Adler and Dumas (1983) and Coën (2001), (29) shows how the equity premium required by investor sl is linked to its background risks. Solving for the optimal portfolio weights

$$
\mathbf{w}^{sl} = \frac{\frac{1}{\lambda}}{(1-\eta)}\boldsymbol{\Omega}^{-1}(\boldsymbol{\mu} - r\mathbf{i}) + \frac{(1-\frac{1}{\lambda})}{(1-\eta)}\boldsymbol{\Omega}^{-1}\boldsymbol{\varpi}^l - \frac{\eta}{(1-\eta)}\boldsymbol{\Omega}^{-1}\boldsymbol{\kappa}^{sl} \tag{30}
$$

By considering also the $(N+1)$-th weight, that is the risk-free asset, we derive portfolio allocation (7) for the investor living in country l and working in industry s.

The portfolio allocation for investor sl is:

$$
\mathbf{w}^{sl} = \frac{\frac{1}{\lambda}}{(1-\eta)}\underbrace{\begin{pmatrix}\boldsymbol{\Omega}^{-1}(\boldsymbol{\mu} - r\mathbf{i}) \\ 1 - \mathbf{i}'\boldsymbol{\Omega}^{-1}(\boldsymbol{\mu} - r\mathbf{i})\end{pmatrix}}_{\text{logarithmic portfolio}} + \frac{(1-\frac{1}{\lambda})}{(1-\eta)}\underbrace{\begin{pmatrix}\boldsymbol{\Omega}^{-1}\boldsymbol{\varpi}^l \\ 1 - \mathbf{i}'\boldsymbol{\Omega}^{-1}\boldsymbol{\varpi}^l\end{pmatrix}}_{\pi-\text{ hedging portfolio}} - \frac{\eta}{(1-\eta)}\underbrace{\begin{pmatrix}\boldsymbol{\Omega}^{-1}\boldsymbol{\kappa}^{sl} \\ 1 - \mathbf{i}'\boldsymbol{\Omega}^{-1}\boldsymbol{\kappa}^{sl}\end{pmatrix}}_{h-\text{ hedging portfolio}} \tag{31}
$$

where $\mathbf{i}$ is a $N-$vector of ones, $\boldsymbol{\Omega}$ is a (NxN) matrix of instantaneous variances-covariances $\sigma_{j,k}$ of nominal rates of returns, $\boldsymbol{\varpi}^l$ is a $N-$vector of covariances $\sigma_{j,\pi}^l$ between nominal equity return in country j and country l's rate of inflation and $\boldsymbol{\kappa}^{sl}$ is a $N-$vector of covariances σ_{jh}^{sl} between nominal equity return j and investor sl's labor income growth.

Table 1. Nominal wages (Annual Rate of Growth). Descriptive statistics

The table reports descriptive statistics (means and standard deviations) for the annual rates of growth of nominal wages for the three countries (US, Canada and Italy). Nominal wages are considered at both national and industry level (seven industries are included: Financials, Leisure, Manufacturing, Trade, Transports and Communications, Utilities, Other Services). Series are expressed in national currency. The sample period is Jan 1998: Dec 2004. Source: for US data *Current Employment Statistics*, for Canadian data *Survey of Employment, Payrolls and Hours*, for Italian data *Retribuzioni e Lavoro, ISTAT.*

	USA		Canada		Italy	
Investing industries	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**
Trade	0.03	0.02	0.02	0.01	0.03	0.02
Utilities	0.03	0.02	0.02	0.02	0.02	0.02
Transport	0.02	0.02	0.01	0.02	0.02	0.02
Other svs	0.04	0.01	0.02	0.01	0.02	0.02
Manufact	0.03	0.01	0.02	0.02	0.03	0.01
Financial	0.04	0.01	0.02	0.01	0.02	0.01
Leisure	0.03	0.02	0.01	0.04	0.02	0.02
National	0.03	0.01	0.02	0.01	0.02	0.01

Table 2. National and Industry Nominal Wages (Annual Rate of Growth)- Correlations

The table reports, for each country, contemporaneous correlations between national (rows) and industry (columns) specific annual rates of growth of nominal wages for the sample period (1998-2004). Source: for US data *Current Employment Statistics*, for Canadian data *Survey of Employment*, for Italian data *Retribuzioni e Lavoro, ISTAT.*

trade	util	transp	other	manufact	fin	leisure
			USA			
0.67	0.13	-0.15	0.62	**-0.33**	0.71	**0.80**
			Canada			
-0.14	**-0.42**	0.00	**0.73**	0.50	0.38	0.55
			Italy			
0.01	0.38	0.38	0.18	**0.73**	0.27	0.31

Table 3. Nominal stock returns (annual). Descriptive statistics

The table reports descriptive statistics of annual stock indices in local currency for ten destination countries -Canada, France, Germany, Italy, Japan, Netherlands, Sweden, United Kingdom, United States, Rest of the World. The sample period is Jan 1998- Dec 2004. Source: *Datastream Stock Indices.*

	Mean	Std.Dev.
Ca	0.12	0.25
Fr	0.13	0.26
It	0.06	0.37
Jp	0.05	0.20
Nl	0.13	0.36
Sw	0.07	0.20
UK	0.08	0.20
US	0.07	0.27
Ge	0.14	0.29
Rest	0.03	0.26

Table 4. Optimal portfolios for US workers

The table reports optimal equity portfolio shares in 10 equity indexes (rows) for a US investor working in one of seven industries (columns). The last row in each portfolio represents the share invested in risk free assets. In each panel, the first seven columns report the optimal equity portfolio suitable to hedge both the national inflation risk and the industry-specific labor income risk while the eighth column reports the optimal equity portfolio suitable to hedge the national inflation risk and the national average labor income risk. The last column reports, for comparison, the market share for each destination country: this is the efficient in absence of background risk. The table reports the optimal equity portfolio composition derived considering only significant coefficients (at 10% confidence level).

	USA									
								National		
	trade	**util**	**transp**	**other**	**manuf**	**fin**	**leis**	**unrestr**	**restr**	**market share**
Ca	0.24	0.30	0.14	0.08	0.04	0.13	0.25	0.12	0.15	0.03
Fr	0.17	0.17	0.17	-0.05	0.29	0.17	0.17	0.14	0.04	0.05
It	-0.02	-0.02	-0.02	0.16	-0.10	0.10	0.11	0.06	0.09	0.02
Jp	0.11	0.19	0.11	0.18	0.05	0.11	0.11	0.12	0.16	0.11
Nl	0.02	0.02	0.36	0.02	-0.17	-0.24	0.02	-0.10	0.02	0.02
Sw	-0.10	-0.33	0.09	-0.05	0.08	-0.08	-0.13	-0.05	-0.05	0.01
UK	0.09	-0.15	0.09	0.09	0.16	0.09	-0.08	0.09	0.09	0.09
US	0.30	0.38	0.38	0.32	0.50	0.30	0.28	0.34	0.32	0.42
Ge	0.09	0.30	-0.27	0.09	-0.12	-0.04	0.09	-0.01	0.04	0.04
Rest	0.22	0.12	0.10	0.22	0.22	0.28	0.22	0.24	0.22	0.22
T-bill	-0.09	0.02	-0.15	-0.06	0.05	0.17	-0.05	0.04	-0.07	-

Table 5. Optimal portfolios for Canadian workers

This table reports the optimal equity portfolios shares invested in 10 equity indexes (rows) by a Canadian investor working in one of the seven industries (columns). Otherwise the table mirrors Table 4.

	Canada									
								national		
	trade	**util**	**transp**	**other**	**manuf**	**fin**	**leis**	**unrestr**	**restr**	**market share**
Ca	0.14	0.24	0.21	0.10	0.16	0.00	0.10	0.11	0.10	0.03
Fr	0.05	0.05	0.05	0.05	0.24	0.05	-0.54	0.05	0.05	0.05
It	0.18	0.18	0.18	0.28	0.06	0.18	1.06	0.24	0.18	0.02
Jp	0.20	0.20	0.20	0.20	0.20	0.20	0.42	0.21	0.20	0.11
Nl	0.20	0.02	-0.20	-0.19	0.02	0.02	-0.76	-0.08	0.02	0.02
Sw	-0.09	-0.09	-0.09	-0.09	-0.09	0.07	-0.29	-0.08	-0.09	0.01
UK	-0.04	0.09	0.24	-0.04	0.09	0.29	0.09	0.06	0.09	0.09
US	0.33	0.09	0.33	0.56	0.33	0.33	0.33	0.41	0.39	0.42
Ge	0.11	0.31	0.11	0.11	0.11	0.11	0.49	0.14	0.11	0.04
Rest	0.22	0.22	0.22	0.22	0.22	0.22	0.40	0.23	0.22	0.22
T-bill	-0.31	-0.30	-0.24	-0.19	-0.34	-0.47	-0.31	-0.29	-0.26	-

Table 6. Optimal portfolios for Italian workers

This table reports the optimal portfolio shares in 10 equity indexes (rows) by an Italian investor working in one of the seven industries (columns). Otherwise the table mirrors Tables 4 and 5.

	Italy									
								national		
	trade	util	transp	other	manuf	fin	leis	unrestr	restr	market share
Ca	0.03	0.20	0.20	0.03	0.12	0.03	0.21	0.09	0.09	0.03
Fr	0.05	0.05	0.05	0.05	0.05	0.26	0.05	0.03	0.05	0.05
It	0.02	-0.17	0.02	0.02	0.02	-0.18	0.02	-0.07	0.02	0.02
Jp	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Nl	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07	0.02
Sw	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-0.02	0.01	0.01
UK	0.09	0.09	-0.17	0.09	0.09	0.30	-0.19	0.20	0.09	0.09
US	0.42	0.42	0.42	0.51	0.42	0.56	0.42	0.51	0.49	0.42
Ge	0.12	0.12	0.25	0.12	0.12	-0.05	0.12	0.05	0.12	0.04
Rest	0.22	0.06	0.11	0.22	0.13	0.14	0.09	0.17	0.17	0.22
T-bill	0.00	0.18	0.08	-0.08	0.00	-0.10	0.22	0.00	-0.07	-

Table 7a. Hedging components by US investing industries

This table reports, for each US investing industry, the labor and inflation hedging components. Columns 1 – 7 report the labor income hedging component at industry level. Column 8 reports the labor hedging component in the unrestricted national portfolio. Column 9 reports the inflation hedging component which is common to all industries. In the last column the total (labor plus inflation) hedging component for the national unrestricted portfolio is reported. The table considers portfolios where only statistically significant coefficients (at 10% confidence level) are considered. Minimum and maximum figures are in bold face (only values deriving from significant coefficients are considered).

	USA									
	Labor Hedge								Infl Hedge	Tot Hedge
	trade	util	transp	other	manuf	fin	leis	nat. unrestr.		
Ca	0.16	**0.22**	0.07	-	**-0.04**	0.06	0.18	0.05	0.05	0.09
Fr	-	-	-	**-0.22**	**0.12**	-	-	-0.03	0.12	0.09
It	-	-	-	**0.18**	**-0.08**	0.12	0.13	0.08	-0.05	0.04
Jp	-	**0.08**	-	0.07	**-0.06**	-	-	0.01	-	0.01
Nl	-	-	**0.35**	-	-0.19	**-0.26**	-	-0.12	-	-0.12
Sw	-0.12	**-0.34**	**0.08**	-0.06	0.07	-0.09	-0.14	-0.06	-	-0.06
UK	-	**-0.24**	-	-	**0.08**	-	-0.17	0.01	-	0.01
US	-0.09	-	-	-0.06	**0.12**	-0.08	**-0.10**	-0.04	-0.04	-0.08
Ge	0.13	**0.34**	**-0.23**	0.13	-0.08	-	0.13	0.03	-0.08	-0.04
Rest	-	-0.10	**-0.12**	-	-	**0.07**	-	0.02	-	0.02

Table 7b. Relative hedging components by US investing industries

This table reports, for each US investing industry, the ratio of the labor and inflation hedging component to market share: it contains the same figures as in table 7a scaled by the market share of the destination country. The table considers portfolios where only statistically significant coefficients (at 10% confidence level) are considered. Minimum and maximum ratios are in bold face (only ratios corresponding to significant coefficients are considered).

	USA									
	(Labor Hedge)/MS								Infl Hedge MS	Tot Hedge MS
	trade	util	transp	other	manuf	fin	leis	nat. unrestr.		
Ca	5.36	**7.36**	2.25	-	**-1.28**	1.97	5.90	1.57	1.53	3.10
Fr	-	-	-	**-4.81**	**2.73**	-	-	-0.73	2.72	1.98
It	-	-	-	**7.46**	**-3.11**	4.95	5.44	3.42	-1.89	1.53
Jp	-	**0.78**	-	0.64	**-0.56**	-	-	0.07	-	0.07
Nl	-	-	**17.80**	-	-9.87	**-13.51**	-	-6.23	-	-6.23
Sw	-10.62	**-30.91**	**7.18**	-5.58	6.14	-8.01	-12.52	-5.24	-	-5.24
UK	-	**-2.73**	-	-	**0.90**	-	-1.93	0.07	-	0.07
US	-0.21	-	-	-0.14	**0.28**	-0.18	**-0.24**	-0.09	-0.10	-0.19
Ge	3.57	**9.72**	**-6.43**	3.78	-2.30	-	3.80	0.97	-2.15	-1.18
Rest	-	-0.47	**-0.54**	-	-	**0.32**	-	0.10	-	0.10

Table 8a. Hedging components by Canadian investing industries

Table 8a reports, for each Canadian investing industry, the labor and inflation hedging component. Otherwise the table is the same as Table 7a.

	Canada									
	Labor Hedge								Infl Hedge	Tot Hedge
	trade	util	transp	other	manuf	fin	leis	nat. unrestr.		
Ca	0.04	**0.14**	0.11	-	0.06	**-0.10**	-	0.01	0.07	0.08
Fr	-	-	-	-	**0.20**	-	**-0.59**	0.01	-	0.01
It	-	-	-	0.10	**-0.12**	-	**0.87**	0.06	0.16	0.21
Jp	-	-	-	-	-	-	**0.23**	0.01	0.09	0.10
Nl	**0.19**	-	-0.22	-0.21	-	-	**-0.78**	-0.10	-	-0.10
Sw	-	-	-	-	-	**0.16**	**-0.20**	0.01	-0.10	-0.09
UK	**-0.13**	-	0.15	-0.12	-	**0.20**	-	-0.02	0.00	-0.02
US	-	**-0.24**	-	**0.22**	-	-	-	0.07	-0.09	-0.02
Ge	-	**0.20**	-	-	-	-	**0.38**	0.02	0.08	0.10
Rest	-	-	-	-	-	-	**0.19**	0.01	-	0.01

Table 8b. Relative hedging components by Canadian investing industries

Table 8b reports, for each Canadian investing industry, the ratio of the labor and inflation hedging component to market share: it contains the same figures as in table 8a but scaled by the market share of the destination country. Otherwise the table is the same as Table 7b.

Canada										
	(Labor Hedge)/MS								Infl Hedge MS	Tot Hedge MS
	trade	util	transp	other	manuf	fin	leis	nat. unrestr.		
Ca	1.40	**4.54**	3.71	-	1.93	**-3.28**	-	0.45	2.38	2.82
Fr	-	-	-	-	**4.32**	-	**-12.96**	0.20	-	0.20
It	-	-	-	4.04	**-4.84**	-	**35.42**	2.28	6.42	8.70
Jp	-	-	-	-	-	-	**2.10**	0.11	0.80	0.92
Nl	**9.54**	-	-11.45	-10.95	-	-	**-39.97**	-4.98	-	-4.98
Sw	-	-	-	-	-	**15.05**	**-18.20**	1.27	-9.22	-7.95
UK	**-1.46**	-	1.75	-1.43	-	**2.31**	-	-0.28	-	-0.28
US	-	**-0.57**	-	**0.53**	-	-	-	0.17	-0.21	-0.04
Ge	-	**5.56**	-	-	-	-	**10.67**	0.65	2.23	2.88
Rest	-	-	-	-	-	-	**0.86**	0.05	-	0.05

Table 9a. Hedging components by Italian investing industries

Table 9a reports, for each Italian investing industry, the labor and inflation hedging component. Otherwise the table is the same as Tables 7a and 8a.

Italy										
	Labor Hedge								Infl Hedge	Tot Hedge
	trade	util	transp	other	manuf	fin	leis	nat. unrestr.		
Ca	-	0.17	0.17	-	**0.09**	-	**0.18**	0.05	-	0.05
Fr	-	-	-	-	-	**0.21**	-	0.04	-	0.04
It	-	**-0.19**	-	-	-	**-0.20**	-	-0.04	-	-0.04
Jp	-	-	-	-	-	-	-	-	-	-
Nl	-	-	-	-	-	-	-	-	-0.09	-0.09
Sw	-	-	-	-	-	-	-	-	-	-
UK	-	-	-0.26	-	-	**0.21**	**-0.27**	-	-	-
US	-	-	-	**0.08**	-	**0.13**	-	0.05	-	0.05
Ge	-	-	**0.13**	-	-	**-0.18**	-	-0.02	0.09	0.07
Rest	-	**-0.16**	-0.11	-	-0.08	**-0.08**	-0.13	-0.05	-	-0.05

Table 9b. Relative hedging components by Italian investing industries

Table 9b reports, for each Italian investing industry, the ratio of the labor and inflation hedging component to market share: it contains the same figures as in table 9a but scaled by the market share of the destination country. Otherwise the table is the same as Table 7b and 8b.

	Italy									
	(Labor Hedge)/MS								Infl Hedge MS	Tot Hedge MS
	trade	**util**	**transp**	**other**	**manuf**	**fin**	**leis**	**nat. unrestr.**		
Ca	-	5.66	5.50	-	**2.99**	-	**6.05**	1.51	-	1.51
Fr	-	-	-	-	-	**4.72**	-	0.81	-	0.81
It	-	**-7.87**	-	-	-	**-8.29**	-	-1.51	-	-1.51
Jp	-	-	-	-	-	-	-	-	-	-
Nl	-	-	-	-	-	-	-	-	-4.73	-4.73
Sw	-	-	-	-	-	-	-	-	-	-
UK	-	-	-3.00	-	-	**2.48**	**-3.16**	0.05	-	0.05
US	-	-	-	**0.20**	-	**0.32**	-	0.11	-	0.11
Ge	-	-	**3.59**	-	-	**-4.94**	-	-0.59	2.49	1.90
Rest	-	**-0.72**	-0.50	-	-0.39	**-0.35**	-0.59	-0.23	-	-0.23

Table 10. Size of hedging components: industry vs national restricted

The table reports, for each country, the size of hedging components, i.e. the hedging components in absolute value. Panel a) refers to US investing country, panel b) and c) to Canada and Italy, respectively. In columns (1) and (2) we report the size of inflation hedging component common to all industries. In (3) and (4) we report the weighted average of the size of the labor hedging components across all industries. Columns (5) and (6) report the size of the labor hedging component in the national restricted portfolio. In the last column of the table we report, for comparison, the market share of each destination country. The last row in each panel reports the sum of the absolute hedging components across all destination countries. Results are derived for portfolios with all coefficients ((1), (3), (5)) and for those with only significant coefficients ((2), (4), (6)).

	Infl Hedge		**Abs Labor Hedge** *industry wgt av*		**Abs Labor Hedge** ***national restr.***		
	all coeffs	**sign. coeffs**	**all coeffs**	**sign. coeffs**	**all coeffs**	**sign. coeffs**	**market share**
	(1)	(2)	(3)	(4)	(5)	(6)	
a) USA							
Ca	0.05	0.05	0.06	0.06	0.08	0.08	0.03
Fr	0.12	0.12	0.09	0.07	0.13	0.13	0.05
It	0.05	0.05	0.11	0.11	0.11	0.11	0.02
Jp	0.01	-	0.04	0.03	0.05	0.05	0.11
Nl	0.02	-	0.17	0.15	0.03	-	0.02
Sw	0.02	-	0.08	0.08	0.06	0.06	0.01
UK	0.02	-	0.07	0.02	0.06	-	0.09
US	0.04	0.04	0.08	0.08	0.07	0.07	0.42
Ge	0.08	0.08	0.10	0.08	0.09	0.09	0.04
Rest	0.02	-	0.05	0.03	0.00	-	0.22
sum hedge	***0.42***	***0.33***	***0.84***	***0.71***	***0.67***	***0.58***	
b) Canada							
Ca	0.07	0.07	0.06	0.04	0.01	-	0.03
Fr	0.07	-	0.10	0.07	0.01	-	0.05
It	0.16	0.16	0.12	0.11	0.00	-	0.02
Jp	0.09	0.09	0.04	0.01	0.01	-	0.11
Nl	0.10	-	0.17	0.16	0.05	-	0.02
Sw	0.10	0.10	0.05	0.04	0.01	-	0.01
UK	0.08	-	0.13	0.10	0.00	-	0.09
US	0.09	0.09	0.11	0.08	0.06	0.06	0.42
Ge	0.08	0.08	0.07	0.02	0.03	-	0.04
Rest	0.00	-	0.03	0.01	0.00	-	0.22
sum hedge	***0.85***	***0.59***	***0.88***	***0.64***	***0.19***	***0.06***	
c) Italy							
Ca	0.02	-	0.05	0.05	0.03	0.06	0.03
Fr	0.04	-	0.09	0.04	0.14	-	0.05
It	0.01	-	0.08	0.04	0.05	-	0.02
Jp	0.01	-	0.04	-	0.06	-	0.11
Nl	0.09	0.09	0.04	-	0.09	-	0.02
Sw	0.01	-	0.04	-	0.08	-	0.01
UK	0.03	-	0.15	0.07	0.13	-	0.09
US	0.02	-	0.07	0.05	0.10	0.06	0.42
Ge	0.09	0.09	0.11	0.04	0.05	-	0.04
Rest	0.01	-	0.06	0.05	0.02	0.05	0.22
sum hedge	***0.33***	***0.18***	***0.74***	***0.32***	***0.75***	***0.17***	

Table 11. Absolute distance industry-national

The table reports for each optimal portfolio weight at industry level the absolute distance from the optimal corresponding weight at national level. Here only significant differences are considered (Wald test at 10% confidence level). The optimal portfolio hedging the national labor income risk (*national restricted ptf*) is reported in the last column, while columns from 1 to 7 show the distance of each optimal industry portfolio weight from the corresponding weight in the *national restricted ptf*. Panel a) refers to US investing industries, panel b) and c) to Canadian and Italian industries, respectively.

a) USA

	trade	util	transp	other	manufact	fin	leisure	national restricted
Ca	0.08	-	-	0.07	0.11	-	0.10	0.15
Fr	0.09	0.19	0.18	0.09	0.26	0.14	-	0.04
It	0.13	-	0.17	0.07	0.19	-	-	0.09
Jp	0.05	0.03	-	-	0.11	-	-	0.15
Nl	-	-	**0.37**	-	-	0.23	-	0.02
Sw	0.06	-	0.14	-	0.13	-	0.08	-0.07
UK	0.11	0.18	-	-	0.14	0.13	0.11	0.05
US	-	-	-	-	0.18	-	-	0.32
Ge	-	0.26	0.31	0.05	0.17	-	-	0.04
Rest	-	0.10	0.12	**0.04**	-	0.07	-	0.20

b) Canada

	trade	util	transp	other	manufact	fin	leisure	national restricted
Ca	0.05	0.15	0.12	-	0.07	0.09	-	0.09
Fr	-	-	-	-	0.19	-	0.60	-0.02
It	-	-	-	0.10	0.12	-	**0.87**	0.19
Jp	-	-	-	**0.03**	-	-	0.24	0.19
Nl	0.24	-	-	0.16	-	-	0.72	-0.14
Sw	-	-	-	-	-	0.15	0.21	-0.08
UK	0.13	-	0.15	0.13	-	0.20	-	0.01
US	0.09	0.30	0.12	0.17	-	-	-	0.39
Ge	-	0.23	-	-	-	-	0.41	0.09
Rest	-	-	-	-	-	-	0.18	0.06

c) Italy

	trade	util	transp	other	manufact	fin	leisure	national restricted
Ca	-	0.11	0.10	-	**0.03**	0.08	0.12	0.11
Fr	-	-	-	-	-	0.20	-	0.01
It	-	0.17	-	-	-	0.18	-	-0.01
Jp	-	-	-	-	-	0.07	-	0.11
Nl	-	-	-	-	-	-	-	-0.14
Sw	-	-	-	-	-	0.07	-	-0.03
UK	-	-	0.25	-	0.09	0.23	**0.26**	0.11
US	-	-	-	-	-	0.07	-	0.50
Ge	-	-	0.11	-	0.08	0.19	-	0.14
Rest	-	0.11	0.06	-	0.04	-	0.08	0.04

Table 12. Synthetic measures of dispersion (fully hedged)

Panels 12.I and 12.II report synthetic measures of dispersion of optimal equity portfolios across investing industries for fully hedged and unhedged positions, respectively. The measures of dispersion are computed around the national restricted portfolio. Reported measures are derived, alternatively, on all distances ((1), (3), (5)) and on significant distances only ((2), (4), (6)). Panel a) reports the standard deviation of industry portfolios (around the national portfolio) while panel b) reports the standard deviation of individual weights in industry portfolios (around individual weights in the national portfolio). Both unweighted and weighted measures are considered (in the weighted measure the weights are computed considering the labor compensation of each investing industry on total labor compensation in each country). The unweighted standard deviation of the S industry portfolios in country *l* with respect to the restricted national portfolio *l* is computed as

$$\sigma^{l}_{PU} = \sqrt{\frac{\sum_{s=1}^{S}\sum_{j=1}^{N}\left(w_j^{\,sl} - \overline{w^{l}}_{\,j}\right)^2}{S}}$$

where S is the total number (seven) of industries in country *l*, *N* is the total number of destination equity indices (ten), w_j^{sl} is the optimal weight of equity index *j* in the portfolio of industry *s* in country *l*, $\overline{w_j^{l}}$ is the optimal weight of equity index *j* in the restricted national portfolio of country *l*. The weighted standard deviation of the S industry portfolios in country *l* with respect to the restricted national portfolio *l* is computed as

$$\sigma^{l}_{PW} = \sqrt{\sum_{s=1}^{S}\sum_{j=1}^{N}\nu^{sl}\left(w_j^{\,sl} - \overline{w^{l}}_{\,j}\right)^2}$$

where ν^{sl} here is the relative weight of industry *s* in country *l*, measured by the total labor income compensation paid in industry *s* relative to the total labor income compensation in country *l*.

The unweighted and weighted standard deviations of the S industry portfolio *weights* in country *l* with respect to the *weights* in restricted national portfolio *l* are computed, respectively, as

$$\sigma^{l}_{wU} = \sqrt{\frac{\left(\sigma^{l}_{PU}\right)^2}{N}} \quad \text{and} \quad \sigma^{l}_{wW} = \sqrt{\frac{\left(\sigma^{l}_{PW}\right)^2}{N}}$$

I. Fully hedged

	United States		Canada		Italy	
	all dist. (1)	**sign. dist.** (2)	**all dist.** (3)	**sign. dist.** (4)	**all dist.** (5)	**sign. dist.** (6)
			a) portfolios			
weighted sd	0.33	0.32	0.44	0.42	0.29	0.22
unweighted sd	0.39	0.36	0.62	0.56	0.32	0.25
			b) weights			
weighted sd	0.10	0.10	0.14	0.13	0.09	0.07
unweighted sd	0.12	0.11	0.19	0.19	0.10	0.08

II. Unhedged

	United States		Canada		Italy	
	all dist. (1)	**sign. dist.** (2)	**all dist.** (3)	**sign. dist.** (4)	**all dist.** (5)	**sign. dist.** (6)
			a) portfolios			
weighted sd	0.33	0.32	0.43	0.40	0.31	0.25
unweighted sd	0.39	0.37	0.59	0.53	0.33	0.28
			b) weights			
weighted sd	0.11	0.10	0.13	0.13	0.10	0.08
unweighted sd	0.12	0.14	0.19	0.17	0.10	0.09

Table 13. Home bias

Table 13 compares our results on home bias for the three investing countries with findings in Baxter and Jermann (1997), Bottazzi et al. (1996) and Coen (2001). The first two columns report the actual position invested in domestic equities together with their market share (in parenthesis). Column (3) to (9) report the home bias measured as the actual position minus the optimal positions in domestic equities. In columns (6) and (7) the home bias measure is computed with respect to the optimal equity portfolios derived in the paper (in which we retain all nominal variable expressed in local currency), while in columns (8) and (9) report the home bias is measured with respect to optimal equity portfolios computed (but not reported here) considering all nominal variables expressed in the currency of the investing country (i.e. exchange rate positions are unhedged).

	Actual % Invested in domestic equities *(MS)*		**Home bias**						
			Baxter-Jermann*	**Bottazzi *et al.*****	**Coen****	**Our Paper - National portfolio*****			
						Fully-Hedged		***Unhedged***	
	1994	**2003***				**restr**	**unrestr**	**restr**	**unrestr**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Canada	0.72 *(0.03)*	0.70 *(0.03)*		-1.12	0.70	0.62	0.61	0.62	0.64
Italy	0.85 *(0.05)*	0.58 *(0.02)*		1.20	0.83	0.56	0.59	1.30	1.30
US	0.92 *(0.48)*	0.86 *(0.42)*	1.04	0.25	0.51	0.56	0.50	0.46	0.41

***** Actual positions are those at the end of year 2003, while market shares are evaluated at the end of year 2004 (source Sorensen et al., 2007).
****** The home bias is computed using data on actual positions and market shares at the end of 1994.
*** The home bias is computed using data on actual positions at the end of 2003.